Mini Air Vehicles for Military Operations

Gus Ordonez, Honeywell Defense & Space
AIAA Unmanned Aerospace Vehicles, Systems, Technologies, and Operations
22 May, 2002
Changing Role of Armed Forces

- **Vietnam**
  1968 (peak)
  536,100 U.S. Troops

Role Of The Army In Joint Operations

- *From Army Vision 2010 Document*

<table>
<thead>
<tr>
<th>Operation</th>
<th>Year</th>
<th>Troops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam (1968)</td>
<td>1968</td>
<td>536,100</td>
</tr>
<tr>
<td>Kosovo (1999)</td>
<td>1999</td>
<td>5,488</td>
</tr>
</tbody>
</table>

Army must respond to increasing number of deployments and missions.

Full Dimensional Protection, Focused Logistics, and Precision Engagement

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OAV Mission Concepts meet Design Goals

Battleground situational awareness & Mission effectiveness become reality

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Military Operations – Urban Terrain (MOUT)

OAV Vertical Launch/Recovery in Response to Request from Field Commander

At Waypoint, OAV Transitions to Hover/Search Mode

Need NLOS COMMs and Collision Avoidance Sensors

Once Enemy Assets Located, OAV Transitions to Standoff Targeting and BDA

Urban Terrain
Cave Surveillance

Networked Communications

OAVs Deployed to Investigate Caves
OAV - Aid to Extending Battalion Tactical Reach

- Forward observer increases the domination radius.

- Higher rate of advance: terrain independent

- OAV enables units to see, decide, and act first:
  - Shape the fight
  - Fight on our terms
  - Finish decisively

Battalion Operational Radius

Now

Future

5 km

12 km
Second, or Multiple OAV(s) can be Launched to Continue Mission if Endurance Limit Reached

OAV Vertical Launch/Recovery in Response to IUGS Queue

At Waypoint, OAV Transitions to Search Mode

Once Enemy Asset Confirmed, OAV Transitions to Standoff Targeting and BDA
OAV - Mine Countermeasures (MCM)

- Organic Air Vehicles/ Advanced sensors
- 110 million unexploded land mines in 64 countries
- 5 million new mines are laid each year.
- Active for decades.
- Mines cost vs. deactivation cost:
  -$3 each vs. $3,000 each.

- 1000 years and $33B deactivation cost

A land mine is a perfect soldier: “Ever courageous, never sleeps, never misses.” - Khmer Rouge General
A set of Organic Air Vehicles can map & identify targets in a 30mi x 30mi beachhead in 4 hours.
Airborne Manned Unmanned System Technology (AMUST)

- AH-64D Apache Longbow with Hunter UAV.
  - Teaming technology enabled the aircrew to control the flight path of the UAV and to manually control the UAV’s sensor payload, providing direct real-time UAV video to the Apache displays.
  - Level 4 interaction allowed Apache to control UAV flight path through *waypoint* navigation, and manually control the UAV EO/IR Sensor.
1. Li Batteries
2. 0.5 kg Payloads
3. Fuel Tanks
4. Video CPU, MUX
5. GPS CPU
6. Trans. Antenna
7. IMU
8. Radar Altimeter
9. Coll. Avoid Sensor
10. Servo Actuators
11. Flight Computer
12. Memory
13. Collision Avoid Cif
14. GPS Antenna
15. Pressure Sensors
16. Color/IR Cameras
Autonomous Hover
IR TV Display and Flight Profile Relay capability

Vehicle health, Terrain recognition and Data relay information available
OAV: Kestrel Program Accomplishments

- Risk reduction
- Production roadmap (Dec 02)
- Successful autonomous way point navigation
- MDO code correlation to scalable vehicle
- Mission effectiveness analysis
- FCS requirements validation
- Successful flight test accomplishments
- Designed integral TEG/ acoustic liner/ engine exhaust system
- Flight controls/ simulation/ stability analysis /gain definition process
- Successful way point navigation, downlink, data analysis and GPS overlay
Vehicle Flight Performance

Autonomous flight, transition to cruise, and return to base within 3 ft. of take-off coordinates
Honeywell Kestrel 1 Vehicle: An author

- Over 250 successful flights
- Over 400 hours of test
- Attitude hold
- Altitude hold
- Vector tracking
- Bridge inspection
- Over the hill reconnaissance
- Scalable configuration from 9-17 inches
- Proven manufacturing
Design commonality:

Common platforms enhance reliability and lowers production costs
FeatherIR Camera Technology

![Image of FeatherIR Camera Technology](image-url)
The Changing Operational Environment

1990’s to Present...

US undisputed master of the conventional ground battlefield
- Superb leaders and soldiers
- Unprecedented mobility, lethality and survivability
- Technologically advanced
- Dominate all threats, capable of dictating operational tempo

...Present to Future

- Traditional and new military threats
- Technology explosion and proliferation
- Enemy use of
  - Information Operations
  - Asymmetric tactics
- Threat will attempt to
  - destroy force effectiveness
  - degrade US ISR and air capability
- Urban / complex terrain combat likely
- Humanitarian issues pervasive
- Intense media glare
- Goal of inflicting casualties and prolonging conflict
Closing With and Destroying the Enemy

- **Develop situation out of contact as a mission**
- Decide on Red Zones
- Isolate / shape one or more Red Zones through stand-off fires to create and exploit weakness
- Maneuver to position of advantage out of contact
- Enter contact at time and place of choosing
- Continue fire and maneuver in changing situation
- Finish enemy by tactical assault

**Central feature is ability to:**

- **See first** - See entire environment before & more clearly than enemy
- **Understand first** - Rapidly process and distribute knowledge; discern patterns
- **Act first** - Retain freedom of action to shoot, move and reengage
- **Finish Decisively** - Destroy enemy in detail through mounted / dismounted assault
Material Needs Implications for the Force

Advanced C4 and ISR for Information Superiority
- Knowledge-based operations
- Integrated technical and human sensors
- Space empowered
- Functionally aligned

The Future Combat System
- Synergy achieved through a seamless Teams of Teams
- Organic and Complementary Fires
- Integrated tactical and operational ISR
- Vertical and Ground Maneuver

Revolution in Military Logistics
- Efficiencies in fuel, power and footprint
- Ultra-reliability, systems commonality

Training
- Ease of operation; embedded training and rehearsal
CONOPS

 Mounted Scout Platoon
 OAV

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Mounted Scout Platoon

• Situation.

– Mix of open rolling, heavily wooded, and hilly areas with ridgelines.

– Small towns (up to 1000 residents) and a well-developed road network are situated throughout.

– Area of operations is 50 km in length and 15 km wide; the tactical assembly area (TAA) covers 25 square km.

– Scout Platoon’s parent Battalion task force is in a rear assembly area preparing to conduct a 50 km tactical road march to TAA, then establish a defense along an international border.
Acoustic attenuation and TEG power
OAV Integrated Avionics

- Flight Management Unit
  - MEMS IMU
  - GPS
  - Autonomous Flight Control
  - Actuation commands
  - Payload selection
  - Payload pointing & stabilization
  - On-board image storage
  - Engine monitoring & control
  - Perch & Stare Image Processing
- Payloads, compression & gimbal
- Robust high-bandwidth rain/fog immune communications system

- Survivable - Shock, Vibe, Temperature
- Commonality of hardware leads...
Target Position Determination

Vehicle position & altitude known

Payload stare vector relative to vehicle position known

Ground station uses terrain elevation map to calculate intersection of stare vector and terrain to determine position

GPS-Inertial-altimeter based geographic location and altitude

GPS-aided IMU attitude accurate to ~2 milliradians
## Payload Weight and Power Requirements

**OAV Payload Sizing**

<table>
<thead>
<tr>
<th>Vehicle Size</th>
<th>Engine HP</th>
<th>Gross T/O Weight (lbs)</th>
<th>Duration</th>
<th>Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-inch</td>
<td>2.1</td>
<td>10.0</td>
<td>30 Min.</td>
<td>1.4 lbs</td>
</tr>
<tr>
<td>16-inch</td>
<td>2.7</td>
<td>16.5</td>
<td>30 Min.</td>
<td>3.5 lbs</td>
</tr>
<tr>
<td>27-inch</td>
<td>12.2</td>
<td>62.9</td>
<td>30 Min.</td>
<td>14.1 lbs</td>
</tr>
<tr>
<td>9-inch</td>
<td>1.3</td>
<td>7.2</td>
<td>47 Min.</td>
<td>0.38 lbs</td>
</tr>
<tr>
<td>16-inch</td>
<td>4.6</td>
<td>23.5</td>
<td>30 Min.</td>
<td>3.8 lbs</td>
</tr>
<tr>
<td>27-inch</td>
<td>5.4</td>
<td>36.6</td>
<td>60 Min.</td>
<td>3.4 lbs</td>
</tr>
<tr>
<td>16-inch</td>
<td>5.4</td>
<td>36.6</td>
<td>47 Min.</td>
<td>5.2 lbs</td>
</tr>
</tbody>
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Vehicles Are Identified By Their Unique Signatures

Figure 2

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The MDO Code is built on a foundation of experimental data.
MDO Code Analysis

- Using the Multidisciplinary Design Optimization (MDO) code, missions were analyzed and then applied to the vehicle in order to find the best scale for the mission.

![MDO Code Analysis Table]

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Project 1: Performance Analysis

- Endurance Calculations
- Mission Analysis
- Power Requirements

Power Required for Varied Altitudes

\[
\text{power} = \text{DuctFactor}(1 + \text{Duct Loss Factor}) \cdot \frac{\sqrt{\frac{\text{Disc Loading}}{2p}}}{550 \text{figure of merit}}
\]

```
<table>
<thead>
<tr>
<th>Altitude (ft)</th>
<th>Power Required (hp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.4000</td>
</tr>
<tr>
<td>2000</td>
<td>1.4500</td>
</tr>
<tr>
<td>4000</td>
<td>1.5000</td>
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<tr>
<td>6000</td>
<td>1.5500</td>
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<tr>
<td>8000</td>
<td>1.6000</td>
</tr>
<tr>
<td>10000</td>
<td>1.6500</td>
</tr>
<tr>
<td>12000</td>
<td>1.7000</td>
</tr>
</tbody>
</table>
```
Second Generation Mini Air Vehicle

- AVIONICS PODS
- PROPELLION FAN
- IR CAMERA
- BODY
- VIDEO CAMERA
- CONTROL SURFACES

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OAV Kestrel Phase II... Inboard Profile