Status and Design Features of the new NASA GRC Reverberant Acoustic Test Facility (RATF)

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NASA Glenn Research Center

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Test Facility Overview

- The Space Power Facility (SPF) at the NASA Glenn Plum Brook Station in Sandusky, OH is developing an environmental test capability for NASA’s future space programs.
- SPF will provide *one-stop shopping* for a wide variety of space environmental testing.

**Environmental Facility Capability:**

- Acoustic
- Mechanical Vibration
- Modal
- Thermal-Vacuum
- EMI/EMC

- The focus of this presentation is the status and design of the Reverberant Acoustic Test Facility (RATF).
Space Power Facility (SPF)
Provide and Support Future NASA Testing

- Acoustic Testing
- Sine Vibration and Modal Testing
- Disassembly Bay Area
- Thermal Vacuum and EMI/EMC Testing
Benham Corporation is Prime Contractor

* RATF Suppliers:

TEAM: MK VI and MK VII Modulators

Wyle: WAS 5000 Modulators

m+p International: Acoustic Control System
RATF Acoustic Requirements

- Wide range of OASPL
- Diverse spectral energy requirements
  - Low frequency dominant spectra
  - High frequency dominant spectra
  - Twin peaked spectra
## Acoustic Test Series

<table>
<thead>
<tr>
<th>Test</th>
<th>Date</th>
<th>Location</th>
<th>Test Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRC I and II</td>
<td>December 2007 - January 2008, April 2008</td>
<td>NRC, Ottawa, Ontario, Canada</td>
<td>Acoustic response characterization of the TEAM modulators and initial horn evaluation. (Benham/Aiolos)</td>
</tr>
<tr>
<td>Redstone</td>
<td>May 2008</td>
<td>Redstone Arsenal, Huntsville, AL</td>
<td>NASA independent acoustic characterization of TEAM modulator and horns, including high frequency horn. Comparison of results with WAS 3000 modulator. (NASA)</td>
</tr>
<tr>
<td>Phase 2</td>
<td>October 2009</td>
<td>NRC, Ottawa, Ontario, Canada</td>
<td>Multiple modulator control. WAS 5000 acoustic characterization. (Benham/Aiolos)</td>
</tr>
<tr>
<td>Paint Absorption</td>
<td>February - March 2010</td>
<td>Owens-Corning, Granville, OH</td>
<td>Test characterization of acoustic absorption of RATF wall paint. (Cambridge Collaborative Inc. for NASA)</td>
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</tbody>
</table>
Reverberant Acoustic Test Facility (RATF)

**Chamber Properties**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber Size</td>
<td>47.5 ft L x 37.5 ft W x 57 ft H</td>
</tr>
<tr>
<td>Chamber Volume</td>
<td>101,189 ft³</td>
</tr>
<tr>
<td>Acoustic Modulators</td>
<td>23 TEAM Modulators &amp; 13 WAS 5000 Modulators</td>
</tr>
<tr>
<td>Horns</td>
<td>36 (grouped at 7 different horn cut-off frequencies)</td>
</tr>
<tr>
<td>Nominal GN₂ flow rate</td>
<td>72,000 scfm</td>
</tr>
<tr>
<td>Main Door Opening</td>
<td>34.5 ft wide</td>
</tr>
<tr>
<td>Number of Main Doors</td>
<td>2</td>
</tr>
<tr>
<td>Door Type</td>
<td>Sliding and hinged</td>
</tr>
<tr>
<td>OASPL, empty</td>
<td>163 dB OASPL</td>
</tr>
</tbody>
</table>

Minimum 10 minute continuous run times (worst case)
Designed for 47 ft tall x 20 ft diameter test article
# RATF Modulators and Horns

## TEAM MK VI

![Image of TEAM MK VI modulator and horn setup]

## Wyle WAS 5000

![Image of Wyle WAS 5000 modulator and horn setup]

<table>
<thead>
<tr>
<th>Horn</th>
<th>25 Hz</th>
<th>35 Hz</th>
<th>50 Hz</th>
<th>80 Hz</th>
<th>100 Hz</th>
<th>160 Hz</th>
<th>250 Hz</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulator</td>
<td>MKVII</td>
<td>MKVII</td>
<td>MKVII</td>
<td>MKVII</td>
<td>MKVI</td>
<td>MKVI</td>
<td>WAS5000</td>
<td>36</td>
</tr>
<tr>
<td>Final Design Count</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>13</td>
<td>36</td>
</tr>
</tbody>
</table>
RATF Horn Wall Layout

- Two 25 Hz horns
- Two 35 Hz horns
- Four 50 Hz horns
- Three 80 Hz horns
- Four 100 Hz horns
- Eight 160 Hz horns
- Thirteen 250 Hz horns (expandable to 20 horns)

**Total:** 36 horns
Aiolos’ Predicted RATF Spectra

C1

C2

C3

C4
Aiolos’ Predicted RATF Spectra

**C5**

Band SPL, dB re 20 micro Pascals vs. 1/3 Octave Band Centre Frequency, Hz

- TEAM: 25 Hz(4), 50 Hz(4), 100 Hz(7), 160 Hz(6); WAS5000(0)
- OASPL163.2dB; Total Flow 42,800 scfm
- C5 - Upper end
- C5 - Low end

**C6**

Band SPL, dB re 20 micro Pascals vs. 1/3 Octave Band Centre Frequency, Hz

- TEAM: 25 Hz(4), 50 Hz(0), 100 Hz(4), 160 Hz(2); WAS5000(0)
- OASPL153dB; Total Flow 21,700 scfm
- C6 - Upper Bound
- C6 - Lower Bound

**C7**

Band SPL, dB re 20 micro Pascals vs. 1/3 Octave Band Centre Frequency, Hz

- TEAM: 25 Hz(4), 50 Hz(0), 100 Hz(4), 160 Hz(2); WAS5000(0)
- OASPL153dB; Total Flow 21,700 scfm
- C7 - Upper end
- C7 - Low end

**C8**

Band SPL, dB re 20 micro Pascals vs. 1/3 Octave Band Centre Frequency, Hz

- TEAM: 25 Hz(3), 50 Hz(3), 100 Hz(4), 160 Hz(12); WAS5000(13)
- OASPL163dB; Total Flow 67,800 scfm
- C8 - Upper end
- C8 - Low end
RATF Construction

Foundation started in April 2008
Horn Wall – Installation of Horn Frames

Legend

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Color</th>
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</thead>
<tbody>
<tr>
<td>25 Hz</td>
<td>Blue</td>
</tr>
<tr>
<td>35 Hz</td>
<td>Red</td>
</tr>
<tr>
<td>50 Hz</td>
<td>Purple</td>
</tr>
<tr>
<td>80 Hz</td>
<td>Green</td>
</tr>
<tr>
<td>100 Hz</td>
<td>Pink</td>
</tr>
<tr>
<td>160 Hz</td>
<td>Orange</td>
</tr>
<tr>
<td>250 Hz</td>
<td>Black</td>
</tr>
</tbody>
</table>

Space Available for Future Expansion

Scarring (for 250 Hz)
Overhead View – Preparation Horn Room Pour 1

Installation of horn frames and rebar
Concrete pour #1 completed October 2009
Concrete pour #1 completed with forms removed
Overhead View – Preparation Horn Room Pour 2

Horn wall level 2 horn frame and rebar installation
Overhead View – Horn Room Pour 2

Concrete pour #2 completed with forms removed
Looking Forward

**Spring/Summer 2010:**
Installation of vaporizer system, horns, and modulators

**Fall 2010/Winter 2010-11:**
Door installation; Benham Verification Testing with turnover to NASA

**Spring/Summer 2011:**
NASA Integrated Systems Testing (IST)

**Fall 2011:**
Available for Testing

RATF Facility Manager: Mr. Aron D. Hozman,
Phone: (419)-621-3301, Aron.D.Hozman@nasa.gov
**RATF will be the most Powerful Large Reverberant Acoustic Chamber in the World!**

<table>
<thead>
<tr>
<th>(Active) Reverberant Acoustic Test Facility</th>
<th>Location</th>
<th>Volume (ft$^3$)</th>
<th>Max. OASPL (dB) Empty Chamber</th>
<th>Year Commissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockheed Martin Missiles and Space, bldg.156, cell no.1, LVATF</td>
<td>Sunnyvale, CA</td>
<td>189,200</td>
<td>156.5</td>
<td>1973</td>
</tr>
<tr>
<td>NASA Plum Brook Station</td>
<td>Sandusky, OH</td>
<td>101,200</td>
<td>163.0</td>
<td>Planned for 2011</td>
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<tr>
<td>Lockheed Martin Space Systems</td>
<td>Denver, CO</td>
<td>75,900</td>
<td>154.0</td>
<td>1985</td>
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<tr>
<td>Boeing Satellite Development Center (Boeing SDC)</td>
<td>El Segundo, CA</td>
<td>67,800</td>
<td>155.0</td>
<td>2004</td>
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<tr>
<td>Lockheed Martin Missiles and Space (LMMS), bldg.159</td>
<td>Sunnyvale, CA</td>
<td>64,000</td>
<td>157.3</td>
<td>1996</td>
</tr>
<tr>
<td>Mitsubishi Electronics</td>
<td>Kamakura, Japan</td>
<td>61,700</td>
<td>152.0</td>
<td>2002</td>
</tr>
<tr>
<td>Large European Acoustic Facility (LEAF) at ESTEC</td>
<td>Noordwijk, The Netherlands</td>
<td>59,000</td>
<td>154.5</td>
<td>1990</td>
</tr>
<tr>
<td>Northrop Grumman Space Technology (NGST), LATF</td>
<td>Redondo Beach, CA</td>
<td>51,600</td>
<td>154.0</td>
<td>1996</td>
</tr>
</tbody>
</table>
Thank you

Contact Information:
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