



JAMI

Flight Termination System

A Cooperative Development

Between

NAWC/CL and KAMAN

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Andy Yuenger, Co-Author

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Abstract		
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Overview



- **Joint Advanced Missile Instrumentation**
 - Roles
 - System
- **FTSA**
 - Requirements
 - Features
 - Block Diagram
 - Design/
Implementation
 - Test Results
 - Status
 - Plans



DEVELOPMENT UNDER CRADA



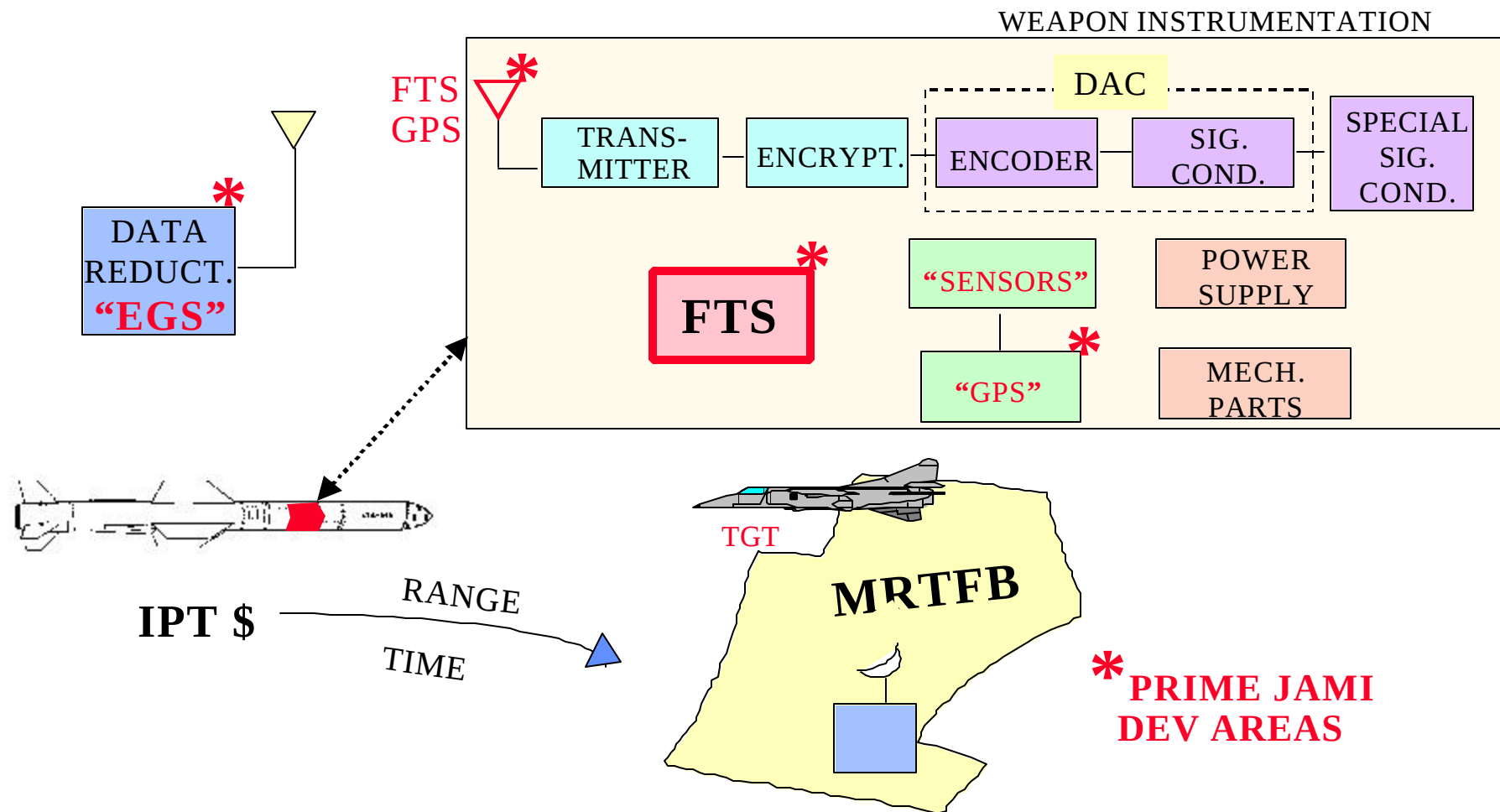
- Cooperative Research and Development Agreement
 - Raymond Engineering Operations (REO)
 - Signed 12 April 1999
 - Division of Responsibilities
 - **China Lake**
 - **Electrical/Explosive Design and Development**
 - **Environmental Testing**
 - **REO**
 - **Packaging**
 - **Hardware Manufacturing**



JAMI FTS TEAM

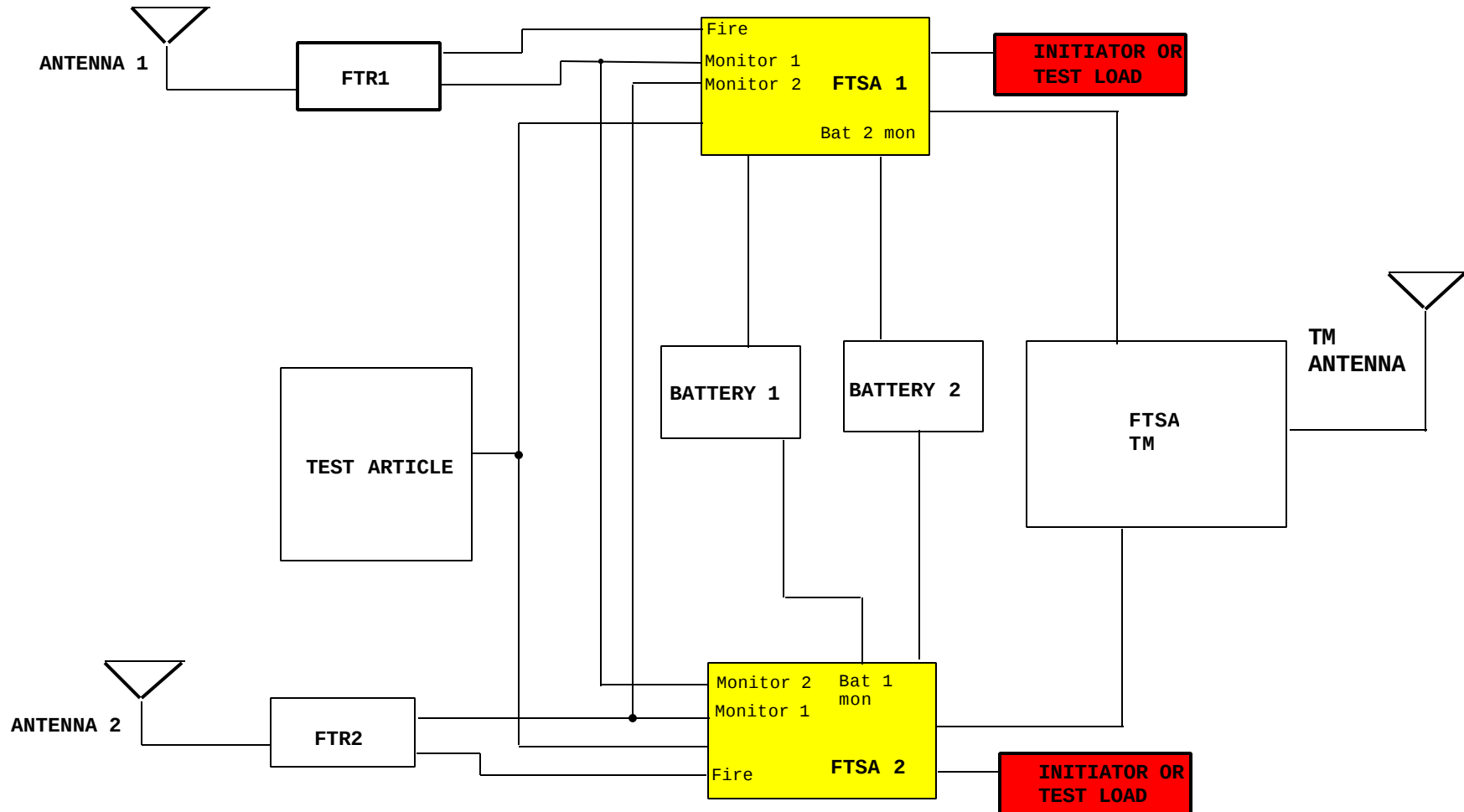


- **Program Dir :** **Mr. Don Scofield**, NAWCWD, China Lake
- **Navy Deputy:** **Mr. Dave Powell**, NAWCWD, Pt Mugu
- **Project Engr:** **Mr. Andy Yuenger**, NAWCWD, China Lake
- **EE Design (Past):** **Mr. Mike Haddon**, NAWCWD, China Lake
- **EE Design (Present):** **Mr. Gabe Soto**, NAWCWD, China 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 in JAMI System





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 BENIFETS



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



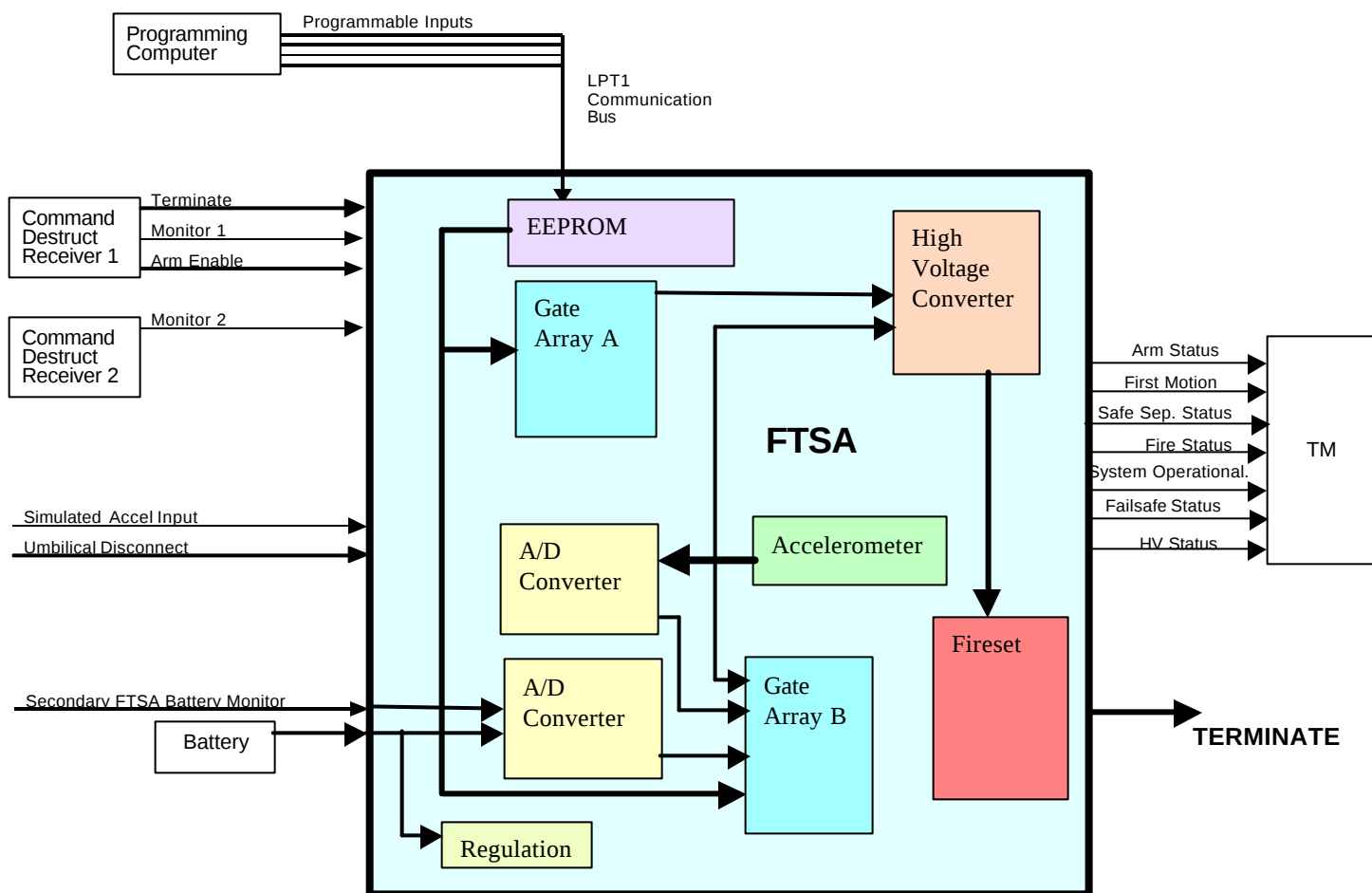
JAMI FTSA Requirements



- Compliant With **RCC 319-99**
- **Programmable** For Multiple Applications (at test facility)
- **Small Size** ($< 9 \text{ in}^3/\text{unit}$)
- Low Cost (**$\sim \$2000/\text{unit}$**)
- 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





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**

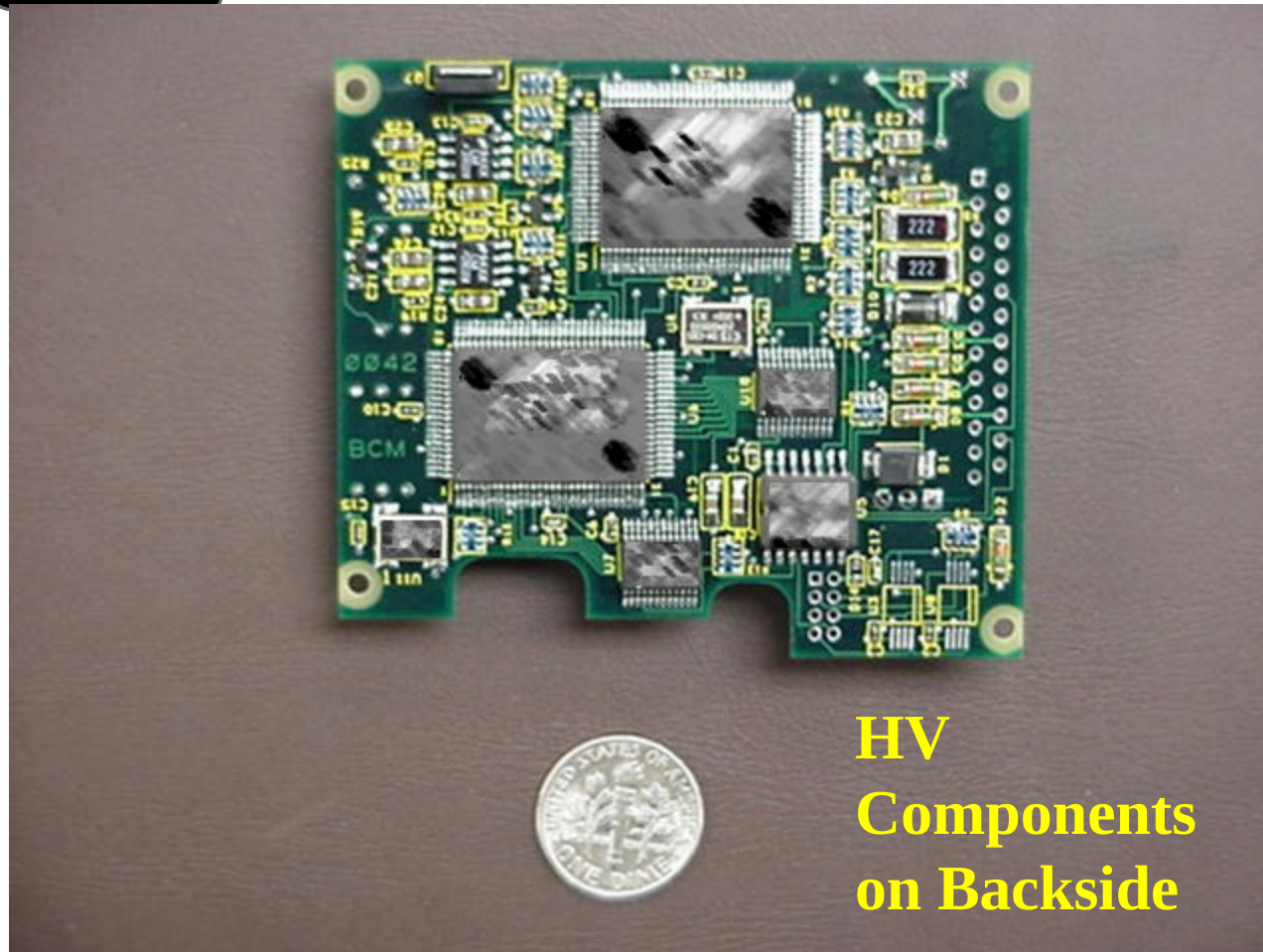
- **Terminate Command**

- **OUTPUTS**

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

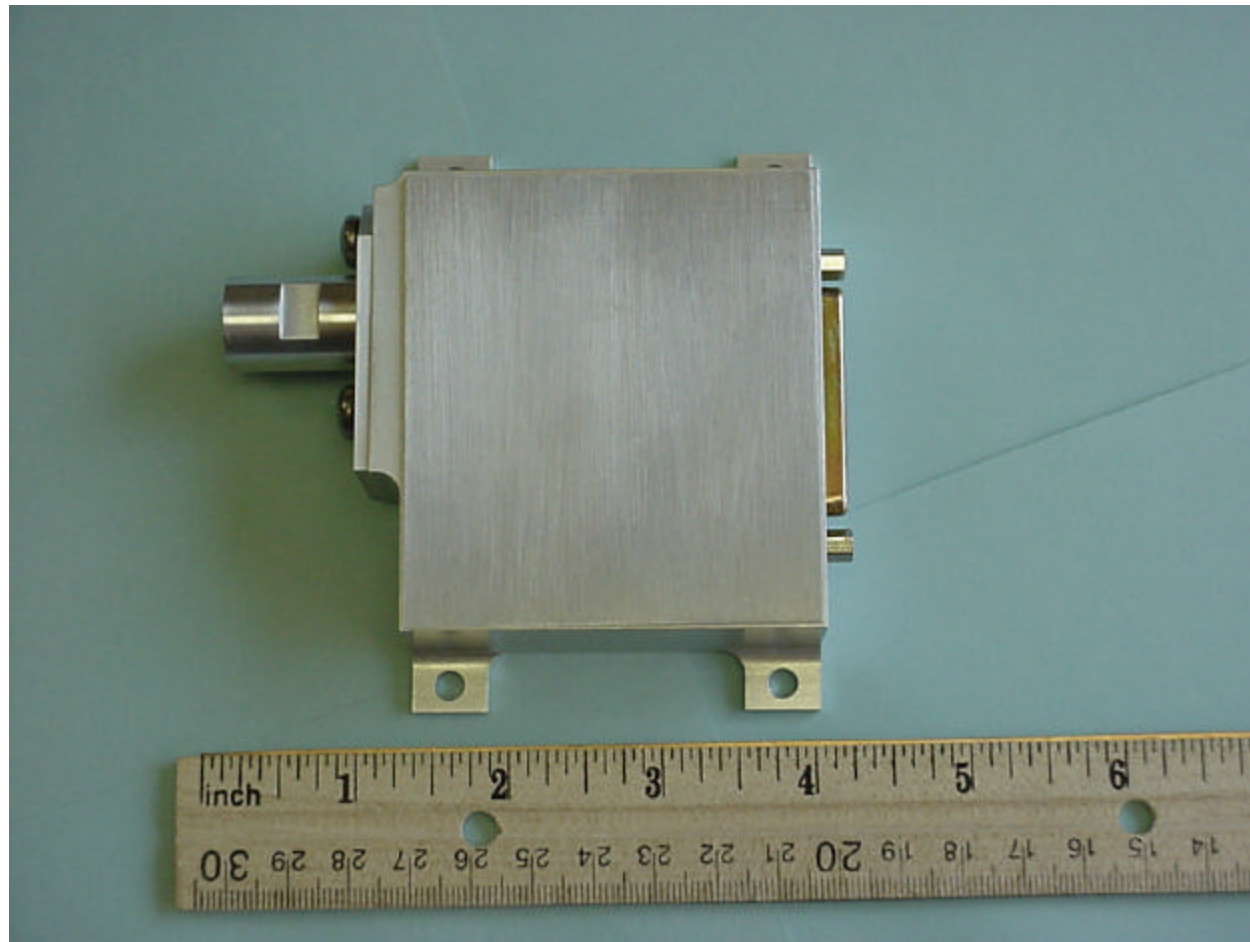


Logic Circuits



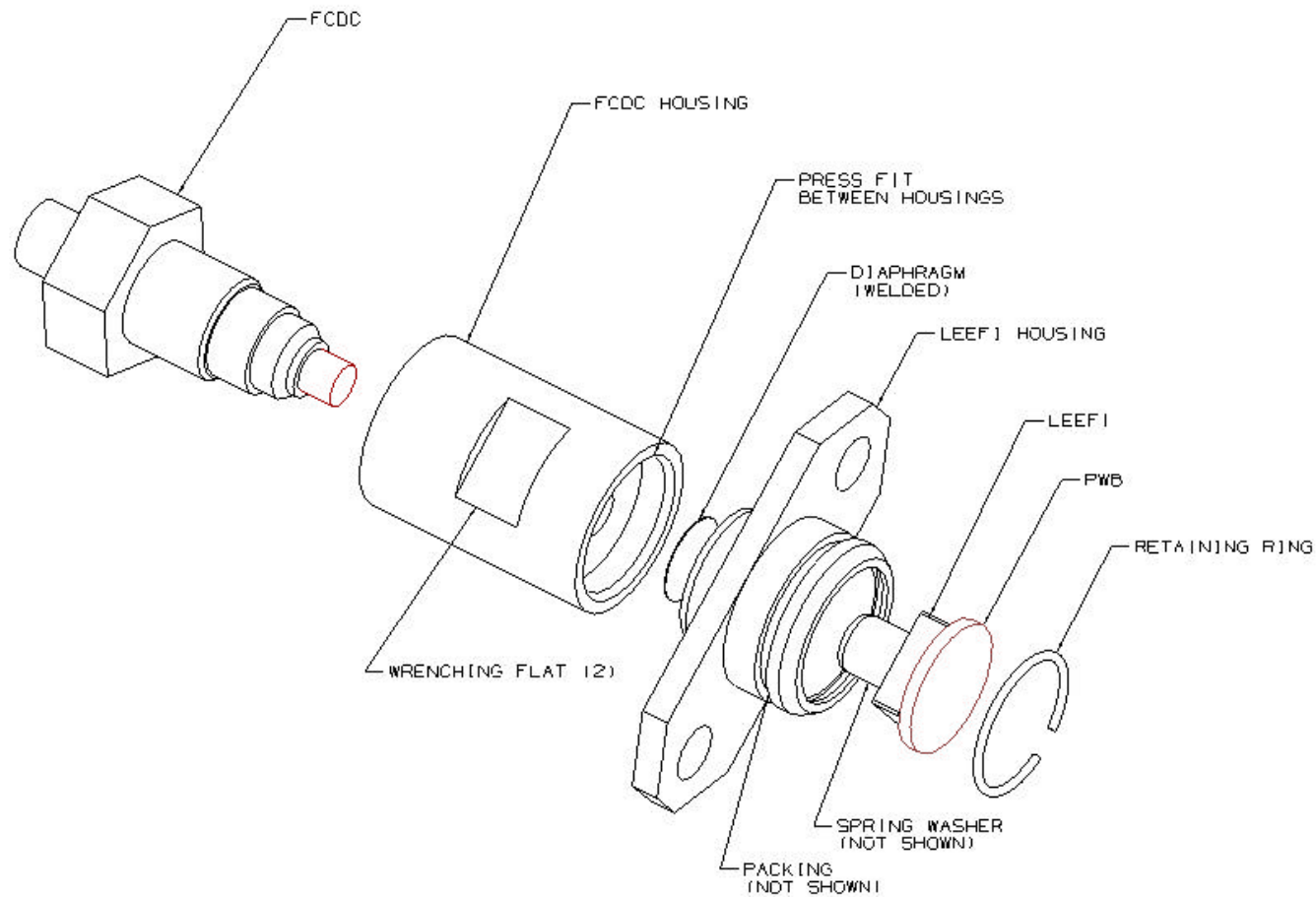


FTSA Housing Model





FCDC Components

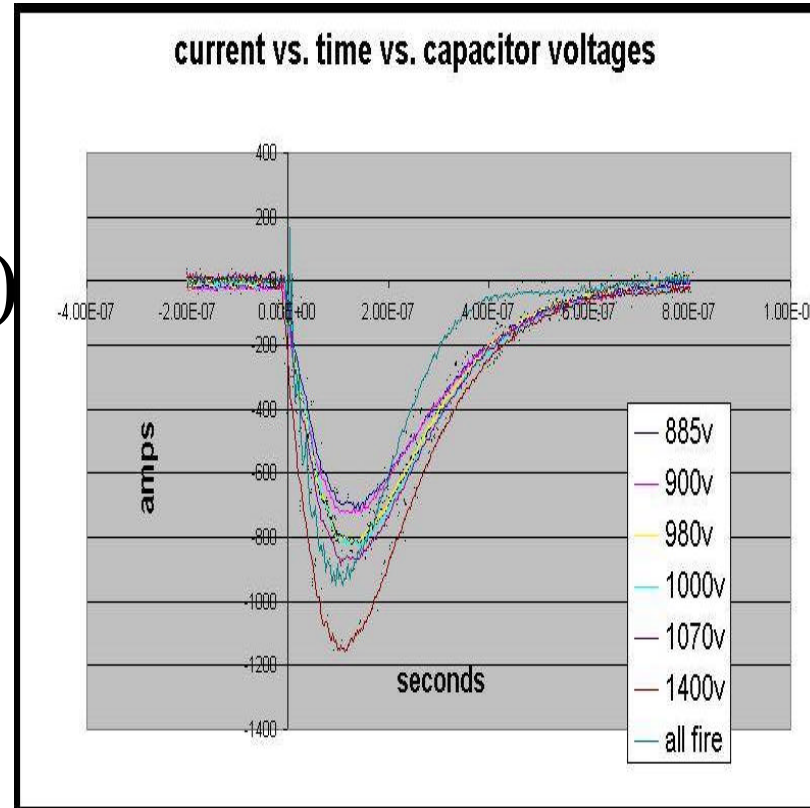




JAMI FTSA FIRESET



- 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 $+92^{\circ}\text{C}$
 - 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

Programmed Time	Measured Time	% Error
5 Seconds	5.017	0.3
10 Seconds	10.017	0.2
155 Seconds	154.90	0.06
160 Seconds	160.03	0.02

Safe Separation

Programmed Time	Measured Time	% Error
0.1 Seconds	0.10000	0
10 Seconds	10.2	0.19
25 Seconds	25.6	2.3



Functional Verification Tests



Loss of Power Threshold

Programmed Time	Measured Voltage	% Error
21 Volts	20.74	1.2
22 Volts	21.22	3.7
23 Volts	22.27	3.3
24 Volts	23.6	1.7
25 Volts	24.9	0.4
26 Volts	25.7	1.1
27 Volts	27.2	0.7
28 Volts	28.5	1.7

Loss of Tone

Programmed Time	Measured Time	% Error
1 Second	1.02	2.0
2 Seconds	2.04	2.0
31 Seconds	31.7	2.2
32 Seconds	32.79	2.4



- | MILESTONE | 00 | 01 | 02 | 03 |
|--|----|----|----|----|
| • Prototype built & tested.....D | | | | |
| • Pre-production boardsD
built and tested | | | | |
| • CDR.....D | | | | |
| • Qualification Hardware built...D | | | | |
| • Qualification.....D | | | | |



FTSA Feedback



- Your Comments, Questions or Concerns