



# Secure, Robust CNS Technologies for Naval Aviation via the Joint Precision Approach and Landing System



**I-CNS Technologies  
Conference Briefing  
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# Outline



- Overview
- Concept of Operations
- JPALS Architectures
- CNS ATM Functions
- Demonstrations
- International Cooperation
- Summary

***Transformational, network-centric technology  
for sea-based air operations and precision landing***



# JPALS Overview

## Need & Operational Environment



**Fixed Base**



**Tactical**



**Special Missions**



**Shipboard**

***JROC validated Mission Need Statement, Aug 95***

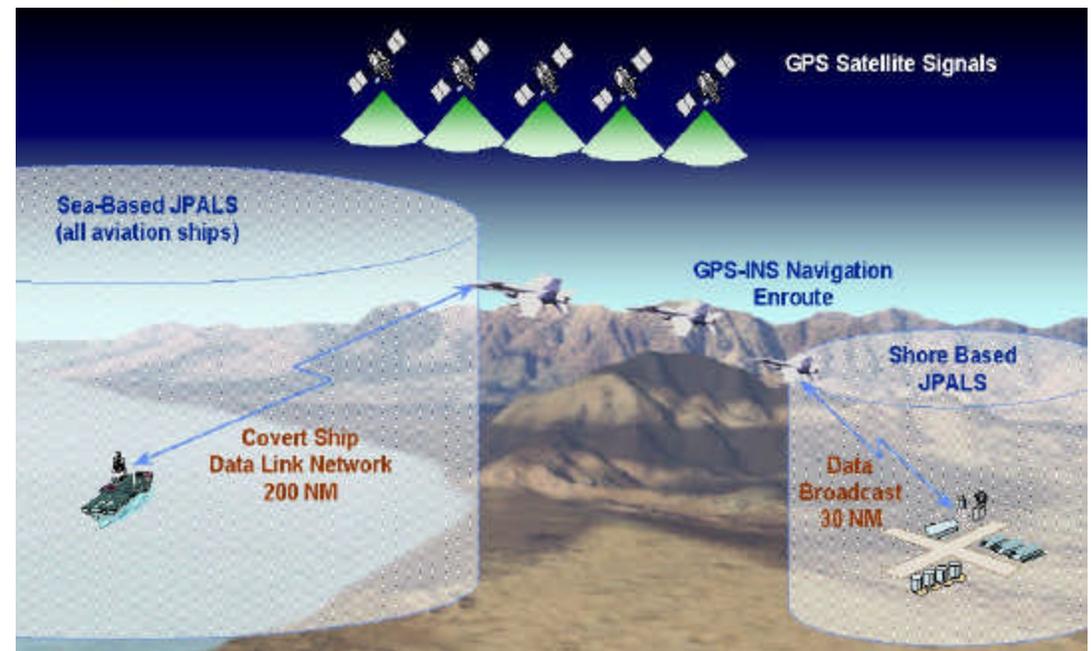
“...a rapidly deployable, adverse weather, adverse terrain, survivable, maintainable, and interoperable precision approach and landing system (on land and at sea) that supports the warfighter when ceiling and visibility are limiting factors...”



# JPALS Overview



- **A network-centric concept to support landing ashore and all phases of flight in the shipboard environment**
  - Covert, secure, anti-jam
  - Low latency, high integrity, fault-tolerant
- **Responsibility for all approach modes with vertical navigation**
- **Interoperable**
  - Services
  - Allies
  - Civil airspace





# JPALS (Navy Applications)



**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 deg coverage



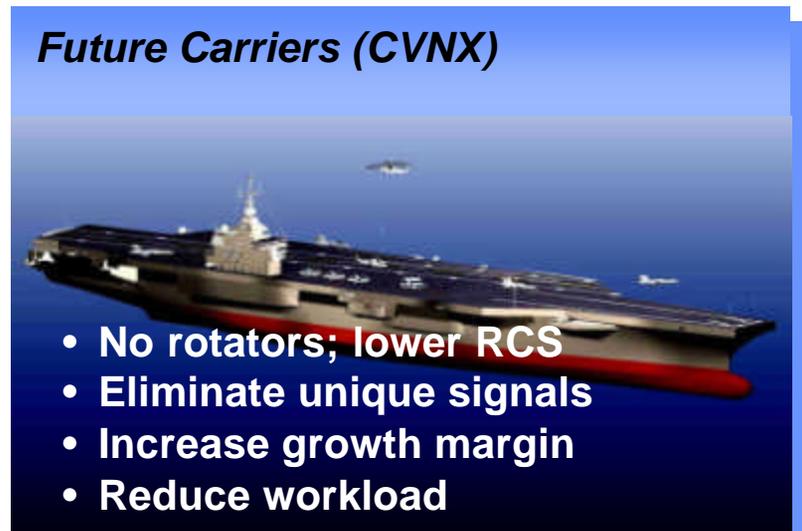
**Naval UCAV**

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



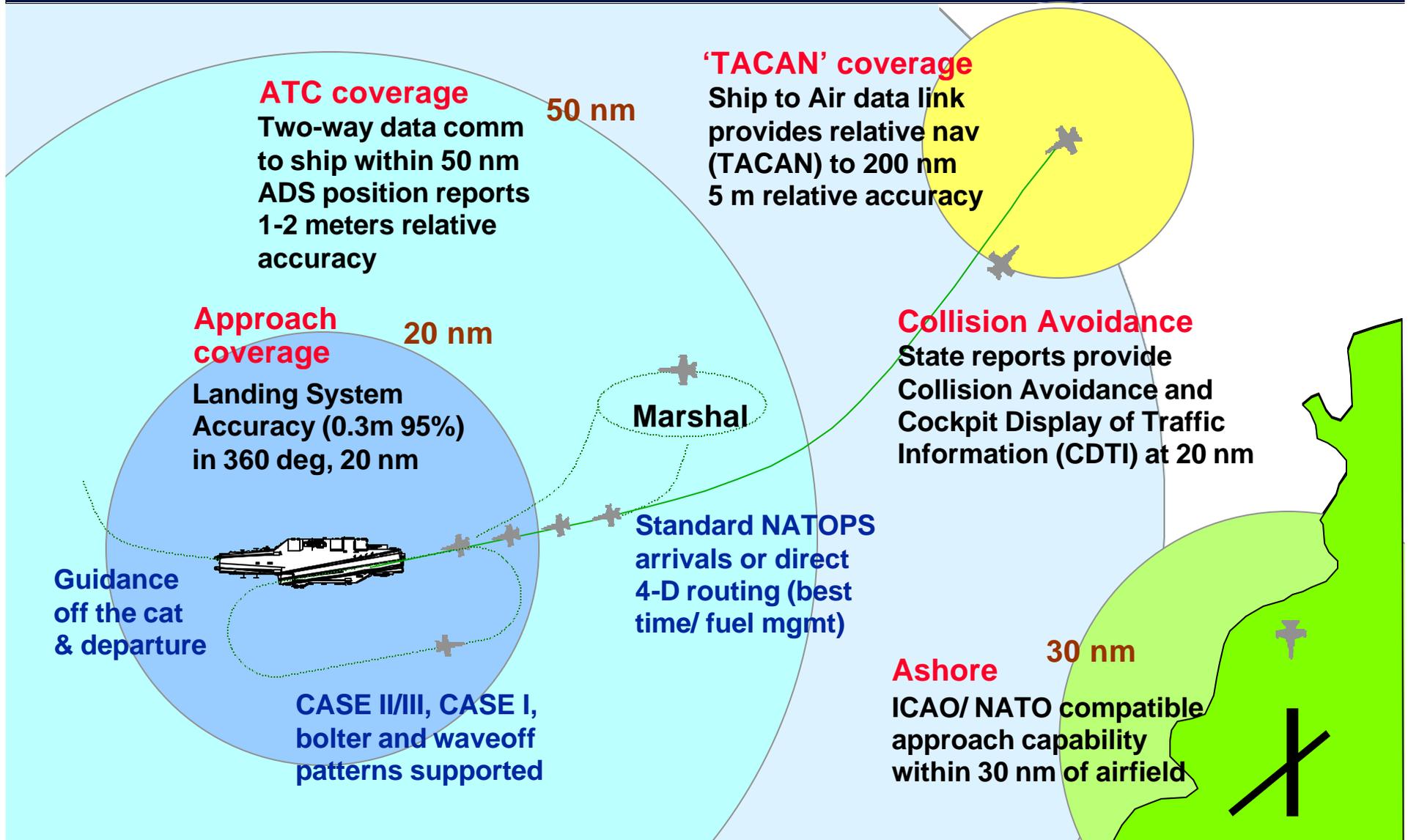
**Future Carriers (CVNX)**

- No rotators; lower RCS
- Eliminate unique signals
- Increase growth margin
- Reduce workload





# Concept of Operations for the Carrier at Sea

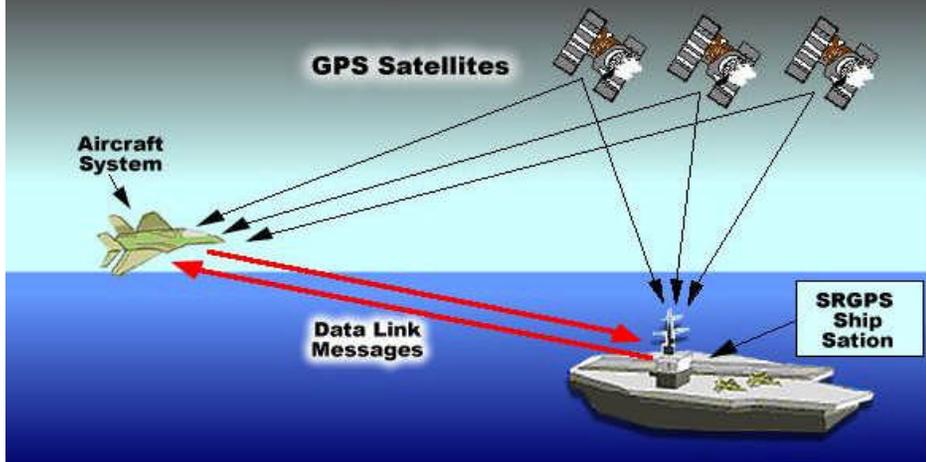




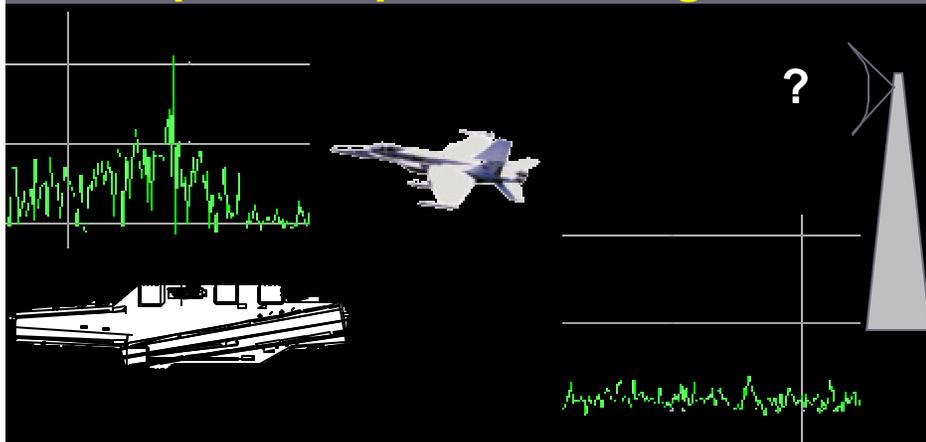
# How JPALS Works



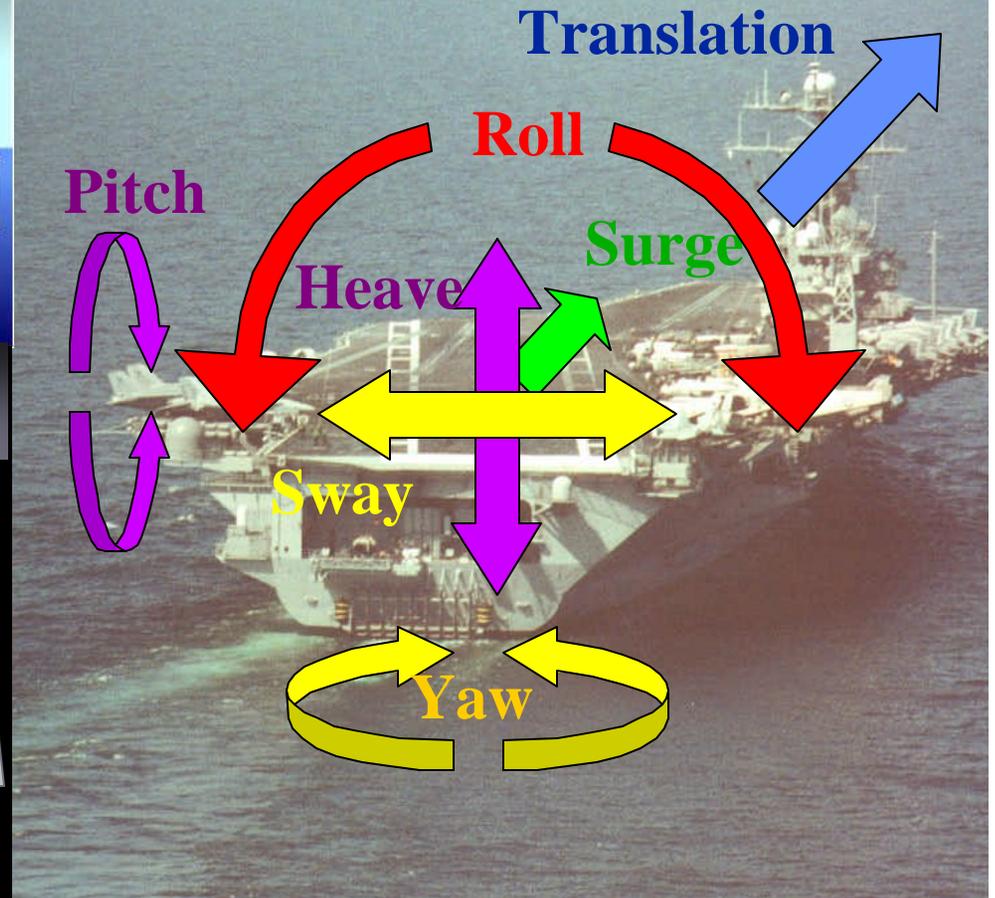
Differential GPS gives relative position with high accuracy and integrity



COMSEC and "Featureless" Spread Spectrum protect the signals



Inertial Navigation System data used to compensate for ship's motion





# JPALS Architecture



## Ground Equipment

## Airborne Equipment

**Fixed/Civil/International**



**Local Area Augmentation System (LAAS)**




**C/A-Code  
WAAS & LAAS**

**Tactical/Special Mission**



**Y/M Code, Beam-forming Anti-Jam**



**VHF Data Broadcast**

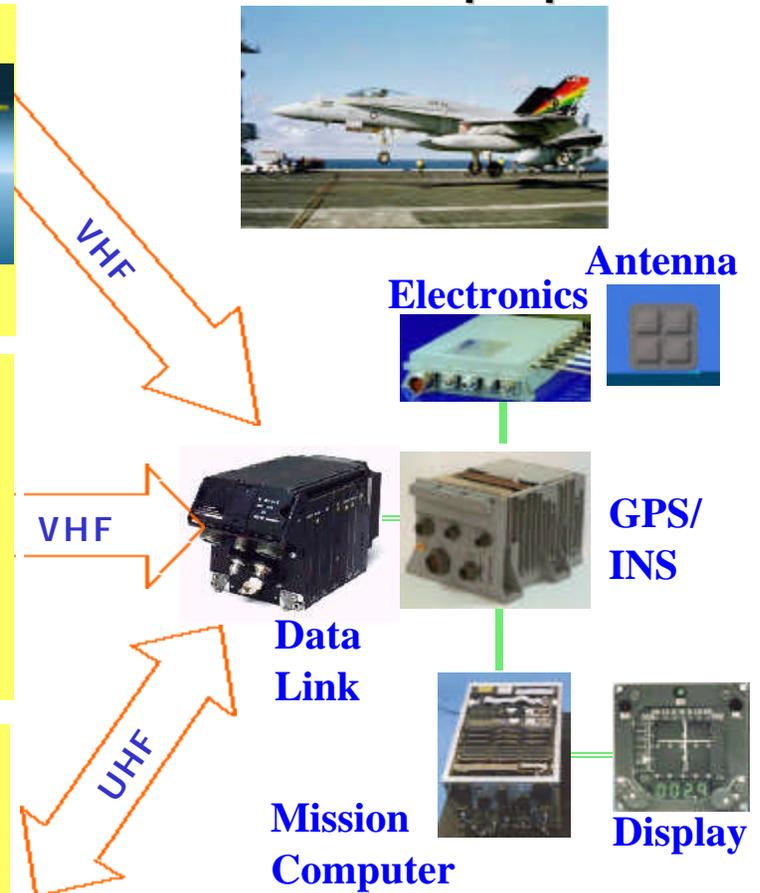
**Shipboard**



**Y/M Code, Beam-forming Anti-Jam**

**Two-Way UHF LPI data link**

**ATC & Landing**



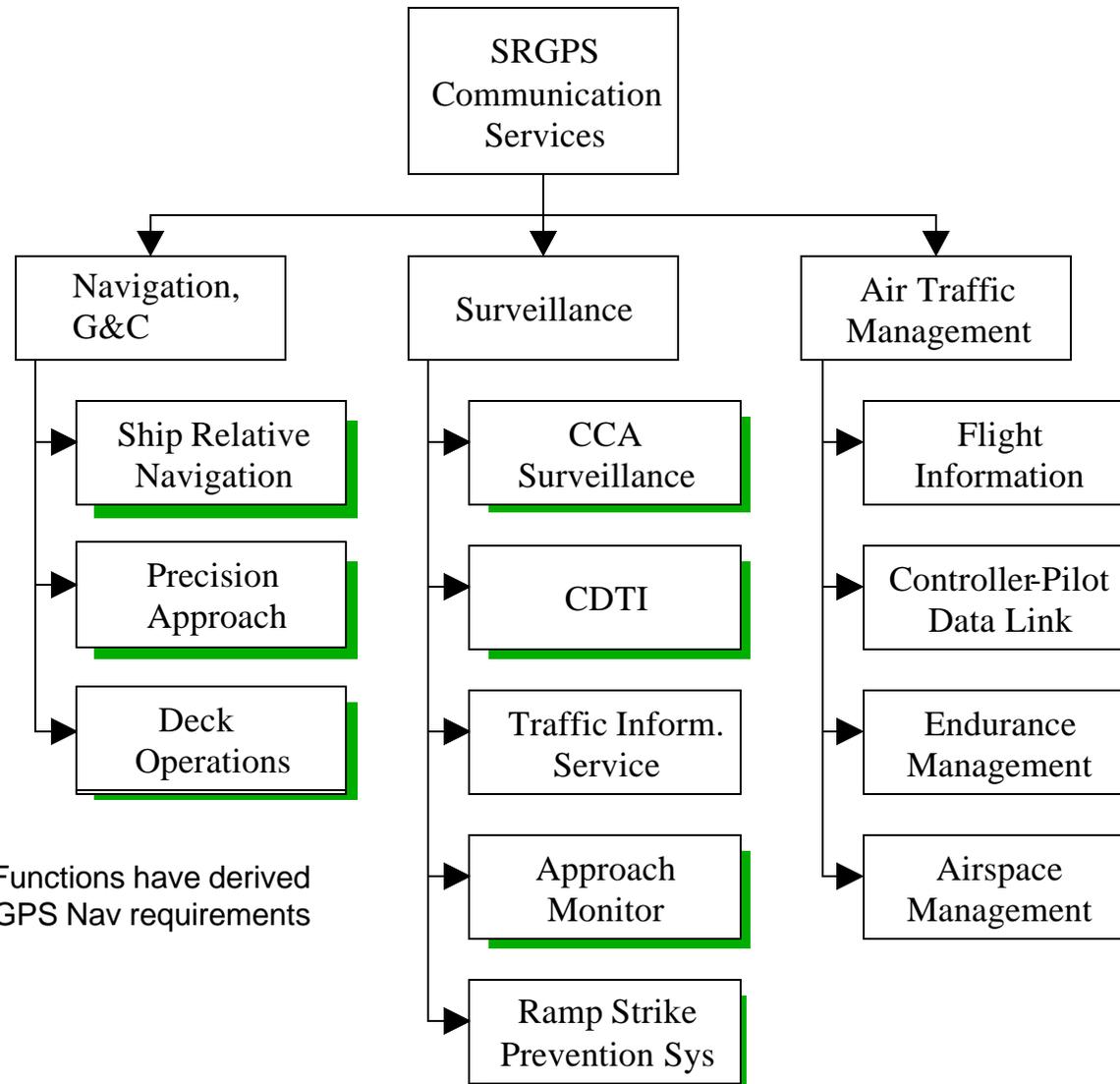
# JPALS CNS/ATM Functions



- **JPALS Performs Four Primary Functions:**
  - Communications
  - Navigation
  - Surveillance
  - Air Traffic Management
- **JPALS Replaces or Enhances Today's Systems:**
  - Provides LPI Communications
  - Replaces Navigation: TACAN, ACLS, ICLS
  - Enhances Surveillance: AN/SPN-43, AN/UPX-29
  - Provides ATM: Assists ATC Controller Tasks
- **JPALS Employs/Integrates Technologies:**
  - GPS/INS
  - Digital Data Link
  - Voice Synthesis/Voice Recognition
  - Fault-Tolerant Processors
  - ATC Application-specific Algorithms



# Shipboard Relative GPS Functions



**G&C:** Guidance and Control

**CCA:** Carrier Control Area

**CDTI:** Cockpit Display of Traffic Information



# JPALS ATM Services



- **Flight Information Service (FIS):** Automated meteorological data, including wind speed and direction over deck, temperature, humidity, barometric pressure.
- **Traffic Information Service (TIS):** Primary and secondary radar tracks from off-board sensors providing CDTI and collision avoidance.
- **Controller Pilot Data Link Control (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 cont for unmanned operations.
- **Endurance Management Air Traffic System (EMATS):** Given a flight plan, algorithms compute optimum time of arrival, schedule 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:** Automated system assigns airspace regions to aircraft. System monitors the aircraft, projects aircraft state appropriately. Upon detection of impending spill-out, the system generates alarm to CPDLC, MCS operator, or to the unmanned platform itself.



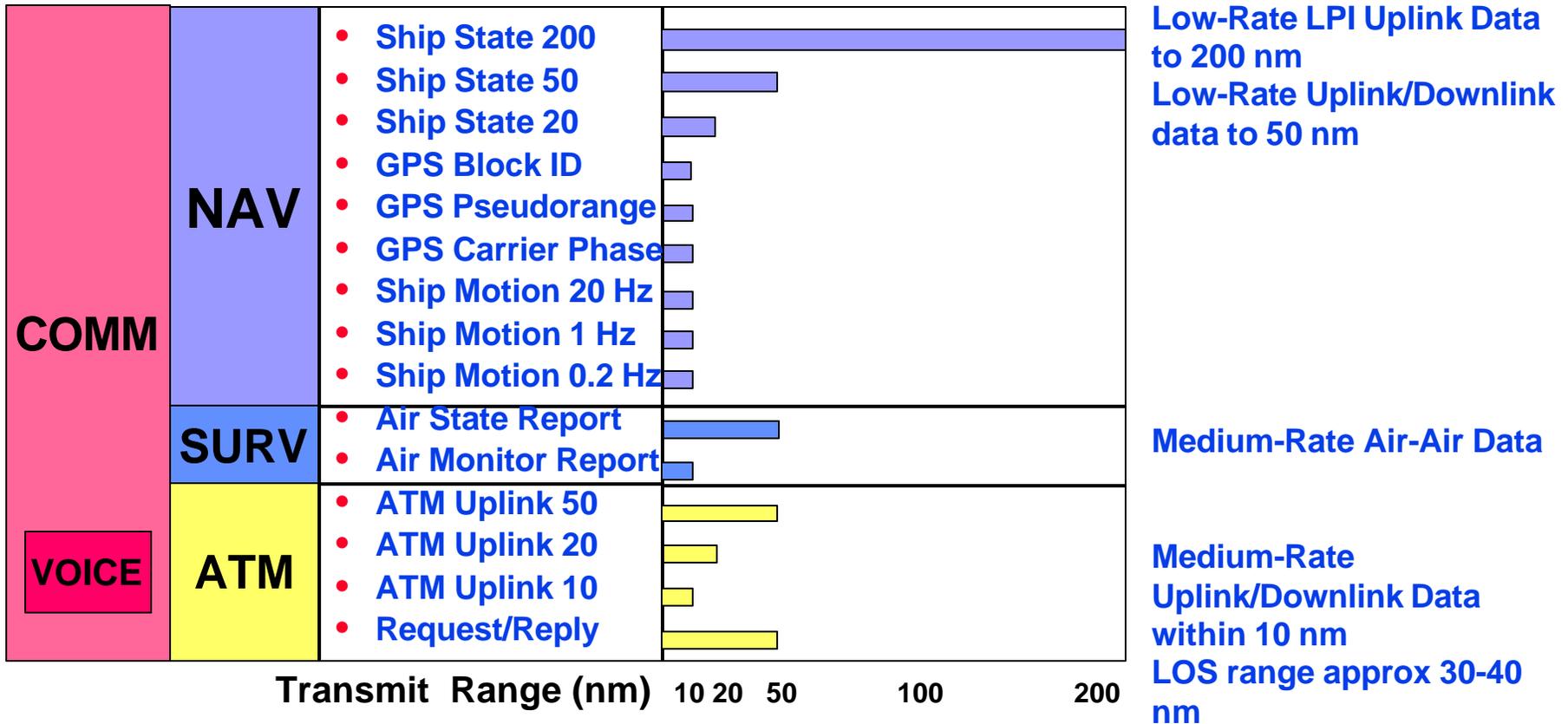
# JPALS Surveillance Services



- **Shipboard Tracking:** Within 50 nm, JPALS displays manned and unmanned platforms on controller consoles from integrated dependent surveillance SRGPS track information with primary radar and IFF.
- **Cockpit Display of Traffic Information (CDTI):** Includes 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:** Airborne platforms are accurately monitored with automated CAS functions, MCS display, and/or final approach display.
- **Ramp Strike Prevention System:** An approach monitor function which includes projection of aircraft state and variable alarm limits for LSO monitoring and/or as a part of vehicle flight control system integration.



# Link System Design and Navigation Service

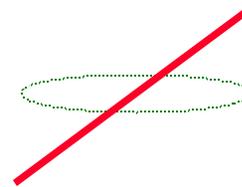


## Navigation Service:

- En route (GPS stand alone) guidance to 10m lateral, 20 m vertical
  - Relative Shipboard Approach Guidance
    - <5m lateral guidance out to 200 nm                      < 15 cm 3-D guidance within 10 nm
    - <2 m lateral guidance within 50 nm                              < 10 cm deck handling navigation



# Examples of Data Link messages



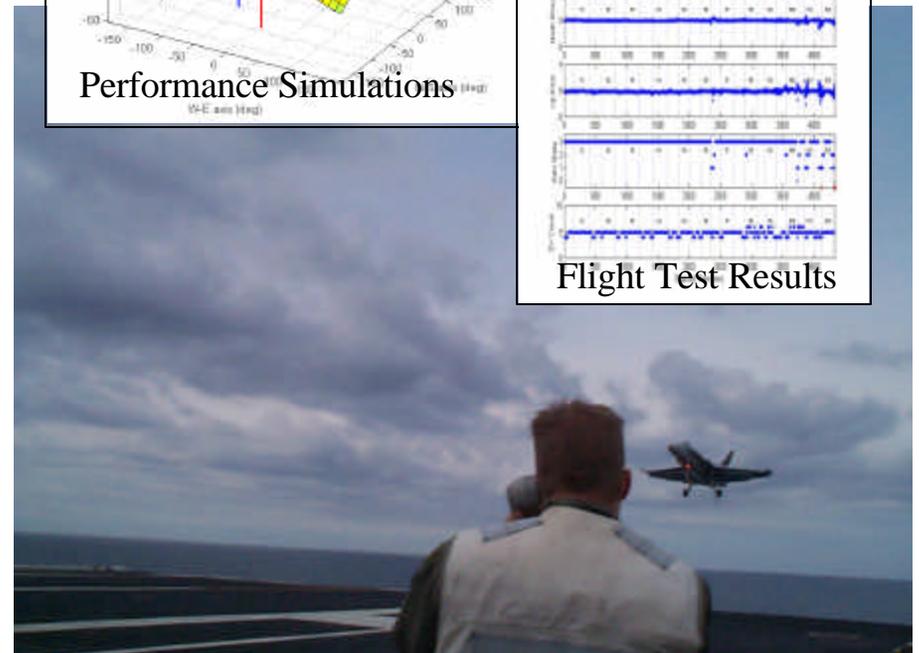
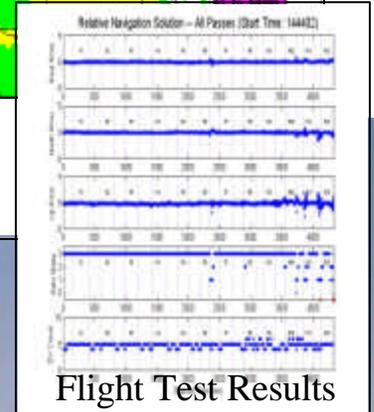
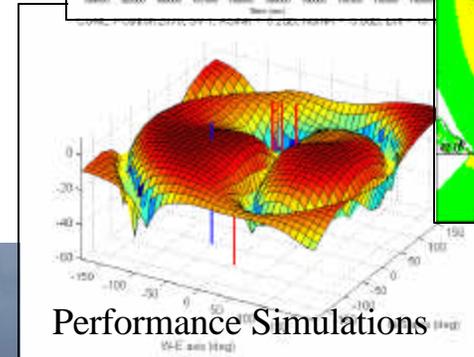
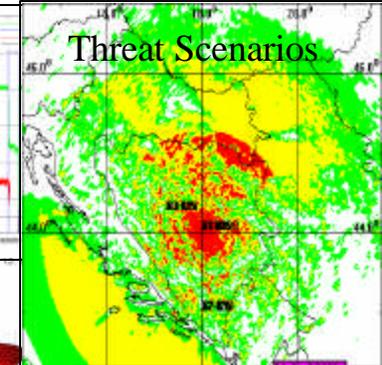
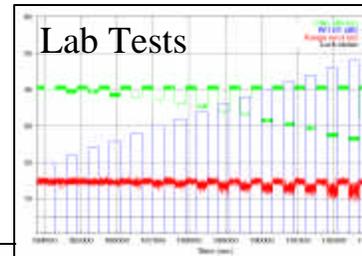
Start / Alert	Taxi / Launch	Departure	Msn	Check-in	Approach	Trap / Maint
Log-on	Weight	4D guide, CPDLC departure reports	TAC - AN	D-ATIS / PIM	4D guide & CPDLC arrival reports	Weight On Wheels
Ships Information (D-ATIS equivalent)	Status	Updated CLNC/ WX/Position of Intended Movement (PIM)		CPDLC Marshal	Weight / approach data	BIT
(BIT) Built In Test	Weight Off Wheels	Maintenance data		Weapons / systems / fuel status	Maintenance / WX data	Maintenance data & deck troubleshoot
Situational Awareness (SA)	Collision Avoidance Function (CAF)	CAF/ SA / tanker position		Hot/drop areas CAF/SA	Tanker hawk / position & guidance / CAF / SA	Log-off



# Navigation System Performance



- Shipboard landings require more stringent levels of accuracy and integrity than ashore.
  - Accuracies of less than 15 cm with integrity assurance of no more than 1.1 meter error in 10 million landings.
  - Also require high levels of availability in the presence of hostile or own interference.
  - Current anti-jam techniques sacrifice accuracy and are not compatible with high integrity or carrier phase systems.

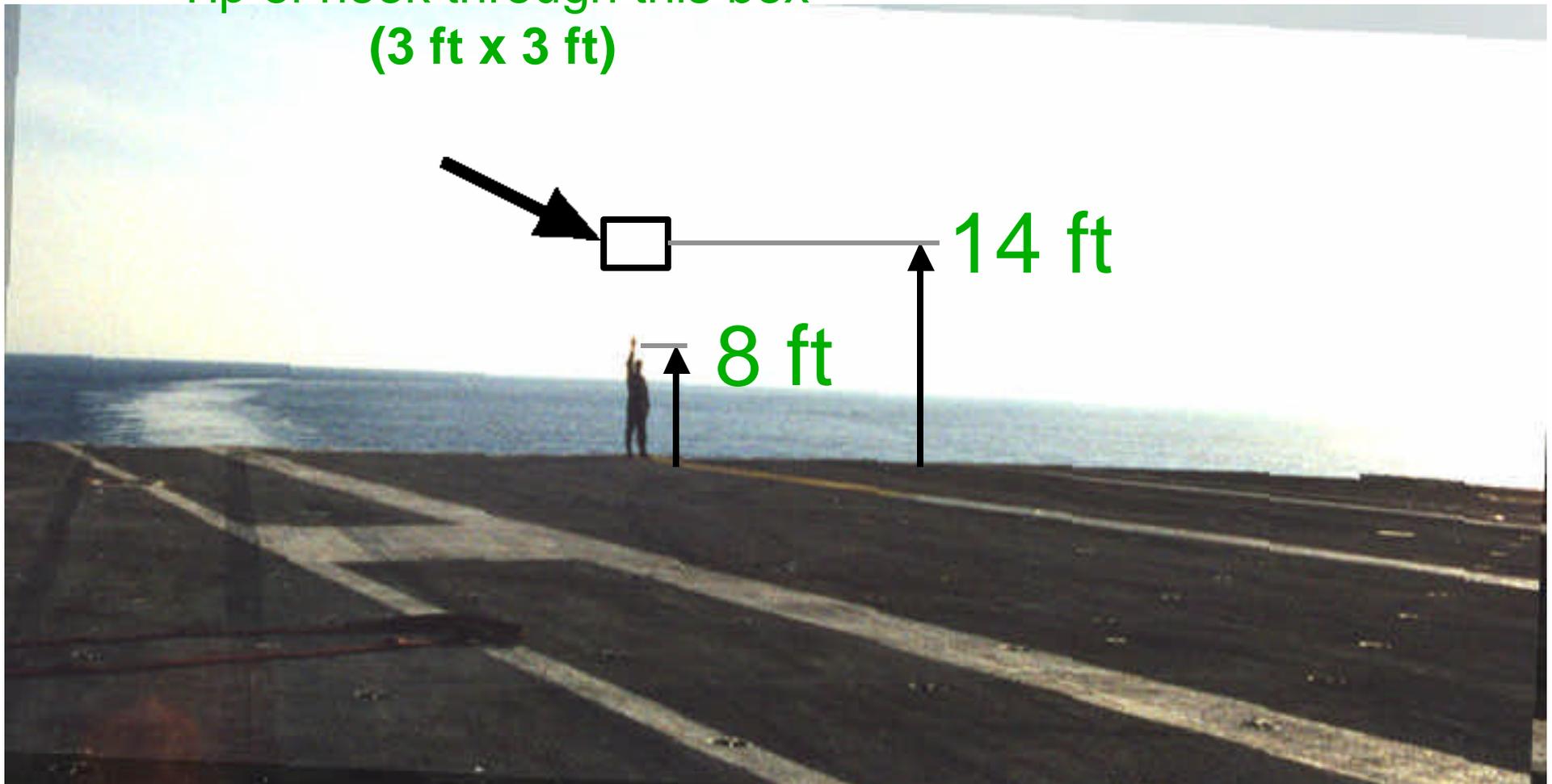




# Why Accuracy is so important!

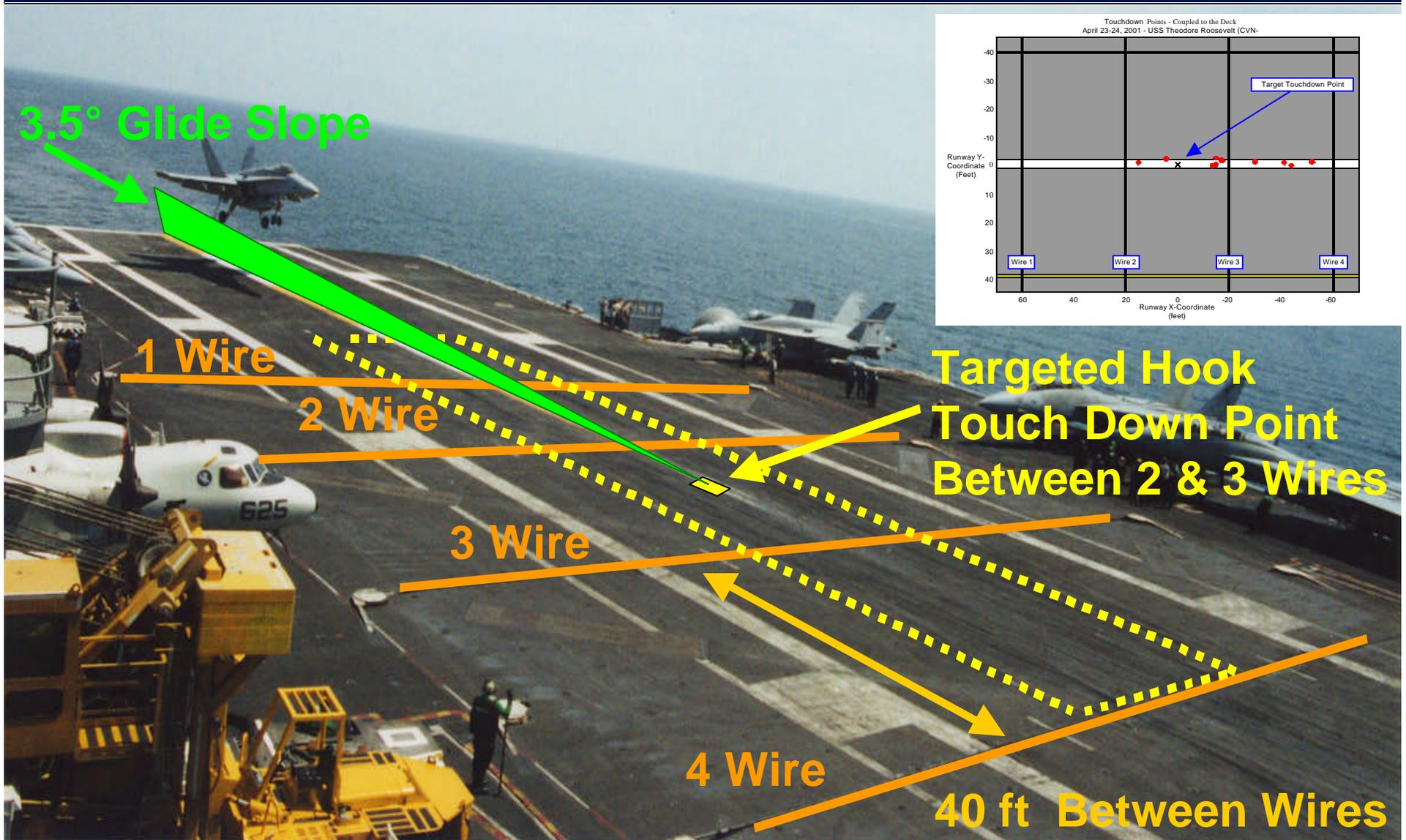


Tip of hook through this box  
(3 ft x 3 ft)





# Carrier Deck Landing Area





# JPALS Testing Success



- Conducted shipboard test of SRGPS aboard the USS Roosevelt (CVN-71) accomplishing 10 fully auto-coupled landings in Apr '01.
- Flew LAAS avionics (FedEx 727) using the JPALS Ground Station to perform 10 auto-coupled landings Aug '01.
- Completed 276 approaches at Holloman AFB in clear air and jamming conditions Jul-Aug'01.

Automatic Shipboard Landing



Civil Interoperability



Precision Approach in Jamming





# International Cooperation



- **UK has companion program (UK-JPALS)**
  - MOU in work with United States
  - UK testing STOVL implementation to support JSF
- **Data Exchange agreement with Germany**
  - Interest within Spain, Italy, and France
- **NATO**
  - Precision Approach and Landing System decision planned for Oct 2002
  - New group established to work ship standards



Flight Testing of JPALS Autolands  
in UK VAAC Harrier



# Summary



- **The shipboard component of JPALS combines state of the art navigation technologies**
  - **GPS surveying technology**
  - **Aviation integrity concepts from civil aviation**
  - **Advanced military beam-forming anti-jam systems**
  - **Integration of kinematic GPS with inertial systems**
- **Increases safety, efficiency and reduces vulnerability with CNS technologies provided with a LPI link**
- **Meets critical mission need for future aircraft and ships (JSF, UCAV, CVNX...)**