JAMI
Flight Termination System
A Cooperative Development Between
NAWC/CL and KAMAN

Dale Spencer, Presenter
Andy Yuenger, Co-Author

45th Annual Fuze Conference
Long Beach, California
April 18th, 2001
# JAMI Flight Termination System: A Cooperative Development Between NAWC/CL and KAMAN

## Report Details

<table>
<thead>
<tr>
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<th>Dates Covered (from... to)</th>
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<td>N/A</td>
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### Title and Subtitle
JAMI Flight Termination System: A Cooperative Development Between NAWC/CL and KAMAN

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### Performing Organization Name(s) and Address(es)
Kaman

### Sponsoring/Monitoring Agency Name(s) and Address(es)
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### Supplementary Notes

### Report Classification
Unclassified

### Subject Terms

### Abstract

### Number of Pages
25
Overview

- **Joint Advanced Missile Instrumentation**
  - Roles
  - System

- **FTSA**
  - Requirements
  - Features
  - Block Diagram
  - Design/Implementation
  - Test Results
  - Status
  - Plans
DEVELOPMENT UNDER CRADA

• Cooperative Research and Development Agreement
  – Raymond Engineering Operations (REO)
  – Signed 12 April 1999
  – Division of Responsibilities
    • China Lake
      – Electrical/Explosive Design and Development
      – Environmental Testing
    • REO
      – Packaging
      – Hardware Manufacturing
JAMI FTS TEAM

- Program Dir: Mr. Don Scofield, NAWCWD, China Lake
- Navy Deputy: Mr. Dave Powell, NAWCWD, Pt Mugu
- Project Engr: Mr. Andy Yuenger, NAWCWD, China Lake
- EE Design (Past): Mr. Mike Haddon, NAWCWD, China Lake
- EE Design (Present): Mr. Gabe Soto, NAWCWD, China Lake
- Analyst: Mr. Jim McVay, NAWCWD, China Lake
- Industry Partner: Kaman Aerospace Corporation/ Raymond Engineering
  - ME Design: Mr. Robert Spooner
  - FCDC Interface: Mr. Ted Horbacewicz
  - Test Engineer: Mr. Mario Fasulo
  - Reliability & Safety: Mr. Pete Rohner
  - Firmware: Mr. Pete Solari
  - Project Engineer: Mr. Dale Spencer
FTSA VS S&A

• FTSA
  – Overriding Concern is to Not Allow the Weapon to Go Outside the Range Footprint
  – Defining Specification is RCC 319-99

• S&A
  – Overriding Concern is to Not Allow Unintended Initiations
  – Defining Specification is Mil-Std-1316
JAMI FTSA BENEFITS

- Standardization
- Off-the-shelf availability
- Low Unit Cost
- Small Size & Weight
JAMI FTSA Requirements

- Compliant With RCC 319-99
- Programmable For Multiple Applications (at test facility)
- Small Size (< 9 in³/unit)
- Low Cost (~$2000/unit)
- Qualified To “Worst Case” Environmental Levels
  - Based on Environments of Potential Users
- Removable Explosives (LEEFI, Etc.)
- Fully Testable (Including HV Output)
Block Diagram of JAMI FTSA

- Programming Computer
- LPT1 Communication Bus
- Programmable Inputs
- Command Destruct Receiver 1
  - Terminate
  - Monitor 1
  - Arm Enable
- Command Destruct Receiver 2
  - Monitor 2
- Simulated Accel Input
- Umbilical Disconnect
- Secondary FTSA Battery Monitor
- Battery
- Gate Array A
- Gate Array B
- A/D Converter
- A/D Converter
- Accelerometer
- Fireset
- Regulation
- EEPROM
- High Voltage Converter
- System Operational
- First Motion
- Safe Sep. Status
- Fire Status
- FailSafe Status
- HV Status
- TERMINATE
**INPUTS & OUTPUTS**

**Programmable Inputs**
- Failsafe Enable
  - Loss of Monitor (tone)
  - Loss of Power
- First Motion Enable
  - First Motion Valid Time
- Acceleration Enable
  - Axis of Acceleration
  - Acceleration Level
- Umbilical Disconnect Enable
- Safe Separation Time
- Arm Enable

**Non-Programmable**
- Terminate Command

**OUTPUTS**
- Flight Destruct (Explosive)
- Safe/Arm Status
- Fire Status
- Safe Separation Status
- First Motion Status
- System Operational
- Failsafe Status
Logic Circuits

HV Components on Backside
FCDC Components
JAMI FTSA FIRESET

- Novel Design
- Small In Size
- Low In Cost (<$20)
- High Reliability
  - 3200 shots @ 1500A
- No Unique Parts
  - All COTS
TEST ENVIRONMENTS

• Range Safety Document RCC 319-99
  – May be First FTSA Fully Qualified to New Document

• Database of Environmental Profiles of Numerous Weapons Systems
STATUS

• Specification Completed
• Housing Design Complete
• FCDC Interface Complete
• Electrical Design Complete
• Prototype Board built and tested
• Fireset Studies Complete

• Pre-production
  – Design Update in final stage
  – Boards planned
  – Pre-Qualification tests to be run to find “weak points”
  – Expect Qualification Completion Second Qtr 2002
Developmental Testing Summary

• Fireset
• Logic Circuits
  – Functional Test of Disable Parameters
  – Programmable Time and Thresholds Verification
• Temperature Range Tests
Developmental Test
Errata

• Electrical Corrections
  – Q1 pins 3 & 4 Reversed
  – R19 & R25 Resistance Value Change for Specified Threshold
    • 47.5k to 68k
  – Missing Run from R21 Node 6 to node 5
  – Missing Pad R17
  – Maxim A/D MAX154 no longer std. production item
  – 2SK2663 (HV Transistor) no longer in production.

• Mechanical Corrections
  – Component interference with Tactical Connector
  – Q7 on wrong side of board, through hole reverse placement
  – Component Height
Design Analysis
Summary

• Tolerance
  – Preliminary circuit tolerance analysis performed with pre-production design

• Stress
  – Design performed with TE000-AB-GTB-010 as a guideline

• Fault Tree
  – Design performed to preclude single point failure and implement desired modes of operation.

• Final Analysis, including FMECA, to be completed in conjunction with pre-production evaluation testing.
Fire Circuit Tests

- Established All-Fire Voltage
  - Explosive Tests forthcoming
- Temperature Cycled -30°C to +92°C
  - Output Current degraded 5% maximum
- Range Safety Requirement for 50% Energy Margin Exceeded by 105 milli-joules threshold (predicted), 203 milli-joules available. Based on nominal capacitor value.
### Functional Verification Tests

#### First Motion Valid

<table>
<thead>
<tr>
<th>Programmed Time</th>
<th>Measured Time</th>
<th>% Error</th>
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<tbody>
<tr>
<td>5 Seconds</td>
<td>5.017</td>
<td>0.3</td>
</tr>
<tr>
<td>10 Seconds</td>
<td>10.017</td>
<td>0.2</td>
</tr>
<tr>
<td>155 Seconds</td>
<td>154.90</td>
<td>0.06</td>
</tr>
<tr>
<td>160 Seconds</td>
<td>160.03</td>
<td>0.02</td>
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</table>

#### Safe Separation

<table>
<thead>
<tr>
<th>Programmed Time</th>
<th>Measured Time</th>
<th>% Error</th>
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<tbody>
<tr>
<td>0.1 Seconds</td>
<td>0.10000</td>
<td>0</td>
</tr>
<tr>
<td>10 Seconds</td>
<td>10.2</td>
<td>0.19</td>
</tr>
<tr>
<td>25 Seconds</td>
<td>25.6</td>
<td>2.3</td>
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</table>
# Functional Verification Tests

## Loss of Power Threshold

<table>
<thead>
<tr>
<th>Programmed Time</th>
<th>Measured Voltage</th>
<th>% Error</th>
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<tbody>
<tr>
<td>21 Volts</td>
<td>20.74</td>
<td>1.2</td>
</tr>
<tr>
<td>22 Volts</td>
<td>21.22</td>
<td>3.7</td>
</tr>
<tr>
<td>23 Volts</td>
<td>22.27</td>
<td>3.3</td>
</tr>
<tr>
<td>24 Volts</td>
<td>23.6</td>
<td>1.7</td>
</tr>
<tr>
<td>25 Volts</td>
<td>24.9</td>
<td>0.4</td>
</tr>
<tr>
<td>26 Volts</td>
<td>25.7</td>
<td>1.1</td>
</tr>
<tr>
<td>27 Volts</td>
<td>27.2</td>
<td>0.7</td>
</tr>
<tr>
<td>28 Volts</td>
<td>28.5</td>
<td>1.7</td>
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## Loss of Tone

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<th>Programmed Time</th>
<th>Measured Time</th>
<th>% Error</th>
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<tbody>
<tr>
<td>1 Second</td>
<td>1.02</td>
<td>2.0</td>
</tr>
<tr>
<td>2 Seconds</td>
<td>2.04</td>
<td>2.0</td>
</tr>
<tr>
<td>31 Seconds</td>
<td>31.7</td>
<td>2.2</td>
</tr>
<tr>
<td>32 Seconds</td>
<td>32.79</td>
<td>2.4</td>
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**Plans**

- **Qualification Plan in Process**
- **Number of units under CRADA is 12**
  - 2 Pre-qualification Engineering
  - 10 Range Qualification Units

### Milestone Table

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<td>Prototype built &amp; tested...</td>
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<td></td>
<td>Δ</td>
<td></td>
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<tr>
<td>Pre-production boards built and tested</td>
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<td>Δ</td>
<td></td>
<td></td>
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<tr>
<td>CDR</td>
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<td>Δ</td>
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<tr>
<td>Qualification Hardware built...</td>
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<tr>
<td>Qualification</td>
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FTSA Feedback

- Your Comments, Questions or Concerns