Hovering Missiles: New Tools for Target ID, Interior Precision Strike, Friendly Fire Mitigation and Persistent Suppression

Professor Ron Barrett
Director of the Adaptive Aerostructures Laboratory (AAL)
Aerospace Engineering Department
The University of Kansas, Lawrence, Kansas USA

AAL ...Backroom for the Innovation-Driven Aerospace Organizations of the world...

44th Annual Gun and Missile Systems Conference & Exhibition
Hyatt Regency Crown Center, Kansas City, MO
8 April 2009
Purpose:

• Expose the Munitions Community to the blurring line between missiles, munitions & UAVs.

• Describe advanced weapon systems which are technically feasible Today.
Outline:

I. History of Underpinning Programs

II. Current Platform Configuration

III. New Missions...

Revolutionary Capabilities
Background in Flight Control

1985
Twist-active plates & flaps
Crawley, Andersen, Spangler, Hall, Lazarus (MIT)

1990
Twist & camber-active subsonic & supersonic wings
Good theory-experiment correlation

1995
1st Adaptive Gun-Launched Munitions
1st Pitch-Active Missile Fins
1st Flying Adaptive UAV
Flexspar Stabilators
VTOL Approach to Urban UAV Flight: 1994 - 1997 The First MAV, Kolibri

The 1st Micro Aerial Vehicle -- by the DoD CounterDrug Technology Office

Enabled by Flexspar Piezoceramic Stabilators

Mission Profile:

- total mass 5.2g
- actuator mass: 380 mg
- max. static deflections: $\pm 11^\circ$
- max power consumption: 14 mW
- pitch corner frequency: 47 Hz
- first natural frequency in pitch: 23 Hz
Low-Level Operations: Serious trouble for UAVs...

DARPA Urban & Sub-Canopy Atmospherics Survey 1998

α >90° is a common event

History and Background   Current Platform   Revolutionary Missions
First Free-Flight VTOL MAVs

6” (15cm) VTOL Coleopter

DARPA
1999 - 2000
Flyoffs @
MacDill &
Quantico
More conventional UAV “Challenges”

Operation Allied Force
Kosovo 1999
(source: Yugoslav armed forces)

UAVs Lost in Kosovo:

Britain: 14 (14 Phoenix)

United States: 17 (3 Predators, 9 Hunters, 4 Pioneers, 1 UAV of undetermined type)

Germany: 7 (presumably all CL-289 turbojet drones)

France: 5 (3 Crecerelle, 2 CL-289)

By Jan. 2003, 30 of 70 RQ-1 Predators crashed or were shot down
(source: Mike Mount CNN Washington Bureau)

4 UAVs of undetermined origin (possibly U.S., German, or Italian)

History and Background  Current Platform  Revolutionary Missions
Advanced/ Hypermaneuverable UAVs: Why?? ... & the Role of Adaptive Aerostructures

“2/3 of eligible targets went undetected, let alone unengaged because of our reconnaissance deficiencies.”

“Folks... it’s going to take something new to fix this problem.”

-Lt. Gen. Bruce Knutson, USMC

History and Background    Current Platform    Revolutionary Missions
Low-Level UAV Ops Challenge:

**New UAVs**

**New Tactics**

Current UAVs offer monocular situational awareness with only one general view -- from above.

Panocular situational awareness is necessary in the modern battlefield.

All overhead surveillance gives the same view.
Changing UAV Operations

*Sharing Airspace -- the fight at altitude*
Current UAV Market

History and Background  Current Platform  Revolutionary Missions
Honeywell’s “Micro Aerial Vehicle” (MAV) or “Organic Aerial Vehicle” (OAV)
Paradigm Shift...

Hypermaneuverable UAVs

**Hover in more places than a helicopter**

**Fly as fast as a missile**

**Convertible Coleopter Configurations**

Heinkel Wespe 1944 (concept only, never built)

Heinkel Lerche 1944 (concept only, never built)
Adaptive Aerostructures Laboratory... from Aha! To Flight

Hypermahneuverable UAVs

XQ-138 Program 2001 -
Heinkel Wespe 1944

more control authority needed for MOUT environment

AA-12 (R-77) (Aamraamski)

high control authority grid/lattice fins

History and Background    Current Platform    Revolutionary Missions
Mission Specification:

- Max. gross weight: 6.8lb (3.1kg)
- Max. payload weight: 2.2 lb (1kg)
- All weather capable
- 12”/hr (31cm/hr) rain
- 25+ kt gust penetration
- Sensors: B/W 0.001 lux, Color 0.1 lux, FLIR
- Flight modes: 1st, 3rd person, fully autonomous w/waypoint nav.
- Sandstorm capable to 100kts
- Vmax 140kts for 1hr (blue sky)
- -40/100°F (38°C), 100% humidity
- Combat shotgun resistant @5m
- 15g MOUT wall strike
- Land + autostart

History and Background  Current Platform  Revolutionary Missions
XQ-138

MDO using best currently available technology

ballistic graphite & boron structure

Kevlar turning vane flaps

titanium powerplant housing

piezoceramic turning vane flap actuators

magnesium motor

mount/fuselage coupler

flight control actuators

graphite racking grid fins

piezoceramic grid fin actuators

History and Background  Current Platform  Revolutionary Missions

Sensor
Transmitter
Receiver
GPS navigator

piezoceramic gyros

SAS system
Fuel tank

1.3hp (970W)
powerplant

Muffler ass’y
XO-138 Weight Fraction Trends...

Adaptive FCS

<table>
<thead>
<tr>
<th>Component</th>
<th>% MGWT</th>
<th>Useful Load</th>
<th>22.2%</th>
<th>8.7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Controls</td>
<td>31.4%</td>
<td></td>
<td>2.4%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Structure</td>
<td>36.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propulsion</td>
<td>19.3%</td>
<td></td>
<td>20.1%</td>
<td>26.0%</td>
</tr>
<tr>
<td>SAS/Coms/Power</td>
<td>14.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11&quot; (28cm) Ø</td>
<td>2.0%</td>
<td>33.2%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11" (28cm) Ø
Tmax = 2960g
(T/W)min = 1.2
Emax = 105min

6" (15cm) Ø
Tmax = 453g
(T/W)min = 1.2
Emax = 34min

4" (10cm) Ø
Tmax = 138g
(T/W)min = 1.2
Emax = 14min
Payload-Range Diagram

- 5% min. reserve thrust margin
- Fuel, PL Weight (gmf)
- Aircraft Gross Weight (gmf)
- GNC & mission packages
- flight control system

**History and Background**

- Current Platform
- Revolutionary Missions
Flight Testing

QuickTime™ and a Cinepak decompressor are needed to see this picture.
New Mission Testing...
Redstone Arsenal, AL

Demonstration of stable launch, transition, missile-mode flight, stable hover and recovery

Remote Launch from Remote Controlled Armored Vehicle

Redstone Arsenal
New Mission Testing...
Eglin AFB, FL, Hellfire Range

BDA following Javelin Missile
Live Fire Shot against a T-60
Launch and Target ID against Ground Target
Stalking Hovering Missile Flight Demonstration

QuickTime™ and a Cinepak decompressor are needed to see this picture.
XQ-381 Mission Profile & Spec.
40mm Weaponized Aircraft

40mm Recoilless
Munition Shots

QuickTime™ and a Cinepak decompressor are needed to see this picture.
Now where???

FAQ-381
Hypermaneuverable
Collocated Close Air Support (CCAS) Hovering Missile
The Next Generation: FAQ-381

Enhanced Mission Specs:

- MGWTO ~50 lb
- Vmax >380kts
- >3hr HOGE
- >5hr Vbr Loiter
- Large Sector Coverage
- Full sensor & coms suites
- Collocated Close Air Support
- Combat resistant

Start-up, T/O 5,000 ft dens. alt.

cruise in 300 kts, 30 min/150 nmi 10,000 ft dens. alt

climb

descend

descend

2 hrs @ 5,000 ft dens. alt.
600 rounds 5.56amm or 50 40mm grenades

landing, shut-down 5,000 ft dens. alt.
The Next Generation: FAQ-381

- forward sensor suite
- GNC/INS/comms package
- turning vane flaps
- rotor guard
- sensor suite
- integral fuel tank in rotor guard
- pivoting M16/40mm grenade launcher
- 3-bladed upper rotor
- 5-bladed lower rotor
- Williams WR-34 turboshaft engine
- empennage assembly

History and Background  Current Platform  Revolutionary Missions
The Next Generation: FAQ-381 CCAS

Iraq:
4 Base Coverage for 20 min Response

Afghanistan:
5 Base Coverage for 20 min Response
The Next Generation: FAQ-381 CCAS

Tankers enable “indefinite” loiter/orbit
The Next Generation: FAQ-381 5 min CCAS

9 Track Coverage for Iraq

10 Track Coverage for Afghanistan
Precision Autorecovery

Sub-millimeter navigation precision, exacting stabilization, gust insensitivity

QuickTime™ and a Cinepak decompressor are needed to see this picture.
Questions?