40th Annual Armament Systems: Guns - Ammunition - Rockets – Missiles Conference

MEMS IMU – Common Guidance
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Program/Business Strategy

- Go To Multiple IMU Design / Manufacturing Teams
  - L3/IEC
  - Honeywell/Draper/Rockwell Collins
- Build to Common Requirement
- Leverage Process Improvements into Multiple DoD Applications
### Technology Investment Areas

<table>
<thead>
<tr>
<th>S &amp; T</th>
<th>ManTech</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PERFORMANCE DRIVERS</strong></td>
<td><strong>COST DRIVERS</strong></td>
</tr>
<tr>
<td>• Size</td>
<td>• Touch Time</td>
</tr>
<tr>
<td>• Weight</td>
<td>• New Capital Equipment</td>
</tr>
<tr>
<td>• Performance</td>
<td>• New Process Development</td>
</tr>
<tr>
<td>• Power</td>
<td>• New Product Development</td>
</tr>
<tr>
<td>• Environment</td>
<td>• Low Volume Production</td>
</tr>
<tr>
<td>• Reliability</td>
<td></td>
</tr>
<tr>
<td><strong>PERFORMANCE IMPROVERS</strong></td>
<td><strong>COST REDUCERS</strong></td>
</tr>
<tr>
<td>• Technology Development</td>
<td>• Automation</td>
</tr>
<tr>
<td>- Design</td>
<td>- Improved Consistency</td>
</tr>
<tr>
<td>- Test</td>
<td>- Reduce Touch Time</td>
</tr>
<tr>
<td>- Evaluate</td>
<td>• Upgrade Equipment</td>
</tr>
<tr>
<td>• Improve Design</td>
<td>- Better Control</td>
</tr>
<tr>
<td>• Improve Technology</td>
<td>- Improved Yield</td>
</tr>
<tr>
<td></td>
<td>• Consolidate</td>
</tr>
<tr>
<td></td>
<td>• Economy of Scale</td>
</tr>
<tr>
<td>• Do It Again</td>
<td></td>
</tr>
</tbody>
</table>

**Using Manufacturing Technology to achieve Technical Performance Goals**
Program Milestones

**Phase 1 (3 KTRs)**
System Process/Definition and Sensor and Electronic Design Development; JCG ICD IMU Demo 10K G, < 75 °/hr, < 9 mg, < 8 cu. in.

**Phase 2 (2 KTRs Min)**
IMU Demo > 20,000g, < 20°/hr, < 4mg, < 4 cu in over Environment,

**Phase 3 (2 KTRs Min)**
IMU Demo > 20K G, 1°/hr, < 1 mg, < 2 cu. in. over Environment, < $1,200/IMU

**Option 1 (2 KTRs Min)**
DIGNU - 53 Months
DIGNU/ ISA-IMU / AJ, 4 cu. in., Intg Demo(s), > 20K G, < 1 °/hr over High-G Enviro < $1500

Contracts Awarded
Deliver 8 Units
Deliver 12 Units
Deliver 36 Units

6 Units (DIGNU-1) 14 Units (DIGNU-2) 36 Units (DIGNU-3)
High-G MEMS IMU Evolution

Phase 1
- <75 Deg/Hr
- <8 in3
- >10 K Gs
- <9 mg
- 18 Months

Phase 2
- <20 Deg/Hr
- <4 in3
- >20 K Gs
- <4 mg
- 18 Months

Phase 3
- <1 Deg/Hr
- <2 in3
- >20 K Gs
- <1 mg
- 24 Months

Incrementally Shrink Volume and Power While Improving Performance
Deeply Integrated Guidance and Navigation Unit (DIGNU)

- Traditional GPS/INS Integration Enhances A/J Loss of Lock Capability
- Deep Integration Concept Provides 15-20 db A/J Over Conventional Tightly Coupled Solutions (SW Solution Only)
- Improves Weapon Effectiveness by Decreasing CEP
- Common Interface Control Document (ICD)
- Single Processor Architecture
- Higher Reliability

Knowing Where You Are And Where You Need To Be
Program Output

Provide Common MEMS IMU/DIGNU for 90% of all DoD Applications

- Common Interface Control Document for compatibility across multitude of platforms
- Common Performance Specification for consistent output signals
- Two qualified suppliers producing interchangeable devices

Implementation of System Engineering principles ensure that customer needs are met!
Quality Function Deployment (QFD)

• Two deployments to date
  1. focus on specific technical characteristics
     • provided valuable specification input
     • answered questions on interfaces, environments, and sensor performance
  2. focus on understanding the customer base and their top level requirements
     • resulted in a prioritized list of customers based on:
       • compatibility of production schedules
       • anticipated production volumes
     • allows evaluation of current requirements/cost drivers
     • provides basis for programmatic decisions

• Use of this SE tool resulted in comprehensive understanding of end-user needs
### QFD – 1
#### Example of Results

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Original Spec</th>
<th>Range of Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per unit cost</td>
<td>&lt;$1200</td>
<td>$1650 to &lt;$1900</td>
</tr>
<tr>
<td>Volume</td>
<td>&lt;2 cubic in.</td>
<td>4 cubic in.</td>
</tr>
<tr>
<td>Dynamic G-range</td>
<td>30 g</td>
<td>70-100 g</td>
</tr>
<tr>
<td>Built in test</td>
<td>Coverage of 80% of testable failures</td>
<td>Max Power up BIT of 95%</td>
</tr>
<tr>
<td>Max input power</td>
<td>≤5W</td>
<td>5.25W</td>
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</table>
## Customer QFD Results (by Phase)

<table>
<thead>
<tr>
<th>Customer</th>
<th>Prod.Yr</th>
<th>IMU vol</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRM</td>
<td>2009</td>
<td>Phase 2</td>
<td>Phase 2</td>
</tr>
<tr>
<td>ERM</td>
<td>2006</td>
<td>Phase 2</td>
<td>Phase 2</td>
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<tr>
<td>PGMM</td>
<td>2008</td>
<td>Phase 2</td>
<td>Phase 2</td>
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<tr>
<td>Excalibur</td>
<td>2005</td>
<td>Phase 2</td>
<td>Phase 2</td>
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<tr>
<td>AGS-LRLAP</td>
<td>2008</td>
<td>Phase 2</td>
<td>Phase 2</td>
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<tr>
<td>SDB</td>
<td>2008</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>APKWS</td>
<td>2006</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>JCM</td>
<td>2008</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>GMLRS</td>
<td>2005</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>JSOW</td>
<td>2009</td>
<td>Phase 2</td>
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<tr>
<td>JDAM</td>
<td>2008</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
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<td>THAAD</td>
<td>2007</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>WCMD</td>
<td>2007</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>Soldier Navigation</td>
<td>2006</td>
<td>Phase 3</td>
<td>Phase 3</td>
</tr>
</tbody>
</table>
Next Steps

• End User feedback on ICD and Performance Specification
  – Contact Information to receive a copy of documents
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  John J. McMullen Associates Inc.
  Engineer
  (202)-741-2041
  TCoombe@JJMA.com

• Requirements data being tracked with SLATE software
• ICD and specs in Configuration Management Control
Summary

• Program structured to meet 90% of end user needs
• Progressing toward meeting both technical and programmatic Phase 3 goals by 1QFY07
• System Engineering has added discipline to the approach