Overview of Loran-C Evaluations
Federal Aviation Administration

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Agenda

- Program Participants
- Recent U.S. Loran-C Activities
- FY ’01 Activities
- Current U.S. Policy
- GPS Vulnerability Study
- Loran-C Program Goals
- Status 2001 Activities
- Scope of FAA Assessments
- A Very Full ILA Program
- Summary
- Questions

FAA Program Participants

- Government
  - Federal Aviation Administration
    - Navigation Systems Engineering, AND-702
    - NAS Architecture, ASD-140
    - CNS Test and Evaluation, ACT-360
    - Flight Standards, AFS-400
    - Certification, AIR-130
    - Special Programs, AVN-5
  - U.S. Coast Guard
    - Aids to Navigation
    - Navigation Center
    - Loran Support Unit

Industry Participants

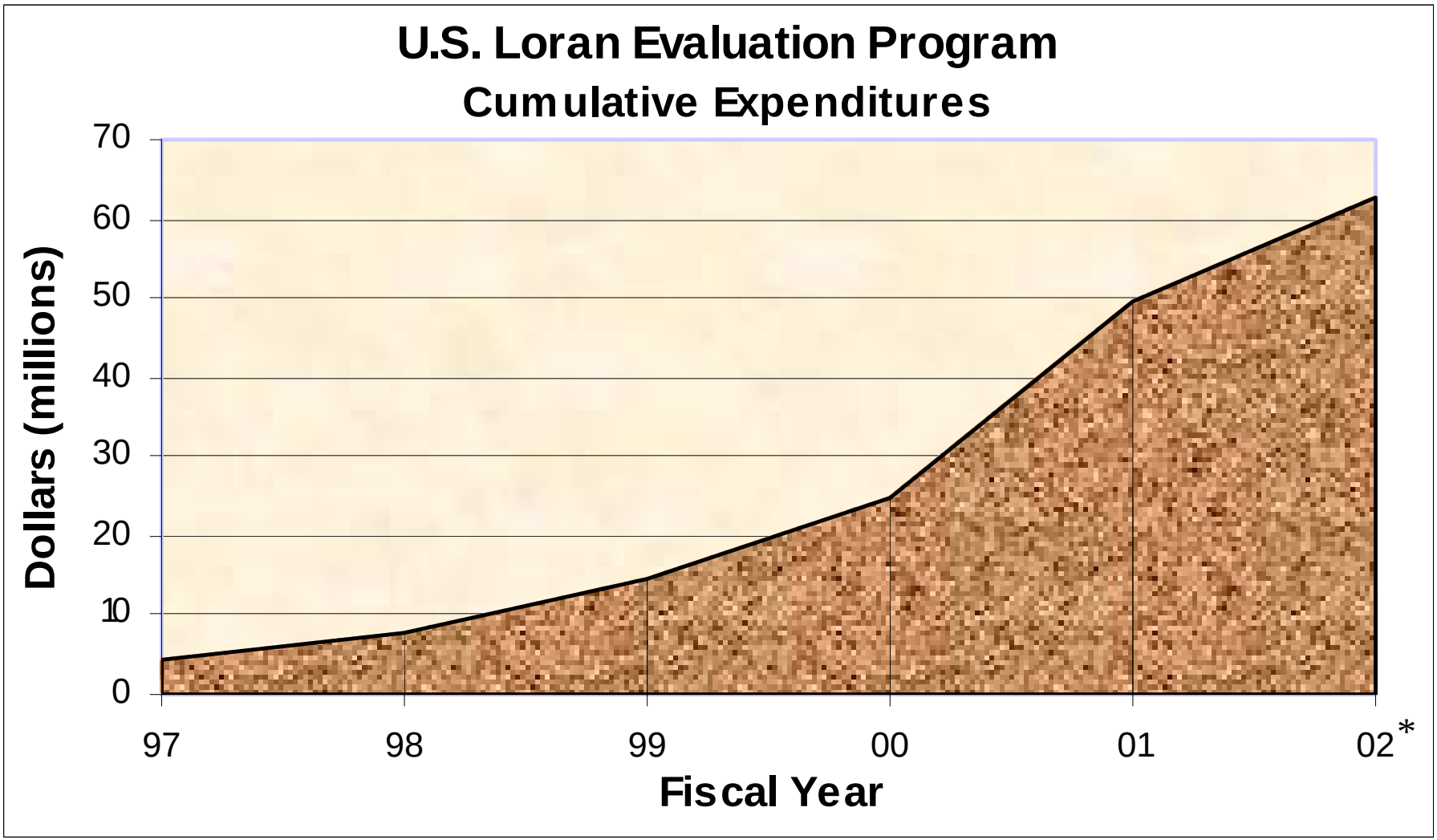
- Academia
  - US Coast Guard Academy
  - Ohio University
  - Stanford University
  - University of Rhode Island
  - University of Alaska
- Industry
  - Peterson Integrated Geo-positioning
  - Locus, Inc.
  - Illgen Simulation Technologies

Program Logo Collection

Recent FAA Loran-C Activities

- FY 1997 ($4.6 M)
  - Congressional Mandate
    - The FY 1997 Congressional budget provided funds to the FAA for "upgrades to the Loran-C navigation system and... to implement an automatic blink system (ABS)."
- FY 1998 ($3 M)
  - Congressional Mandate
    - The FY 1998 Congressional budget directed the FAA "to continue Loran-C upgrades initiated in fiscal 97."
- FY 1999 ($7 M) and FY 2000 ($10 M)
  - Congressional Mandates
    - The Congressional budgets provided funds to the FAA for "further development of the Loran-C navigation system."

A Most Substantial Investment



* Assumes only $13 million

FY '01 FAA Loran-C Activities

- Congressional Mandate
  - $20 M requested, $25 M provided for "further development of the Loran-C navigation system."
  - The FAA/US Coast Guard Loran-C Team:
    - Installed new cesium clocks at all Loran-C stations
    - Evaluated new solid state transmitter proposals and will award contract
    - Will test and evaluate transmitter first article prior to exercise of contract options
    - Will finalize new Loran station building design and transition planning
    - Issued RFP for new Timing and Frequency Equipment (TFE)
    - Will complete tower life inspections and analysis and project costs for sustainment and/or recapitalization

Current US Loran-C Policy

"While the Administration continues to evaluate the long-term need for continuation of the Loran-C radionavigation system, the Government will operate the Loran-C system in the short term. The U.S. Government will give users reasonable notice if it concludes that Loran-C is not needed or is not cost effective, so that users will have the opportunity to transition to alternative navigation aids. With this continued sustainment of the Loran-C service, users will be able to realize additional benefits. Improvement of GPS time synchronization of the Loran-C chains and the use of digital receivers may support improved accuracy and coverage of the service. Loran-C will continue to provide a supplemental means of navigation. Current Loran-C receivers do not support nonprecision instrument approach operations."

- ***Para 3.2.5 B 1999 US Federal Radionavigation Plan***

Volpe GPS Vulnerability Study

- Vulnerability study recognized the *potential* for Loran-C to be a robust backup system for GPS navigation and augmentation and timing.
  - "In an effort to provide the greatest benefit to the users, encourage the development of affordable vehicle-based backups such as GPS/inertial receivers, and, in the event Loran-C becomes a viable terrestrial backups to GPS, aviation certifiable Loran-C receivers, and GPS/Loran-C receivers."
  - "Conduct a comprehensive analysis of GPS backup navigation and precise timing options including VOR/DME, ILS. Loran-C, inertial navigation systems and operating systems."
  - "Continue the Loran-C modernization program of the FAA and USCG, until it is determined whether Loran-C has a role as a GPS backup system. If it is determined that Loran-C has a role in the future navigation mix, DOT should promptly announce this to encourage the electronics manufacturing community to develop new Loran-C technologies."

Loran-C Program Goals

- Determine if an ***enhanced*** Loran-C system can meet the
  - **Accuracy**
  - **Availability**
  - **Integrity, and**
  - **Continuity**

  requirements to support Lateral Navigation (LNAV) during the approach phase of flight, including missed-approach guidance
- Determine whether Loran-C can provide other ancillary benefits to aviation

Loran-C Aviation Issues

Issues	Potential Mitigations
Availability	
Precipitation Static	H-Field Antenna
Loss of Station Power	UPS
Lightning	New Lightning Protection
Chain Availability	All-in-view receivers
Tube overloads	Solid-state transmitters
Accuracy	
Old timing sources	New cesium clocks
Old timing equipment	New timing suite
Tube technology	Solid-state technology

Loran-C Aviation Issues (2)

Issues	Potential Mitigations
Integrity	
Manual System	Automatic Blink System (ABS)
Continuity	
Triad-based approaches	All-in-view navigation
Receiver acquisition time	New DSP technology

Other Potential* Benefits

- Loran-C has the potential* for providing a transmission path for GPS correction information [i.e., Wide Area Augmentation System (WAAS)] corrections.
  - Potential for providing WAAS signal in areas where geo-stationary satellite coverage is limited, questionable, or unavailable (e.g., Alaska, urban canyons)

***The "potential" is now a reality!!!**

Performance Goals

GOAL	SIGNAL IN SPACE PERFORMANCE RECOMMENDATION (ICAO GNSS SARPS)	LORAN CAPABILITY (US FRP)	STATUS
Accuracy (horizontal - 95%)	RNP-0.3 (0.3 nm) 220m	0.25 nm 460m	Provides RNP-0.3 accuracy but does not achieve 220m 95% accuracy recommendation. (Potentially possible with ASF profiles)
Availability	0.99999	99.7%	With UPS and all-in-view receivers, Loran navigation services will approach a 100% availability.
Continuity	1-10-8/h	99.7% (Triad Reliability)	With UPS and all-in-view receivers, Loran navigation services will approach a 100% continuity of function capability.
Integrity	1-10-7/h	10 sec. (with aviation blink)	59 sec. operational outage still exists – Operational procedures being reviewed by USCG.

Status of FY 2001 Activities

- Flight Testing of H-Field antennas and all-in-view receivers
  - P-static characterization testing has been delayed to complete safety analysis of aircraft static charging system, installation of field mill and measurement equipment, and aircraft structural considerations. Testing scheduled later this year.
  - An H-field antenna combined with a DSP receiver has been successfully flight tested.
- Testing of all-in-view DSP receivers
  - DSP receivers successfully flight tested
  - AIV algorithms being reviewed to evaluate their potential to improve the availability of a navigation solution

Status of FY 2001 Activities (2)

- Loran Data Channel development
  - USCG Loran Support Unit, Stanford University, Peterson Integrated Geo-positioning, and University of Rhode Island have made remarkable progress in this area.
  - Using Inter-pulse Frequency Modulation (IFM) a 250 bps data rate is being achieved.
    - Successful flight trials conducted from FAA Technical Center during May and June 2001
    - Successful Alaskan on-site test/demonstration and flight trials conducted August 2001.

Status of FY 2001 Activities (3)

- Future Plans
  - Work with USCG, Academia, and Industry to develop FY 2002 Project Plan, to include
    - Evaluation and quantification of Loran-C navigation and communications benefits to aviation and other transportation modes
    - Continued re-capitalization of Loran-C system and quantification of Loran-C operational cost reductions
  - Share tests results with navigation community as they become available
    - ION
    - ILA
  - Brief RTCA and ICAO on results of test and evaluation, as promised
  - Report results of test and evaluation and recommended near-term course of action to USDOT (mid-FY2002)

Scope of U.S. Loran Assessments

- The U.S. effort is assessing Loran-C developments in four key task areas:
  - A Loran H-field antenna suitable for aircraft installation
  - Evaluate an RTCA DO-194 / FAA TSO-C60b compliant Digital Signal Processing (DSP) Loran receiver
  - Enhanced Loran Communications Capability for Loran-C and GPS integrity and correction data.
  - Development of a hybrid GPS/Loran-C Receiver Architecture

Loran H-field Antenna

KEY TASK: A Loran H-field antenna suitable for aircraft installation	**ISTI / FAATC**	**USGCA**	**Locus**
Assessment effort:	Collection of data to support the characterization of P-static.	Modify a suitable aircraft antenna enclosure, integrate with a DSP receiver and flight test	Modify a suitable aircraft antenna enclosure, integrate with a DSP receiver and flight test
Status:	Pending modifications to test equipment configuration to be installed in FAATC Aero Commander	Bendix-King ADF antenna modified to accept Loran H-field. Has been **successfully flight tested** on King Air and Convair integrated with both PC-104 and DDC Loran DSP receivers.	Phases I and II highly successful. Work will be continuing in FY '02 to further reduce size and increase performance of H-Field and incorporate GPS antenna in same enclosure.

2002 Goals:
1. **Complete H-field P-static characterization trials.**
2. **Develop and flight test a combined GPS / H-field Loran antenna**

DSP Loran Receiver

KEY TASK: Evaluate an RTCA DO-194 / FAA TSO-C60b compliant Digital Signal Processing (DSP) Loran receiver	**ISTI**	**USGCA**	**Locus**
Assessment effort:	Loran-C User Position Software (LUPS)	Optimized PC-104 for flight testing. Developed next generation DSP using DDC	Optimize Satmate performance for flight testing.
Status:	Encoding of the all-in-view (AIV) navigation algorithm completed	PC-104 and DCC Loran DSP receivers completed successful AIV navigation flight tests	Work in progress
2002 Goals:	**1. Flight test a fully TSO operationally compliant DSP Loran receiver.** **2. Confirm baseline for AIV Loran operational performance.** **3. Establish a development partnership with one or more avionics manufacturers to develop a next generation aviation navigation sensor.**		

Loran Data Channel

KEY TASK: Enhanced Loran Communications Capability for Loran-C and GPS integrity and correction data.	PIG / URI / LSU	Stanford	Univ. of Alaska / OU
Assessment effort:	Investigate the potential to achieve a 250 bps LDC.	Characterize to potential for LDC to provide WAAS data,	Support flight testing of LDC
Status:	250 bps WAAS message successfully received during flight tests.	Operational evaluation to be conducted during August LDC test flights.	OU completed successful flights in May 01. Successful Alaskan flight tests completed with N49 and N200U August 01

2002 Goals:

1. **Continue evaluation of the robustness of the LDC for WAAS data**
2. **Establish LDC WAAS transmitting tests sites at LSU, Fallon, or Middletown and Tok.**
3. **Work with European groups to determine whether 250 b/s LDC demonstration in Europe would be helpful.**

NexGen Navigation Receiver

KEY TASK: Development of a hybrid GPS/Loran-C Receiver Architecture	ISTI	USGCA	Industry:
Assessment effort:	Developed proposal for GPS / Loran navigation solution processing.	Integrate DDC with suitable GPS/WAAS sensor.	
Status:	Under review – potential that Loran capability overstated.	Both GPS/WAAS hardware and software options being evaluated and combined antenna under development.	

2002 Goals:

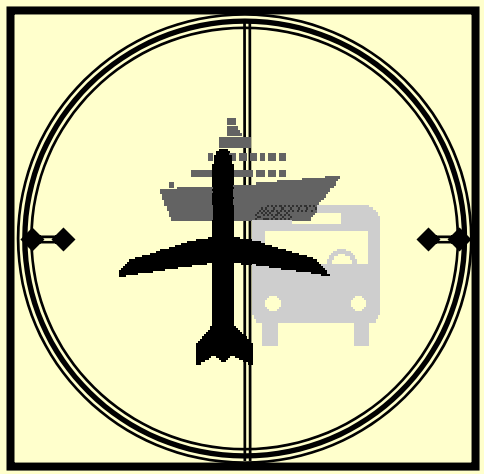
1. **Establish development partnership with one or more avionics manufactures.**
2. **Develop next generation navigation receiver that includes GPS', WAAS', Loran' & LDC.**
3. **Designate an FAA sponsor and establish and RTCA working group.**

NexGen Navigation Receiver

WAAS'
$WAAS_{GEO}$ (W_G)
or
$WAAS_{LDC}$ (W_L)

GPS'
L1 or L2 or L5

LAAS



Loran'
All-in-View
H-Field Antenna
(LNAV)

Inputs
Baro Altimeter
(VNAV)

Other
TBD
(e.g., Low Cost Gyro)

A Very Full ILA Program

- The U.S. Loran-C Evaluation Program has much to be proud of…and equally much to report out at this ILA Meeting.
- What you will see and hear over the next few days includes:
  - 8 October:
    - *Operational Status of Loran Equipment Modernization*
      - *U.S. Coast Guard Navigation Center*
    - *Keeping the Pulse Alive Through Heart Transplants and Face Lifts*
      - *U.S. Coast Guard Loran Support Unit*
    - *Wagging the Tail and Flying with Loran-C Data Channel*
      - *Peterson Integrated Geopositioning*

A Very Full ILA Program (2)

- 9 October:
  - *Development and Status of H-Field Antenna and GPS Receiver for the FAA Loran Program*
    - *Locus, Inc.*
  - *Ohio University Flight Test Support to the FAA*
    - *Ohio University*
  - *Status of Loran-C Evaluations at the FAA*
    - *U.S. Federal Aviation Administration*
  - *Flight Trials Comparing SatMate DSP Receiver, GPS, and Legacy Loran Recievers*
    - *Locus, Inc.*
  - *PC-104 and DDC H-Field Loran-C Navigation Receivers*
    - *U.S. Coast Guard Academy*
- *10 October*
  - *Loran-C User Position Software Navigation Performance with PC-104 and DDC Receiver Flight Test Data in the New Jersey Area*
    - *Illgen Simulation Systems*

Summary

- Excellent progress has been made and FY'01 goals have been achieved – and more!
- The planned FY'02 program should result in prototype avionics that will allow evaluation of Loran for all phases of flight in both stand-alone and multisensor configurations.
- Further development of the Loran data channel (LDC) will allow continued evaluation of $WAAS_L$ in a multimodal transport environment.


FEDERAL AVIATION
ADMINISTRATION

Questions


FEDERAL AVIATION
ADMINISTRATION


FAA NAVIGATION INTEGRATED PRODUCT TEAM