Ship Suitability Test and Evaluation – Preparing for the Future

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Overview

• Ship Integration Considerations
• Ship Suitability Test and Evaluation
• Aircraft Programs
• Ship Programs
• UAV / UCAV Programs
• T&E Tools
• Ship Suitability Unique Challenges
• Summary
Ship Integration Considerations
Design Considerations

• All major aircraft design considerations are driven by requirement to operate on a ship
  – Wingspan / rotor span
  – Aircraft length and height
  – Control surface sizing and flight control system
  – Landing gear
  – Cockpit design
  – Weapons carriage locations
  – Servicing/Maintenance interfaces
  – Support equipment
  – Materials (corrosion / fire)
Environmental Considerations

• Adverse operating environment
  – Ship’s Motion
  – Ship’s Airwake
  – Confined Area
  – Corrosive Hazards
  – Acoustic Hazards
  – Ingestion Hazards
  – Electromagnetic Hazards
Ship Suitability Test and Evaluation

• Provides the engineering people, processes, and facilities to conduct tests to determine air vehicle compatibility with the shipboard operating environment to include
  – Launch and Recovery Equipment
  – Air Traffic Control and Landing Systems
  – Shipboard facilities

• Located at the Naval Air Warfare Center, Patuxent River, MD

• Three Branches within the Integrated Systems Evaluation, Experimentation, and Test Department
  – Fixed Wing
  – Rotary Wing
  – Air Traffic Control and Landing Systems

• Work closely with all engineering and logistics competencies and other countries
Fixed Wing
Ship Suitability T&E

• Charter
  – Determine the performance and compatibility of manned and unmanned conventional and V/STOL aircraft, and aircraft systems in the shipboard operating environment for all classes of aircraft carriers, amphibious ships, and from advanced airfields

• Primary areas of T&E expertise
  – Aircraft low airspeed flying qualities and performance
  – Launch and recovery structural suitability
  – Aviation facility requirements
  – Launch and recovery envelope development
Shake, Rattle, and Roll
Rotary Wing
Ship Suitability T&E

• Charter
  – Determine the performance and compatibility of manned and unmanned rotorcraft, and rotorcraft systems in the shipboard operating environment for all classes of aircraft carriers, amphibious ships, aviation capable ships

• Primary areas of T&E expertise
  – Rotorcraft flying qualities and performance
  – Aviation facility requirements
  – Launch and recovery envelope development
    (Dynamic Interface)
DI Testing

- Over 20 different ship classes
- Over 15 different helicopter types
Air Traffic Control and Landing Systems T&E

• Charter
  – Develop, test, and evaluate shipboard, shore based, and satellite-based Air Traffic Control and Landing Systems (ATC&LS) and related aircraft avionics systems for manned and unmanned air vehicles

• Primary areas of T&E expertise
  – Precision Approach and Landings Systems (PALS)
  – Visual landing aids
  – Aircraft landings aids
    - Auto Throttle Systems
    - Auto Pilot Systems
    - Displays
Aircraft Carrier Landing Aids

IFLOLS

Centerline / Rabbit Lights

AN/SPN-46 ACLS

AN/SPN-41 ICLS Elevation

AN/SPN-41 ICLS Azimuth

LSO

Ladder Lines

Drop Lights/LRLS
PALS Approach
Amphibious Assault Ship Landing Aids

- Tramline
- Hover Spots
- LSO
- V/STOL OLS
- AN/SPN-35 PAR
- AN/SPN-41 ICLS Elevation
- AN/SPN-41 ICLS Azimuth
- HPI
- Drop Lights

Cleared for Public Release
Rotary Wing Aviation Programs

MV-22
UH-1Y and AH-1Z Upgrades
MH-60R/S
Presidential Helicopter Program
Heavy Lift Helicopter Program
• Shore based and shipboard developmental test requirements are complete

• Further testing required
  – Increase launch and recovery wind envelopes for all classes of ships
  – Software regression testing
UH-1Y / AH-1Z

- Major upgrades to the UH-1 Huey and AH-1 Cobra
  - New four bladed main rotor / Increased engine power
  - Increased gross weight
  - New cockpit
  - Survivability upgrades
  - Significant increase in commonality between UH-1 and AH-1

- Test program
  - Shore based and shipboard developmental test requirements are complete, DI tests in 2005
  - Further testing required
    - Increase launch and recovery wind envelopes for all classes of ships
    - Cockpit integration
MH-60R/S

• The MH-60R/S programs are upgrade programs that will provide capability improvements to U.S. Navy SH-60 series helicopters and introduce new capability

  – Mission areas for the MH-60R
    • Undersea Warfare, Anti-Surface Warfare, Area Surveillance and Combat Identification, Naval Surface Fire Support, Search and Rescue

  – Mission areas for the MH-60S
    • Vertical Replenishment, Amphibious Search and Rescue, Vertical Onboard Delivery, Airborne Mine Countermeasures, Combat Search and Rescue

• DI testing
  – MH-60R: Essentially complete
  – MH-60S: On-going
VH-71/CH-53K

- **VH-71 Presidential Helicopter will have shipboard operating capability**
  - DI testing planned in 2009

- **CH-53K Heavy Lift Helicopter**
  - Replaces the CH-53E, improved lift capability / R&M
  - DI testing in 2011/2012 timeframe
Fixed Wing Aviation Programs

- F-18A-F Follow-On Test and Evaluation
- EA-18G
- E-2/C-2 Programs
- F-35B and F-35C
F/A-18A-F

- Continue to conduct carrier suitability “Shake, Rattle, and Roll Tests” for new weapons and systems modifications on all F-18 aircraft
  - New weapons capabilities such as the GBU-38
  - New systems such as AESA
- Gear down flying qualities and performance
  - Increased lateral weight asymmetry testing
  - Transonic flying qualities improvements
- Software regression testing for PALS
EA-18G

• EA-18G will replace the EA-6B
• Air vehicle testing underway with F/A-18E/F aircraft
• Carrier suitability test requirements
  – Flying qualities and performance
    • New external load configuration
  – Catapult launch and arrested landing structural
demonstration of aircraft modifications and external pods
    • Includes increased gross weight for carrier landings
    • Also expanding lateral asymmetry capability for all
      F/A-18E/F/G aircraft
  – PALS testing
E-2 Hawkeye / C-2 Greyhound

- Very successful carrier suitability tests of the NP2000 propeller on the E-2 Hawkeye
  - Shore based flying qualities and performance
  - Shore based catapult launch and arrested landing structural/functional demonstration
  - Shipboard tests aboard the USS JOHN F KENNEDY

- Plan to commence testing the NP-2000 propeller on the C-2 Greyhound to commence late 2006/early 2007

- E-2D Advanced Hawkeye to conduct carrier suitability tests in 2008
  - Increased catapult launch and arrested landing gross weight
    - Structural functional tests
    - Flying qualities and performance
  - PALS
Joint Strike Fighter

• Tests with F-35B STOVL and F-35C Carrier variants
  – F-35B testing scheduled to commence in 2008
    • First all-new STOVL tactical jet aircraft designed for U.S. operational use
    • Ski jump tests
    • First at-sea testing in 2010
  – F-35C testing scheduled to commence in 2009
    • Last of three variants to enter testing
    • Least common of the three variants
    • At-Sea testing in 2010
Air Traffic Control and Landing Systems Programs

Aircraft Carrier and Amphibious Assault Ship PALS Certification
Joint Precision Approach Landing System (JPALS)
MV-22
UCARS
PALS Certification

• **SPN-46 Automatic Carrier Landing System (ACLS)**
  - All CV/CVN ships
    • Includes “hands-off” automatic landing

• **SPN-41 Instrument Control Landing System (ICLS)**
  - CV/CVN and LHA/LHD ships
    • Provides “needles” indication

• **AN/SPN-35 Precision Approach Radar**
  - LHA/LHD ships
    • Provides ship-based controller “talk down” approach capability to all aircraft
JPALS

• Joint Precision Approach Landing System
  – JPALS will provide shore and shipboard precision approach systems
  – Shore based system uses a Local Area Differential GPS (LDGPS) solution.
  – Sea based system uses a relative solution (Shipboard Relative GPS (SRGPS)).
    • Required for N-UCAS
    • Will be implemented in all fixed and rotary wing aircraft
  • ATC & landing during Emissions Control (EMCON)
  • Air Traffic Management for N-UCAS/UAV’s
MV-22

• Shore based developmental and certification test flights have been completed, or are in process on the following Uncoupled and Coupled Flight Director and Autopilot modes:
  – Approach to hover
  – Coupled hover
  – Waypoint mode
  – Instrument Landing System
  – TACAN
UCARS/VTUAV

- The Unmanned Common Automatic Recovery System is being used with the Fire Scout VTUAV for Launch and Recovery
  - UCARS will be incorporated in LCS for VTUAV Launch and Recovery
  - Functions similarly to the AN/SPN-46 ACLS
Ship Programs
LPD 17
Landing Platform Dock

- Strategic for “Forward from the Sea”
- Designed to transport the latest Marine Corps hardware – called the Mobility Triad
  - Advanced Amphibious Assault Vehicles (AAAV)
  - Landing Craft Air-Cushioned (LCAC)
  - MV-22 Osprey
- LPD 17 testing commenced in 2006
  - All Navy/Marine ship-capable helicopters (including V-22)
  - AV-8B Harrier tests in 2007
Littoral Combat Ship

- Flagship for Naval transformation
  - Shift from blue water to littoral operations
  - High speed capability / Long range
  - Missionized modules for
    - Mine warfare
    - Anti-submarine warfare
    - Anti-surface warfare

- Designed for manned and unmanned aircraft operations
  - MH-60R/S
  - VTUAV
- Each contractor to build two ships
  - DI testing of first ship in 2008
DDG 1000

• Revolutionary Design
  – Initial Fleet capability in 2013
  – Two helicopter landing spots
    • MH-60R
    • UAV’s
USS George H. W. Bush
CVN-77

- 10’th and final Nimitz Class carrier
- Similar to USS Ronald Reagan, CVN-76
  - Island shifted aft
  - Three arresting gear wires
- Enters service in 2009
- Modernized island
- New radar tower
CVN 21

- New design
- Optimized flight deck for air operations
- Decreased manpower
- Electromagnetic Aircraft Launch System (EMALS)
- Advanced Arresting Gear (AAG)
UAV and UCAS Programs

Small UAV’s
RQ-8A/B Fire Scout
X-45 / X-47 N-UCAS
Small UAV’s

• Many different UAV’s with many different launch and recovery concepts
  – Fixed Wing UAV’s
    • Pneumatic and bungee powered launchers
    • Net, vertical cable, and horizontal cable arrestment systems
  – Helicopters
    • Harpoon type system for launch and recovery
  – Types of control stations
    • Integrated / stand-alone
  – Vehicle control methods for launch and recovery
    • Manual
    • Automatic
Why We Test UAV’s
RQ-8A/B Fire Scout

- **Vertical Takeoff Unmanned Air Vehicle for the Navy**
  - Design based on a Schweitzer 330 commercial manned helicopter
  - RQ-8A missions include Reconnaissance, Surveillance, and Target Acquisition
  - RQ-8B to add increased payload and weapons capability

- **Autonomous Takeoff and Landing capability (ship and shore)**

- **Successful shipboard demo in Jan 2006 aboard the USS Nashville (LPD-13)**
N-UCAS

• Biggest challenge for ship suitability T&E
  – F/A-18 sized aircraft with weapons capability
  – Long range / persistence
  – Deployed on aircraft carriers
    • Catapult launch and arrested landing capability
  – Autonomous launch and recovery
    • Must be integrated into normal shipboard operations
      - Deck operations
      - Integrated into the Carrier Air Traffic Control Center

• Shore based and shipboard carrier demo in 2009
Ship Suitability
T&E Tools

Demonstrators
Modeling and Simulation
Demonstrators
Demonstrators – HSV / X-Craft

- Used to develop concept of operations for the Littoral Combat Ship
- DI tests conducted on both HSV-1 and HSV-2

- Littoral Surface Craft – Experimental (also known as the X-Craft) christened in February 2005 as USS Sea Fighter
  - DI tests conducted in December 2005
X-35 Concept Demonstrators

• This JSF “X” program was not a fly-off

• The demonstrators were used to
  – Reduce risk in critical areas
    • STOVL lift system design
    • Surface erosion
    • Manufacturing techniques

• Demonstrate modeling and simulation capability
  – Vehicle performance prediction
X-31 VECTOR

• VECTOR - Vectoring ESTOL Control Tail-less Operation Research
  – Tests conducted using the X-31 to evaluate capability to fly approaches at very high angles-of-attack to demonstrate extremely short takeoff and landing technology
    • Requires fully automated landing system
    • Integrated advanced high integrity, highly precise navigation system
    • Use of thrust vectoring for lateral-directional control
  – Evaluated advanced Flush Air Data System
    • Redundancy
    • Accuracy over range of angles-of-attack
Demonstrators – Surrogate Testing

- Often used surrogate vehicles to reduce the cost of testing and complete preliminary evaluations of new technologies
  - Small twin engine commercial aircraft for PALS and JPALS testing
  - VAAC Harrier used for JSF STOVL
    - Control law development and demonstration
    - Autoland development and demonstration
Modeling and Simulation (M&S)

General
Wind Tunnel
CFD
Displays
Other Initiatives
M&S – General

- **Historical improvements**
  - Catapult minimum endspeed predictions
  - Approach airspeed evaluations
  - Degraded flight control modes and emergency configurations
- **F-35 control law development**
- **PALS**
  - Aircraft auto-pilot and auto-throttle control law development
  - Ship/Shore based ACLS system control law development
M&S – Wind Tunnel

- **Measure ship’s airwake**
  - Investigate effects of ship’s topside configuration
  - Used to develop and confirm Computational Fluid Dynamics predictions
- **Ship’s anemometers**
  - Determine optimum location
  - Develop source error corrections for Fleet use
- **Effects of aircraft parked on the flight deck**

Parked helicopters appear to move leading edge vortex closer to aircraft located at LHD spot 5

Pictures courtesy of Kurt Long
M&S – Computational Fluid Dynamics

• Utilizing NAVAIR Advanced Aero expertise and capabilities
• Ship’s airwake predictions
  – Aerodynamic effect of deck and island geometry
  – Fixed wing aero performance and handling qualities investigations
  – Validation for CVN-21
• Predict aircraft interaction
  – JSF engine outwash
• Analysis of fixed wing / rotary wing interactions
  – F-14 engine exhaust velocities on helicopter operating in a new landing spot aft of the island

Pictures courtesy of Susan Polsky
M&S - Visual Displays

- Evaluation of new visual landing aids
- Evaluation of ship’s topside layouts
- Utilize NAVAIR Human Factors expertise
M&S – Other Initiatives

- **In-Work Items**
  - Enhanced rotorcraft aerodynamics models that focus on dynamic stall, rotor tip design, high rate of descent and downwash
  - Helicopter rotor engage/disengage model
  - PC-based visual landing aid (VLA) test tool
  - Helicopter deck traversing and securing analysis tool

Pictures courtesy of Dean Carico
Unique Challenges

UAV / UCAS
Data Collection and Analysis
Fleet/Program Response
Test Techniques
UAV/UCAS Challenges

- Performance specifications
- Innovative Launch and Recovery techniques
- Myth of the expendable air vehicle
- Test unique procedures
  - Test unique flight profiles
  - Replicating the Carrier Controlled Approach (CCA) environment
  - Shipboard testing
Data Collection and Analysis

- **Constraints during shipboard testing**
  - Real estate / situational awareness issues
  - Requirement for quick turnaround of data

- **JPALS data collection challenge**

- **F-35 data quantity challenge**

- **Data analysis tools in development**
  - Intelligent aircraft/ship data analysis options to help support future aircraft/ship testing and related database requirements
  - Analytic capability to support multi-aircraft/ship testing and related analysis
Response Challenges

• Quick response test requirements to provide immediate capability based on emerging Fleet requirements or technical issues

• Within last year, we have deployed teams to:
  – Carrier operating in WESTPAC (PALS support)
  – Carrier operating in Persian Gulf (PALS support)
  – Command and Control ship operating off of Korea (DI)
  – Scan Eagle emerging requirements on four ship types (DI)

• These “pop-up”, immediate support requirements stretch staffing requirements
Test Techniques – Learning from the Past

• C-130 deck launch / AV-8B STOVL / Conventional Ski Jump
  – Reviewing tests conducted decades ago to glean information
  – Not all testing feasible in today’s environment of Operational Risk Management
Test Techniques – New Technology Areas

• On-aircraft test aids
  – Increased capability while testing on ships
  – Dial-a-Function
  – Net capable TM

• Creating new techniques
  – JPALS data collection
  – UAV test requirements and techniques
    • N-UCAS
    • Small UAV’s
Summary

• Large number of aircraft and ship test programs facing the ship suitability T&E group
• Must be able to support these programs with less manpower
  – Test team versatility
  – Increased dependency on M&S
  – Better data analysis tools
• Must learn from past programs
  – C-130
  – AV-8B STOVL
  – Conventional Ski-Jump
• Develop new and innovative test techniques
  – JPALS
  – N-UCAS
JUST ANOTHER DAY AT THE OFFICE

Questions