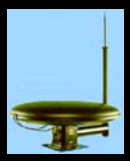
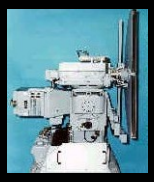
GBAS FAA/Europe International Coordination Meeting



Washington, D.C.
14-15 December 2004

JPALS Technical Overview
Presented by
Tom Sanders



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JPALS Briefing to GBAS

- JPALS Overview
- JPALS Operation
- JPALS Technology
- Summary
- Questions

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Overview

Operational Environments

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Overview
Program Description

Capability Gap

- No single interoperable DoD / Civil precision approach and landing system
  - Only 30% of Navy and 50% of Army aircraft have ILS
  - PAR and Mobile MLS only military deployable landing systems
    - Navy and Army not MLS capable
    - PAR not civil interoperable
    - PAR and MMLS footprint too large for SOF
  - Navy shipboard systems (ICLS and ACLS) are unsupportable
  - Diminishing Manufacturing Source (DMS) issues exist for many of the current Precision Approach Systems
- Emerging shipboard operations cannot be met by any of the existing precision approach and landing systems

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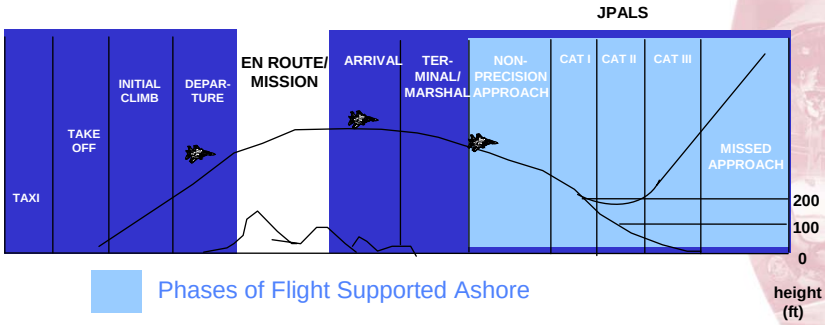
Overview What is JPALS?

JROC validated Mission Need Statement, Aug 95

"…a rapidly deployable, adverse weather, adverse terrain, survivable, maintainable, and interoperable precision approach and landing system (on land and at sea) that supports the warfighter when ceiling and visibility are limiting factors…"



Phases of Flight Supported Ashore

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Overview Why JPALS?

- Highest capability among system alternatives
- Only fully interoperable solution among Services, FAA, and International aviation (ICAO)
- Current precision approach systems are obsolete, difficult to support and maintain
- Lower cost than maintaining status quo
- Only system to meet future aircraft requirements (JSF, unmanned systems)
- Only system to meet future ship requirements (CVF, CVN-21)
- "Network Centric Capability" for Air Traffic Control

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Technology JPALS Shipboard Drivers

General: Recoveries with no limitations due to sea state or weather

- Automatic Landing
- Position/trend to CATCC, LSO
- Approaches for all aviation ships
- Shore DoD/ Civil interoperability

Joint Strike Fighter (JSF)

- Land to any spot (LH)
- Primary mode: automatic takeoff and landing
- 360 degree coverage

J-UCAS

- Very high safety and reliability
- Fully automatic flight in CCA
- ATC control via digital data
- "See and avoid" manned aircraft

Future Carriers (CVN-21, CVF)

- No rotators
- Low RCS
- Eliminate unique signals
- Reduce workload/manning

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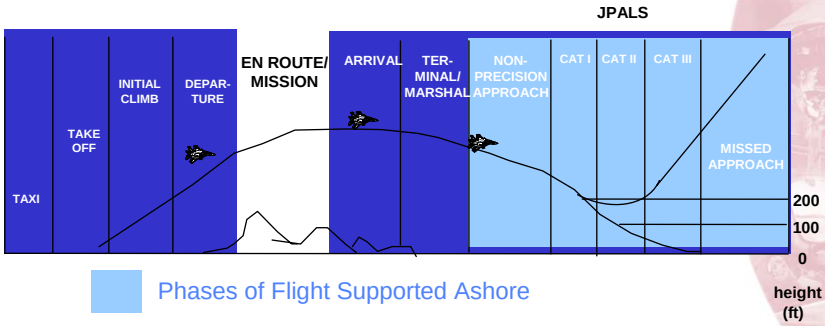
Operation What is JPALS?

JROC validated Mission Need Statement, Aug 95

"…a rapidly deployable, adverse weather, adverse terrain, survivable, maintainable, and interoperable precision approach and landing system (on land and at sea) that supports the warfighter when ceiling and visibility are limiting factors…"



Phases of Flight Supported Ashore

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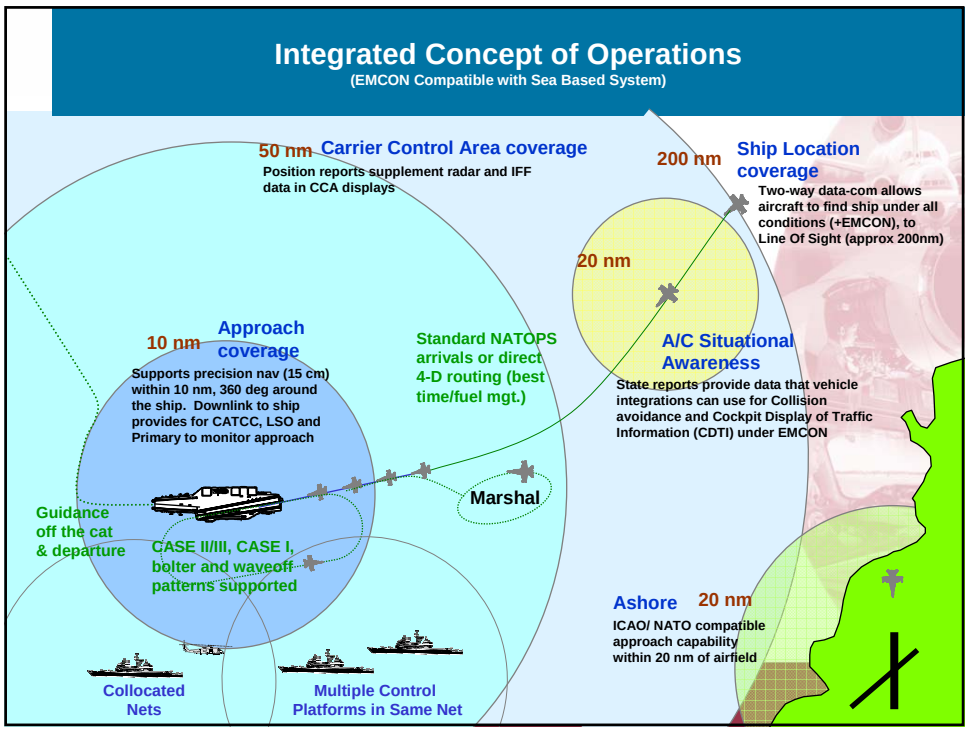

Operation An Approach Capability Consists of…

- Precision 3-D navigation
  - azimuth, elevation, range
- Communications
  - "pilot" / controller
- Missed Approach
- Separation
- CATCC Monitoring
  - e.g. Final Controller's display
- LSO Monitoring
  - LSO Workstation

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Future Technology

- Flight Information Service (FIS)
  - Automated meteorological data, including wind speed and direction over deck.
- Controller Pilot Data Link Communications (CPDLC)
  - A set of commands to the airborne platform which can be initiated either via manual operation, by voice command, or automatic via Auto ATM. Proper handling of "transfer of control" is critical for unmanned operations.

Future Technology (cont)

- Endurance Management Air Traffic System (EMATS):
  - Given a flight plan, algorithms compute optimum time of arrival, scheduled unmanned platforms with other manned aircraft. A display tool provides time of arrival status information to the controller or Mission Control System (MCS) operator with 4-D routing.
- Airspace Management
  - Assigns airspace regions to aircraft. System monitors the aircraft, upon detection of impending spill-out, the system generates alarm to DLCC, MCS operator, or to the unmanned platform itself.

Future Technology (cont)

- **Shipboard Tracking**
  - **JPALS displays manned and unmanned platforms on controller consoles from integrated dependent surveillance SRGPS track information fused with primary radar and IFF.**
- **Cockpit Display of Traffic Information (CDTI)**
  - **Embedded collision avoidance function for manned and unmanned platforms. Operators have information on all local traffic, including 3-D relative range, bearing, and acceleration.**
- **Shipboard Approach Monitor**
  - **Aircraft are monitored with automated Collision Avoidance System (CAS) functions, MCS display, and final approach display.**

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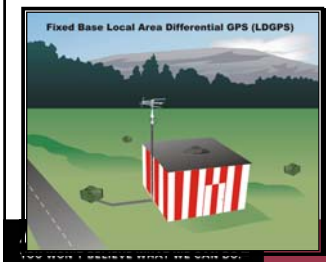
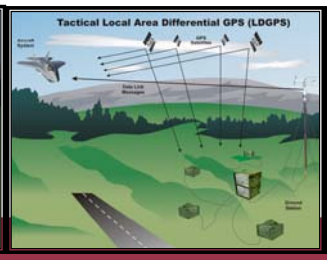
Technology Land Based JPALS

- Land based JPALS uses local area differential GPS (LDGPS) to provide a PALS capability for fixed base, tactical and special mission operations.
- The aircraft system receives data link messages from the ground station containing GPS range corrections and runway data. This data is then used to derive a differentially corrected navigation solution.
- Enabling technologies
  - Advanced anti-jam GPS systems
  - Military differential GPS accuracy and integrity solutions
  - Tactical data link – with Information Assurance attributes for combat operations





Current SRGPS Performance Requirements

Table 3-6: Summary of Deviation Accuracy Requirements

SPL	Distance from Touchdown (DFT)	Vertical Accuracy	Lateral Accuracy	Figure 3-4 Reference
PA	-100 m to 1163 m	2 m	2 m	A
	1163 m to 6979 m	[2 + 2*(DFT-1163)/5816] m	[2 + 2*(DFT-1163)/5816] m	B
	beyond 6979 m	4.0 m	4.0 m	
AL	-100 m to 530 m	0.4 m	0.4 m	A
	530 m to 6979 m	[0.4 + 3.6*(DFT-530)/6779] m	[0.4 + 3.6*(DFT-530)/6779] m	B
	beyond 6979 m	4.0 m	4.0 m	

Note 1: The guidance accuracy includes both NSE and path definition error (PDE). For RN 1-3 the PDE is assumed to be zero.

Note 2: The DFT is positive on the approach side of the TDP and negative after the aircraft has passed the TDP (i.e., the bolter deck roll).

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Technology Sea Based JPALS

- Sea based JPALS uses shipboard relative GPS (SRGPS) to meet the requirements to navigate around and land aboard Naval vessels
  - Kinematic Carrier Phase is used to meet the stringent accuracy requirements
  - Relative inertial navigation is used to compensate for ship's motion
- A two-way data link supports the requirements of shipboard operations
  - Uplink broadcast of GPS and INS data and Air Traffic Control information
  - Downlink of aircraft data to support shipboard monitoring
  - COMSEC and TRANSEC features to support protection of ship's location and operational security
- Enabling technologies
  - Advanced anti-jam GPS systems with shipboard adaptive multipath mitigation
  - Relative GPS-INS positioning with kinematics
  - UHF Low Probability of Intercept Data Link

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Technology JPALS Surface Components

Ground	Ship
AJ Antenna/Electronics*	AJ Antenna/Electronics*
GPS Receivers*	GPS Receivers*
Processor Hdwr*	Processor Hdwr*
LDGPS Software*	SRGPS Software*
VDB Transmitter	UHF LPI Data Link Tx/Rx
Combat Ops Data Link Tx*	Ship Interfaces, e.g., INS
O&M Interfaces*	O&M Interfaces*

* The asterisks indicate the potential for commonality between JPALS ground and shipboard equipment

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Technology JPALS Airborne Components

- JPALS integration in aircraft maximizes use of existing avionics
- Avionics components include:
  - GPS Sensors
  - AJ Antenna Systems
  - Inertial Navigation Sensors
  - Computer Processing Equipment
  - Data Link (Rx for Land Based and Rx/Tx for Sea Based JPALS)
  - JPALS Software Algorithms (LDGPS and SRGPS)

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Technology JPALS Deltas from LAAS

- Use Dual Freq
  - PPS
- Operate in stressed interference environments
  - Intentional and Unintentional Jamming
- Support rapid deployment for Tactical and Special Mission operations
- Use a COMSEC or Information Assurance compliant data link in support of combat and shipboard operations
- Support precision approach to moving platforms (ship)

JPALS Summary

- JPALS is, in many ways a military version of LAAS
  - Dual Frequency
  - Anti-Jam
  - Two Way Data Link (sea based)
- JPALS Technology has extensive overlap with Civil programs such as WAAS and LAAS
- JPALS has built on Civil SatNav Technology Development
  - Stanford University
  - Ohio University
  - Rockwell Collins
  - ARINC

JPALS Briefing

- Questions?

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SRD-Subsystem Allocation Discussion (Cont'd)

- Non-Precision Mode Prediction and Availability Study
- GPS Failure Rate Study
- GPS RFI Environment Assessment Study
- Path Definition Study
- Stabilization Study
- Network Acquisition Study
- Ship Airwake Study
- Ship Dynamics Study
- UHF Signal Environment Study
- Airframe Multipath Phase and Pseudorange Study
- Airborne noise - Satellite Power Study
- Airborne noise - Airborne Antenna Gain Study
- Airborne noise - Implementation Loss Study
- Airborne noise - Thermal Noise Study
- Airborne noise - Broadband Interference Study
- Airborne noise - Jamming Interference
- Airborne noise - Carrier noise is affected by vibration and jitter.
- Residual Antenna phase center data is not available
- Attitude and motion sensor quality is not defined
- Motion filter errors are unknown
- Ship multipath is not quantified for phase and pseudo range
- Troposphere Residual Error
- Ocean Surface to airborne multipath effect not quantified
- Ship Surface to airborne multipath effect not quantified
- Antenna Flexure with respect to center of motion not quantified
- B-Value for phase measurement

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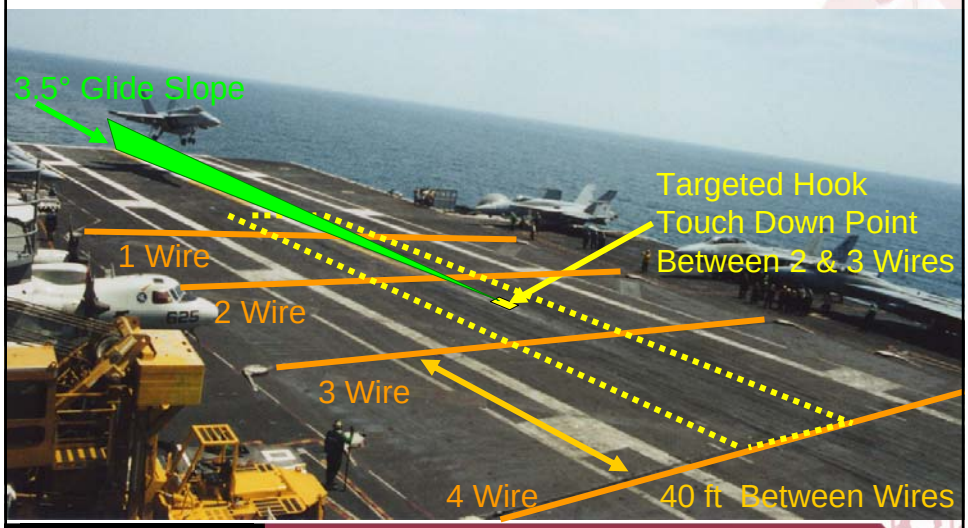
Test Results: USS Theodore Roosevelt

Carrier Deck Landing Area



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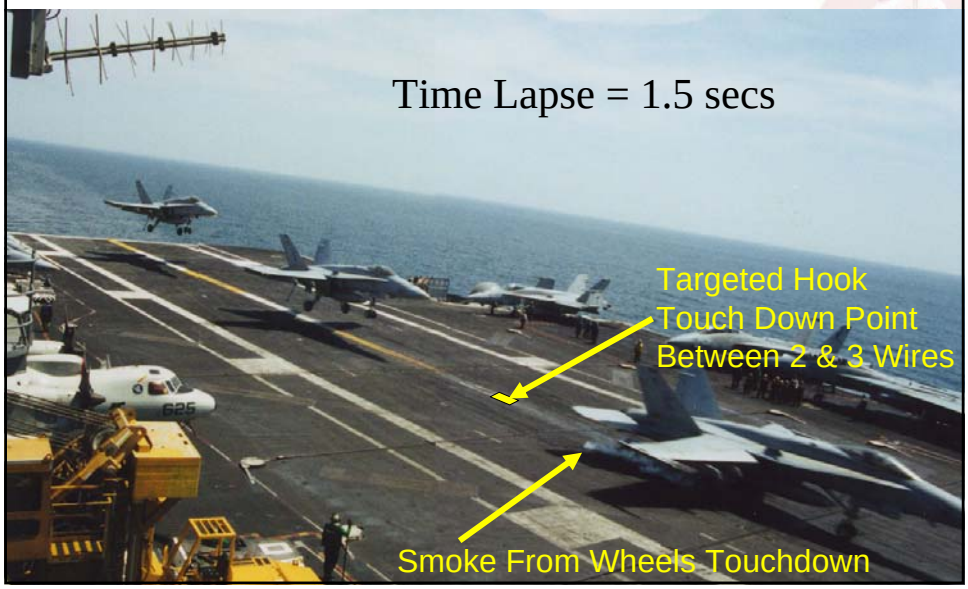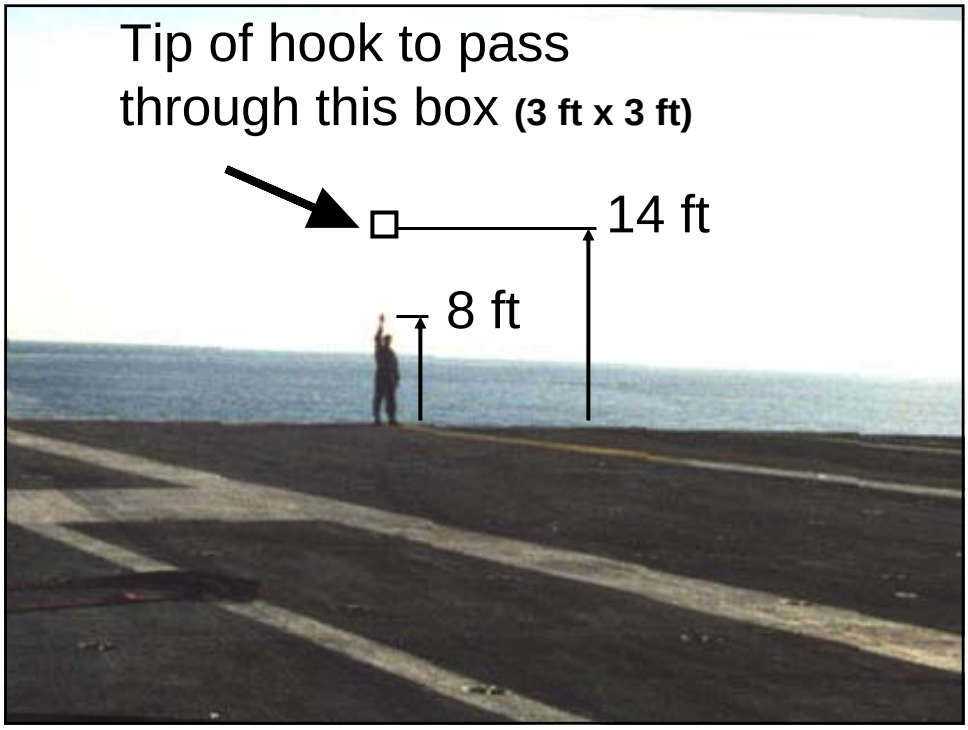
Carrier Landing