Hybrid Aircraft
Envisioned Military Relevance
2 Sept 2009
Steve Huett
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Advanced Development Program Office
Airship Concepts
UK 2000: LTG Mike McDuffy, USA JCS/J4 OBSERVES…

and ENVISIONS the POSSIBILITY
Break-thru in Projection of Ground Combat Power

• Embark a ready-to-fight combat force (troops/armor/helicopters/supplies) at its base of origin

• Transport without loss of unit cohesion or physical / mental “readiness to fight”

• Deliver to locations selected to minimize the possibility for a hostile reception, ready for Immediate Combat Operations

• In spite of “anti-access” measures (no available air/sea ports)

• Anywhere in the world, within a week

ASSUMES AIR DOMINANCE AND ACTIVE AIR COVER
Features of J4’s Visualized Hybrid Aircraft

THE WORLDS FASTEST / SAFEST SHIP

- “Lifting Body Shaped” non-rigid airship (blimp) which never flies Light
- Lift: Static 70% via He / 30% Aerodynamic
- Propulsion: ducted turbo props / gimbaled
- Penta-phibian (air/ground/sea/snow/ice)
- Runway and Sea Port Independent
- Destination Support Requirements: NONE
- Trans-global range at 50 to 100 kts
- Heavy Lift / Out-sized Cargo / CRAF Candidate
Combining Proven Technologies
A Candidate Hybrid Aircraft Design
Product of a J-4 Contractor Pre-design Effort

HULA Combines Aircraft, Airship, Hovercraft, and Catamaran Technologies
Hybrid Design Spectrum

- **Dimensions**  
  - Length  
    - LEMV: ~300 ft  
    - 30T: ~310 ft  
    - 500T: ~800 ft  
  - Width  
    - LEMV: ~120 ft  
    - 30T: ~148 ft  
    - 500T: ~350 ft  
  - Height  
    - LEMV: ~65 ft  
    - 30T: ~80 ft  
    - 500T: ~200 ft  
  - Volume  
    - LEMV: ~1Mft$^3$  
    - 30T: ~1.65Mft$^3$  
    - 500T: ~30Mft$^3$  

- **Payload**  
  - 2.5K  
  - 28 tons  
  - 500 tons  

- **Range**  
  - 2500 mi  
  - 2200 + mi  
  - 4000 + mi  

- **Note:** the largest non-rigid airship ever flown was the Navy ZPG-3W which had a volume of 1.5 million cubic feet (1954)
A Proof of Concept 30T PL HULA
(Hybrid Aircraft Multi Role)
HYBRID Characteristics

+ **Unlike Traditional “Blimps”**, Hybrids can land/off-load almost anywhere w/o assistance or adjusting ballast

+ More Ship than Plane *(cruise speed range: 50 to 100 knots)*

+ Relatively Safe Ocean Transit System: Not Susceptible to mines, torpedoes, CM, fast boats, icebergs, other ships, reefs, heavy seas or jelly fish

  *(undersea population: >200,000 ships)*

+ Pilot Technique: sailing / flying / weather monitoring / planning

+ Operating Cost: Less than Airplanes, More than Ships

  *(60% LESS fuel per ton/mile)*

+ Range: **Trans-global**  Mission Period: Days vs Hours
HYBRID CHARACTERISTICS, cont…

+ Comfortable Travel Environment *(troops can be in prime condition, briefed on current situation and ready to fight upon arrival)*

+ Radar/IR Signature can be lower than big airplanes and ships *(high capacity for CM and Electronic Stealth)*

+ Damage Tolerance / Passenger / Cargo Survivability: Superior

+ C/E Presence and Persistence for Surveillance, C4ISR, Targeting

+ Weatherability: comparable to a prop airplane but more tolerant of ice, snow, rain, turbulence; **not as constrained by low visibility**

+ Nemesis: high wind in an adverse direction

*(typical trip altitude below 10K MSL to avoid pressurization/oxygen)*
Cargo/Passenger Survivability

Airplane/Helicopter 70 year record: In 60% of major accidents, 100% passengers/crew died

Ref: PlaneCrash.com

International Registry of Sunken Ships: Over 110,000 individual wrecks currently listed and 80,000 to 110,000, currently being entered (relatively few survivors).

Ref: SHIPWRECKREGISTRY.com

Airships have the lowest fatalities/accident of any global transportation system

- Exhibit Graceful Degradation when damaged because:
  - Inside vs Outside Pressure is about 1/10psi (rate of loss of lifting gas can be likened to sucking water out of a swimming pool with a straw)
  - Envelope is filled with inert gas: He (a fire suppressant)
  - Envelope can be compartmented to reduce probability of catastrophic loss if a large opening is somehow created
  - PL can be Traded for Cargo Gondola Armor and CM
Supporting Analysis

- **SKYCAT 1000 Engineering Study**
  - OSD, JCS J-4, and Army Office of the Dep. Asst. Secretary for Research & Technology study—2004
    - Examined a notional 1000 ton payload hybrid platform from a technical perspective as well as operationally in intra- and inter-theater airlift scenarios

- **Options for Strategic Mobility Transportation Systems**
  - Congressional Budget Office study—2005
    - Examined acquisition of 14-16 500 ton payload hybrid platforms in comparison to five other equal-cost options (~$11B) for expanded strategic mobility

- **Lighter-Than-Air (LTA) Systems for Future Naval Missions**
  - NRAC report 2006
    - Examined LTA applications for ISR, communication relays, electronic warfare, and heavy lift missions.

- **Analysis Of Hybrid Ultra Large Aircraft’s Potential Contribution To Inter-theater Mobility**
  - Air Force Institute of Technology Graduate Research Project—2006
    - Examined performance of 500 and 1000 ton payload hybrid platforms versus two different mixes of C-5/C-17 combinations

- **Sea Basing and Alternatives for Deploying and Sustaining Ground Combat Forces**
  - Congressional Budget Office study—2007
    - Examined acquisition alternatives to employ one MEB and/or sustain a MEB and one light Army brigade from the sea base

- **Military Potential of Hybrid Airships**
  - RAND study—2008
    - Examined end-to-end delivery of brigade-sized packages (Stryker & Heavy) for four mobility options in four scenarios with both 7 and 30 day requirements
Promise of Military Relevance

**ANYWHERE / ANYTIME!**

- Expand Strategic/Tactical Possibilities for Insertion of Joint Combat Forces

**GHOST SHIPS baffle anti-access measures**

- Delivery Independent of Air or Sea Ports

Deploy Amphibious Armor Delivered by Hybrids onto a Large Lake / Wide River
SeaPower 21: Re-supply at Sea/Force Insertion

ADVANCED SEA BASE CONNECTOR

HUAV CIRS&T PLATFORM
"INSIDE OUT INVASION"
Power Projection Exploiting
HULA and Forward Sea Basing
HULA Insertion of Ready to Fight
Ground Force from CONUS
and/or
Deployed CoCom

IN THE ABSENCE OF FRIENDS….

CONUS COMC

HULA INSERTION

HULA SeaShield
AEGIS Adjunct

FLEXIBILITY/OPTIONS

ADVANCED BASE

BLUE HAS AIR
DOMINANCE

LEMV
CIRTS&T
HYBRID AIRCRAFT: ANGEL SHIP

POST
DISASTER
RELIEF
RESCUE
EVAC
CLEANUP

30-500TON
PAYLOAD
POWER
WATER
MEDICAL
SECURITY
HULA: **1000** Payload Module

**Standard Payload Module (44’ x 27’ x 265’)**

- Designed For Standard Airfreight Cargo Types and Sizes
- Three Cargo Levels with In-Floor Rollers for Commercial Pallets
- Two 8-1/2 x 20 ft Elevators to Upper Decks
- Typical Loading Method Utilizes Standard Cargo Loaders

**Commercial Airfreight Loading**

**Roll On / Roll Off Main Deck**
Load Ready to Fight

Upper Deck (Mil-C Configuration)
- Utility Trucks w/ Trailers
- POL & Water Tanks
- Cargo Trailers
- TROOPS

Lower Deck (Mil-C Configuration)
- Cargo Pallets
- 20 ft Containers
- HMMWVs
- 40 ft Load Ready to Fight
- AH-64s
- RAH-66
- LMTVs w/ Trailers
- Kitchen Trailer
- Truck Fork Lifts
- PLSs w/ Trailers
- Wrecker
- Personnel Carriers
- MTVs w/ Trailers
- LMTVs w/ Trailers

Personnel Fly With Equipment
- Enables In-route Mission Planning
- Maintains Cohesion of RTF Unit

Key to Floor Strength
- 200 #/sqft  Blue
- 300 #/sqft  Green
- 500 #/sqft  Red
IBCT Deployment Ft. Lewis, Wa. To Pacific Rim

- Transport IBCT from CONUS to Korea Within 96 Hours
  - 14,689 Tons of Equipment
  - 1,367 Items
  - 3,566 Soldiers
  - 4,556 NM (one-way)

With minimum degradation of readiness / cohesion
IBCT from Ft. Lewis to a Drop Zone in S. Korea
Goal: training base to combat zone (4556NM) w/o loss of readiness

<table>
<thead>
<tr>
<th>Measure of Effectiveness</th>
<th>HULA 500</th>
<th>C-5</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Aircraft</td>
<td>36</td>
<td>63</td>
</tr>
<tr>
<td># of Flights Required</td>
<td>36</td>
<td>188</td>
</tr>
<tr>
<td>Cruise TAS</td>
<td>90 kt &lt;9000’msl 50 hrs</td>
<td>490 kt 10.3 hr (incl. refuel)</td>
</tr>
<tr>
<td>Crossing Time</td>
<td>110 hr*</td>
<td>102.6 hr*</td>
</tr>
<tr>
<td>Total Scenario Time</td>
<td>3960 hr</td>
<td>3,791 hr</td>
</tr>
<tr>
<td>Total Flight Hours for Fleet</td>
<td>34Mlb</td>
<td>88.9 Mlb</td>
</tr>
<tr>
<td>Fuel Cost per Ton-Mile</td>
<td>$0.08</td>
<td>$0.18</td>
</tr>
</tbody>
</table>

Proposed 500ton HULA based on data from SkyCat Engineering Report

- Cargo Bay Volume: 136,000 ft³ (2 or 3 Decks)
- Cargo Bay Volume: 29,900 ft³ (1 or 1.5 Decks)

* Scenario Time excludes buildup period. Buildup period is the time required to transfer equip/troops to a departure airport. HULA embarks at the home Training Base from an open grass area such as a “jump zone”

Total Equipment: 15,000 tons
Total Troops: (3556)900 tons

TAS $0.90/gal

$0.05 $0.18
## Hybrid 1000 “Ready to Fight” Armed Cav Regiment DELIVERY

<table>
<thead>
<tr>
<th>Measure of Effectiveness</th>
<th>Light ACR</th>
<th>Heavy ACR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SkyCat</td>
<td>C-5</td>
</tr>
<tr>
<td># of Aircraft</td>
<td>18</td>
<td>61</td>
</tr>
<tr>
<td># of Flights Required</td>
<td>18</td>
<td>241</td>
</tr>
<tr>
<td>Cruise Speed</td>
<td>90 kt</td>
<td>490 kt</td>
</tr>
<tr>
<td>Crossing Time (outbound)</td>
<td>66.5 hr</td>
<td>14.5 hr</td>
</tr>
<tr>
<td>Total Delivery Time</td>
<td>4.7 days</td>
<td>20.0 days</td>
</tr>
<tr>
<td>Total Fleet Flight Hours</td>
<td>3,049 hr</td>
<td>6,507 hr</td>
</tr>
<tr>
<td>Total Fuel Burned</td>
<td>29.3 Mlb</td>
<td>152.6 Mlb</td>
</tr>
<tr>
<td>Fuel Cost per Ton-Mile</td>
<td>$0.05</td>
<td>$0.25</td>
</tr>
</tbody>
</table>

Ave Load / Flight: Light ACR: 730Tons Heavy ACR: 892Tons

Note: allows about 500#/soldier (212 or 270 per flight) + flight crews
HYBRID RANGE/SPEED/FUEL CONSUMPTION RELATIONSHIPS

Source: J4 SkyCat 1000 Engineering Study

SkyCat Stops for 1 Hour to Add Ballast

Maximum Speed

Most Efficient Speed

• 700 STon Payload
• No Wind

• 700 STon Payload
• No Wind
HULA Candidate Military Missions

- **Intra-theater Insertion** of Forces / Re-supply from Sea Base
- Re-supply of Naval Forces Afloat

- **Protection of Forces Ashore and Afloat (Sea Shield)**
  - Forever on Station (FOS) Defense: **CM** and surface threats
    + Low Freq Radar and “X” Band Target Illuminators
  - Mine Detection/Clearing and Shallow Water ASW

- Littoral Ocean Patrol Surveillance/Regional Policing: **BAMS**
  - Harbor Security
  - **UAV airborne base** for remote OTH close look

- **Affordable** Surveillance (HUAV): 20,000'/5 day mission
HULA Candidate Military Missions cont........

- Medivac / Airborne MASH / Air-Sea Rescue

- Massive Stand-off Jamming (Sea Strike) Electronic Stealth

- COninuous Over Head Presence for Air Support (CO-OP) ANVIL *(Airborne-Netcentric-Versatile-Integrated-Lethal)*
  - Laser Energy Weapon
  - Large Caliber Gun
  - Multi-spectral Sensors
  - CISR&T for Ground Combat Force
  - UCAV Airborne Base (launch and control)

- SOF Insertion and Retrieval

*Note: mission periods measured in **days** instead of **hours***
# Payload Range Relationships Hula 30

<table>
<thead>
<tr>
<th>Payload Pounds</th>
<th>Range Nautical Miles</th>
<th>Initial Fuel Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>55,000</td>
<td>2200</td>
<td>Fuel Limited by Allowable Useful Load (90,000#)</td>
</tr>
<tr>
<td>45,000</td>
<td>3000</td>
<td>Full onboard tanks</td>
</tr>
<tr>
<td>ferry</td>
<td>4000</td>
<td>Full onboard tanks/no PL</td>
</tr>
<tr>
<td>ferry</td>
<td>6000</td>
<td>Full onboard+cargo bay fuel</td>
</tr>
</tbody>
</table>

Notes: AUL is 90,000#  Max Payload is 55,000#  Max Fuel: 45,000#

Cargobay: L: 82’ W: 12’ H: 10’ Stryker can roll in and out with gun
HULA 30ton MILITARY PASSENGER LAYOUTS  
(NOTIONAL)

LONG/MEDIUM RANGE – 134 PAX MAXIMUM

SHORT/MEDIUM RANGE – 154 PAX MAXIMUM
HULA30 Commercial/Civil Utility

- Tourist travel, sight seeing, gambling
- Hauling ore from remote mining areas
- **Hazardous waste transport** via circuitous routes avoiding populated areas *(DoT)*
- High value products from source to distributor (reduce handling/avoid theft)
- Commuter transport (100 to 300 miles)
- **Disaster Services/Medical/Rescue/Water**
NAVAIR View of Technical Risk

• 2003 Medium to Low
• 2006 Low
• Risk reduced by LM flight demos with the P-791 (major accomplishment with flight control of gimbaled power and ACLS)
• Fabric Technology for 500ton 2 yrs rsch