Aerospace Rocket Research for Opportunities in the Workforce Leadership (ARROW)

Base 11 Site Visit
Ms. Ingrid Ellerbe, Senior VP, Partner and Program Engagement
Ms. Tia Tucker, Senior Programs Manager
December 3, 2018
AIM: To Develop Leadership and Workforce in Aerospace Industry

Morgan State University’s Strategic Plan:

1. Enhancing Student Success: ARROW will provide unparalleled opportunities for students to engage with innovative academic programs;

2. Enhancing Morgan’s Status as a Doctoral Research University: ARROW will provide faculty (as well as students) the opportunity to engage in cutting edge research;

3. Improving and Sustaining Morgan’s Infrastructure and Operational Processes: ARROW will provide Morgan an opportunity to address the new need for new program space following the guidelines for environmental sustainability as demanded by the State of Maryland;

4. Growing Morgan’s Resources: ARROW will provide additional dynamic opportunities to locate and pursue new grant, contract and entrepreneurial pathways to increase Morgan’s resources as well as enhancing and establishing collaborative relationships with public and private entities; and

5. Engaging with the Community: ARROW will provide the University an additional tool to be used to reach out, engage and empower the community and the residents that surround Morgan.
Student Recruitment

- Morgan State University students with STEM backgrounds
- Partner institution students with STEM backgrounds
- Outreach team

Training

Forces on a Rocket

Newton’s Second Law

Differential Form: Force = change of momentum with change of time
or:
Force = change in mass X velocity with time

\[ F = \frac{d(mv)}{dt} \]

With mass constant:
Force = mass X acceleration

\[ F = ma \]

Thrust, Lift, Drag, Weight

Ballistic Flight Equations

For a vertical launch:

- At highest point:
  \[ V = V_0 - g \frac{t}{2} \]
  \[ y = V_0t - \frac{1}{2} gt^2 \]
- At ground impact:
  \[ y = 0 \]
  \[ V = -V_0 \]

\[ \text{Coasting Ascent}
\]
\[ \text{Coasting Descent} \]

- Launch: \[ V_0 \]
- g = 32.2 ft/sec^2, 9.8 m/s^2
- t = time
- y = height
- V = velocity

Rocket Thrust Summary

- Known:
  \[ \dot{m} = \frac{A}{T_t} \]
  \[ T_t = T_2 - T_1 \]
  \[ A_c = \frac{A}{R} \]
  \[ T_e = \left(1 + \frac{T_2 - T_1}{M_2^2 - M_1^2}\right) \]

- Mass Flow Rate:
  \[ \dot{m} = \frac{A}{T_t} \sqrt{\frac{T_2}{R}} \]
  \[ \frac{n}{T_t} = (\frac{T_1}{T_t} + 1) \frac{M_0}{M_2} \]

- Exit Mach:
  \[ A_c = \left(\frac{\gamma + 1}{2}\right) \sqrt{\frac{T_2}{T_1}} \]
  \[ \frac{t}{T_t} = (1 + \frac{T_2 - T_1}{M_2^2 - M_1^2})^{-1} \]

- Exit Pressure:
  \[ \frac{P_e}{P_t} = (1 + \frac{T_2 - T_1}{M_2^2 - M_1^2})^{-1} \]

- Exit Velocity:
  \[ V_e = M_e \sqrt{RT_2} \]

- Thrust:
  \[ F = \dot{m} V_e + (p_e - p_0) A_e \]
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<thead>
<tr>
<th>Phases</th>
<th>Altitude 13,000</th>
<th>Altitude 100,000</th>
<th>Altitude 150,000</th>
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<tbody>
<tr>
<td><strong>Phase I: Design</strong></td>
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<td><strong>Phase III: Safety</strong></td>
<td>Lead: Dr. Lee Co-Lead: Dr. Chen Students (n = 4)</td>
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Phase I: Design

- SEB 104 Design Stations
- 3D printer
- Earthquake simulator
- Wind Tunnel
- CAD/CAM (Drawing Generation)
- CFD (Theory Analysis)
- 3D Printer (Prototype)
- Wind Tunnel (Experimental Analysis)
- Rocket design simulator (like OpenRocket or ANSYS)
Phase II: Build

Rocket Engine Components
• Air Frame
• Payload
• Recovery System

CBEIS 018: Component Fabrication

MEB 136 Lab: Components Assembly
Phase II: Build

Arc-Welding Machine

Injection Molding Machine

CNC Cutting Machine

Other Tools
Establish Morgan Safety Council
- Vice President of Research and Economic Development
- Manager of Building Construction and Management
- Fire Marshall
- Lead faculty
- Supporting staff

Conduct Safety Training

Observe Safety Precautions

Contact Information for Safety Related Issues

Fire Marshal
Christopher G. Evans
Fire Life and Environmental Health Safety Programs - DCM
Phone: 443-885-4451
Cell: 443-757-7486, Fax: 443-885-8269

For Minor Accidents
University Health Center

For Serious Accidents Dial:
911 or 0

Hospital & Ambulance
Med-Star Good Samarian Hospital
Create safety guidelines and procedures

- General rules
- Work areas and apparatus
- Injuries and accident guidelines
- Emergency procedures
- Personal protective equipment
- Guidelines to use tools and equipment
Phase IV: Launch

1. Training and Combustion Testing
2. Launch Location Coordination
   - Goddard Space Flight Center or
   - Wallops Space Flight Center
3. Launch Window Determination
   - Risk Analysis
     - Determining go or no-go flight launch at
       • our flight headquarters.
4. Recovery by Streamer, Parachute or GPS
5. Evaluation