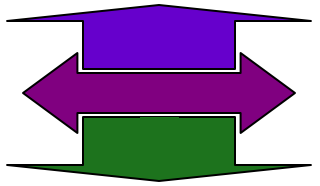
GOODRICH

Aircraft Interior Products



"Next - Generation" Thermo-Electric Digital Time Delay Device

Replacement for current Pyrotechnic Delay Cartridges

Presenter:
Dave Harrington
Co-Author:
Kenneth Hicks

Goodrich Corporation
Aircraft Interior Products
Propulsion Systems

October 25, 2005

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
SEP 2004	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Next-Generation Thermo-Electric Digital Time Delay Device	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Goodrich Corporation Aircraft Interior Products Propulsion Systems Phoenix, AZ 85027**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
Published in the Proceedings of the Forty Second Annual SAFE Association Symposium, Held in the Salt Lake City, Utah, September 27-28, 2004. SAFE Assocation, Post Office Box 130, Creswell, OR 97426-0130. http://www.safeassociation.org, The original document contains color images.

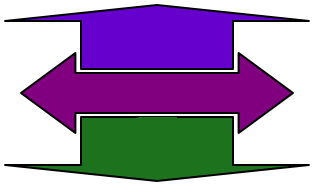
14. ABSTRACT

15. SUBJECT TERMS
Safe

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**19**	

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

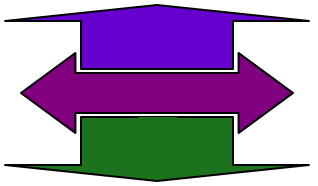
Topics



- Introduction
- History
- Operational Diagram
- Block Diagram Operations
- Proof of Concept
- Specifications
- First Generation Devices
- Integrated Circuitry
- Technology Partnerships
- Next-Generation Device
- Technology Developments
- Advantages
- Envelope Sizes
- Summary

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Introduction

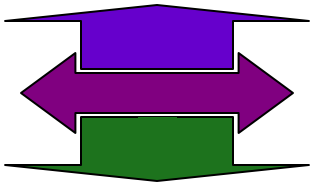


- **What is the digital time delay or DTD?**
  - A new thermo-electric device which can directly replace many existing pyrotechnic time delay cartridges.
  - Requires no external source of power and does not contain batteries.
  - Provides order of magnitude improvement in timing accuracy.

- **How does it operate?**
  - It converts heat energy into electric power using a thermo-electric module.
  - It uses a low power digital micro-controller with a crystal oscillator to accurately measure delay time.

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

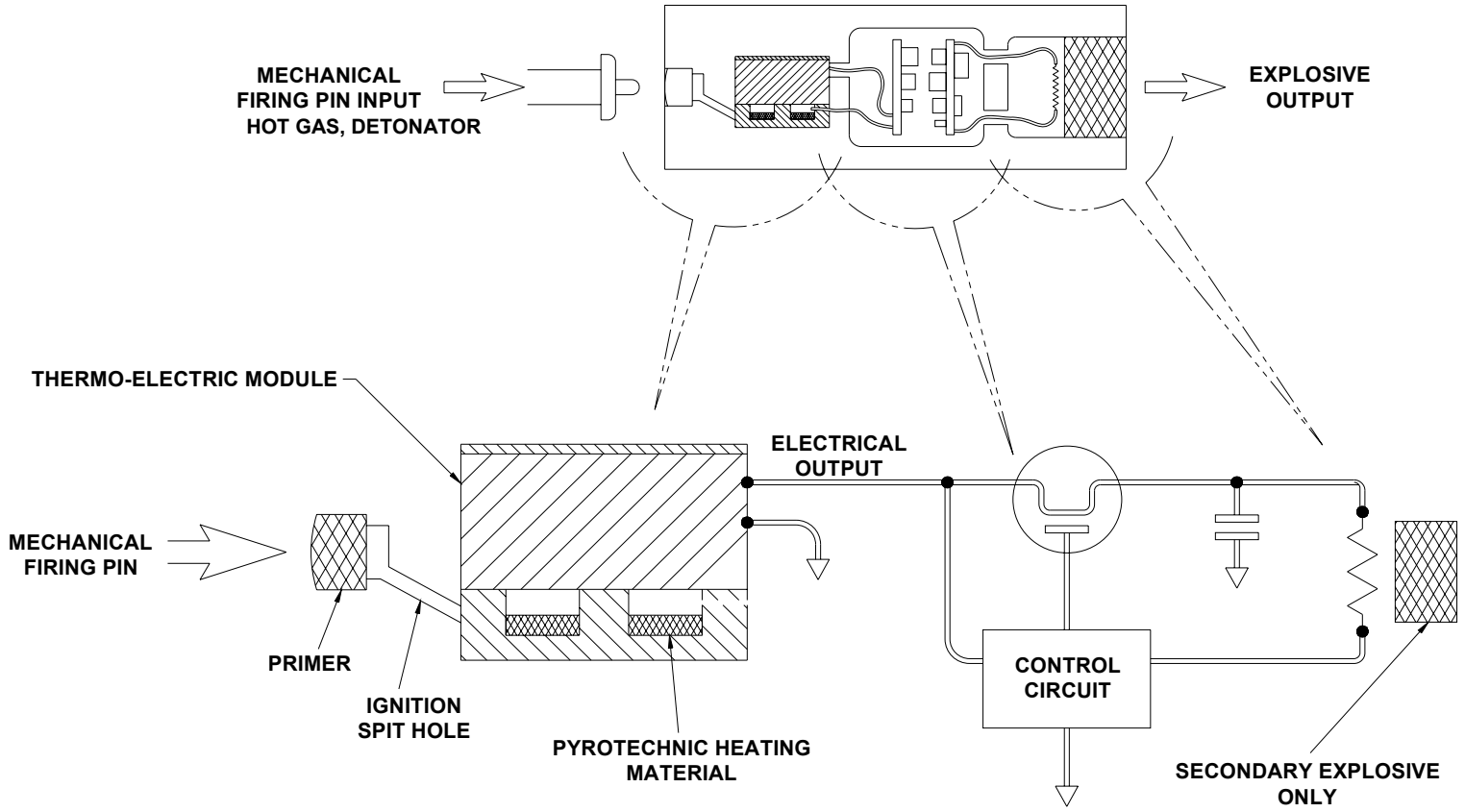
History



- 3,100 different pyrotechnic delay cartridges configuration are now in use by all Services.
- Many of the delay cartridges are man-rated, requiring a high degree of reliability.
- Example: There are 112 CAD/PAD cartidges in the B-2 and 222 CAD/PAD devices in the F-14 aircraft,
- Majority of these devices could be replaced with the Goodrich *Thermo-Electric Digital Time Delay Device.*

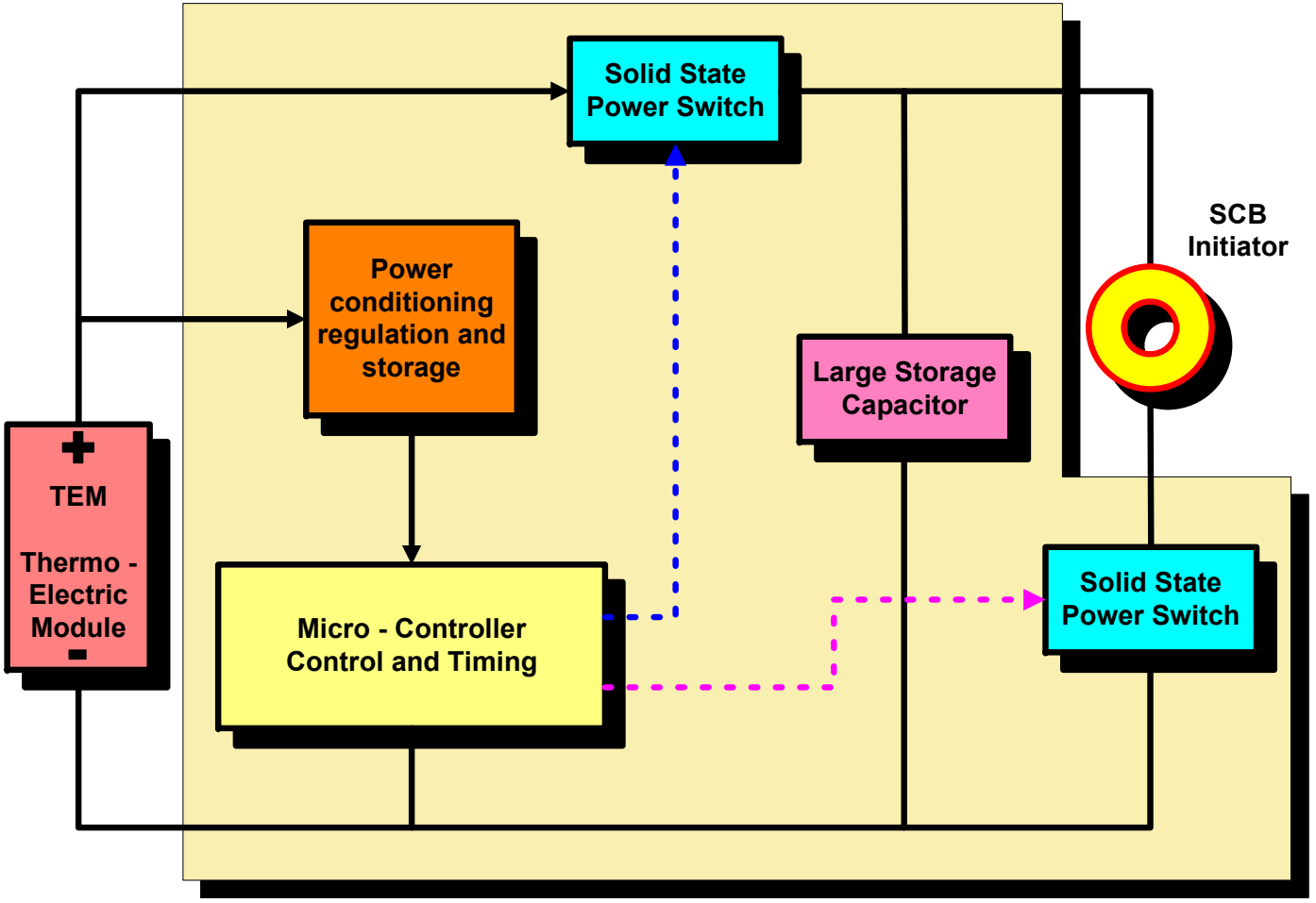
GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Operation Diagram



GOODRICH
Aircraft Interior Products
Propulsion Systems CA

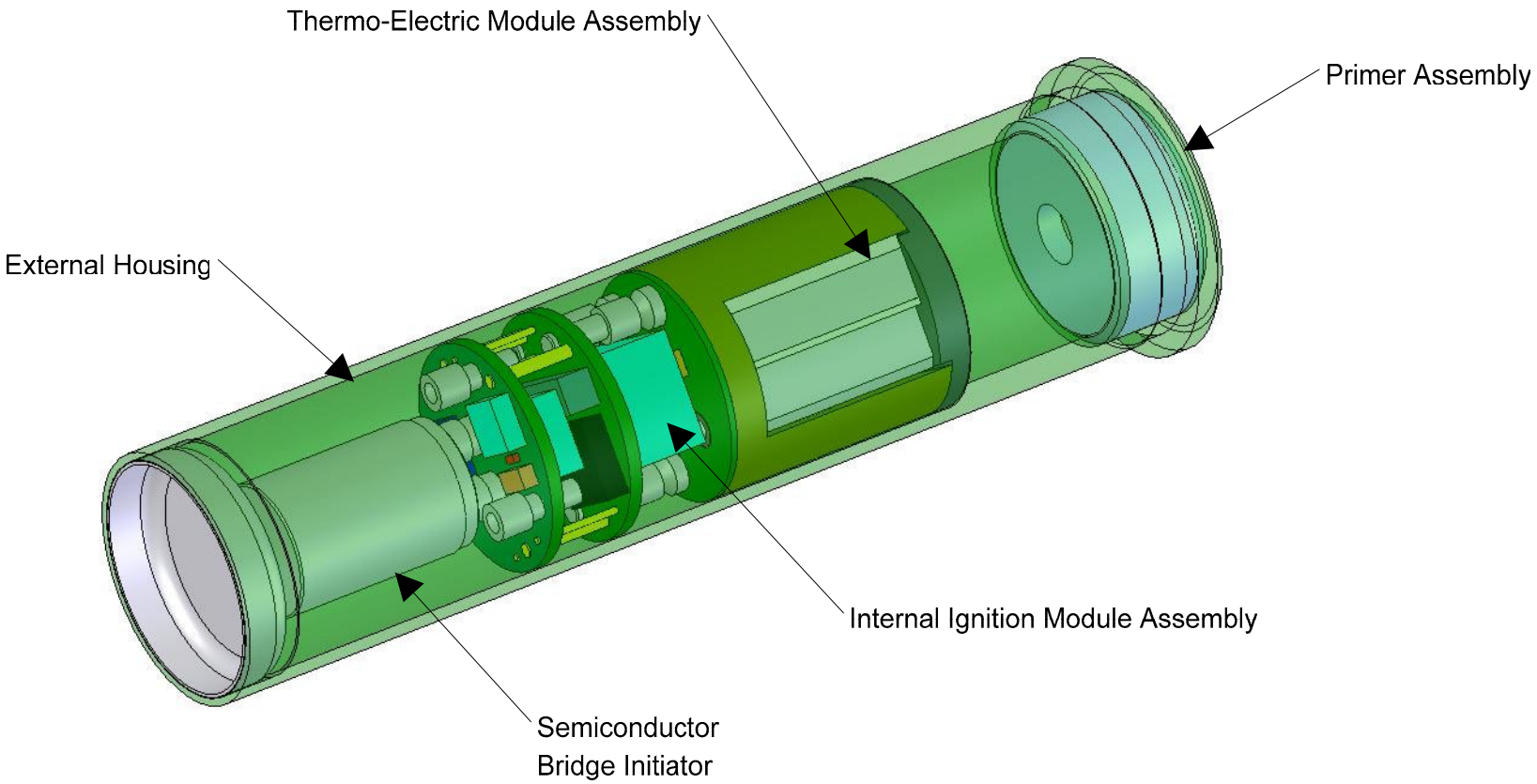
Block Diagram Electronic Module



GOODRICH
Aircraft Interior Products
Propulsion Systems CA

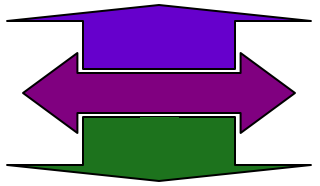
Proof of Concept Overview

First Generation Digital Time Delay
(Size: 1.65 long x .38 diameter)



GOODRICH
Aircraft Interior Products
Propulsion Systems CA

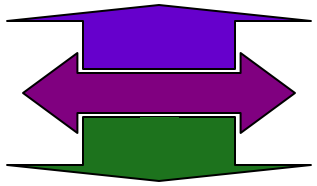
Specifications



Requirement	Status
Timing Accuracy of ±1-4% (Over Temperature)	**Meets or Exceeds (Proven)**
Temperature Range of. -65 °F to +200 °F.	**Meets or Exceeds (Proven)**
Primary Test time 575ms (300ms-1.34sec delay time tested & proven)	**Meets or Exceeds (Proven)**
Standard Aircraft Shock and Vibration Levels.	**TBD**
Minimum 5 Year installed life.	**Hermetically sealed dry pyrotechnics – all materials will exceed 5 year life**

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Proven Technology



First Generation Prototypes operated within a 1%-4% tolerance range.

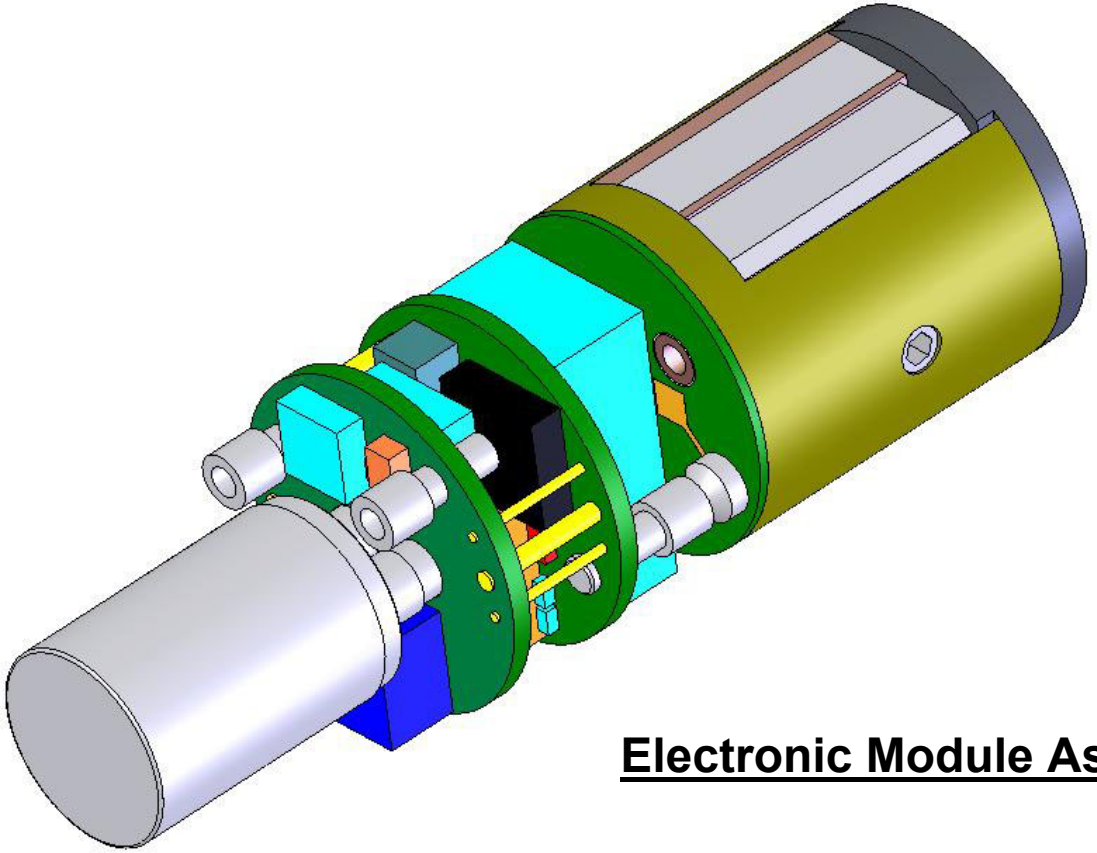
Prototype devices also demonstrated the ease and simplicity to adjust the timing controller to accommodate a variety of delay times.

Proof of Concept (5 firings)		
Unit	Temp	Firing Time Goal 575 (milliseconds) ±2% Range (564ms - 586ms)
1	Cold (-65°F)	568
2	Ambient (80°F)	574
3	Hot (200°F)	578
4	Ambient (80°F)	572
5	x	Atrition

First Generation (20 firings)		
Unit	Temp	Firing Time (milliseconds) ±2% Range (564ms - 586ms)
1	Ambient (80°F)	574
2	Ambient (80°F)	580
3	Ambient (80°F)	600
4	Ambient (80°F)	595
5	Ambient (80°F)	591
6	Hot (200°F)	568
7	Hot (200°F)	569
8	Hot (200°F)	579
9	Hot (200°F)	569
10	Hot (200°F)	571
11	Cold (-65°F)	571
12	Cold (-65°F)	573
13	Cold (-65°F)	571
14	Cold (-65°F)	564
15	Ambient	291 (programmed for 300ms)
16	Ambient	1.32 (Programmed for 1.32sec)
17-20	x	Atrition
		1% tolerance range
		2% tolerance range
		3% tolerance range
		4% tolerance range
		Optional Programmed Times

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

First Generation Device



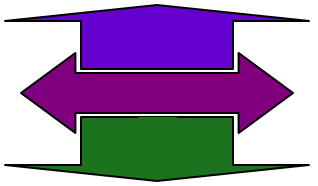
Electronic Module Assembly (EMA)

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

First Generation Electronics

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Next Generation – Integrated Circuitry



The TEM for the Digital Time Delay can either be produced with film technology and/or micro-bulk materials.

Electronic controls will be developed into a single substrate, comprised of advanced thermo-electric materials and imbedded circuitry.

❖***Film TEM***

High thermal conductivity substrates are increasingly important when the size of the module is decreased. It is also critical to have low contact resistances in the metal-semiconductor interfaces.

❖***Thick Film TEM***

Thick film technology is very suitable for large-scale production and has the potential to be very cost effective.

❖***Micro Bulk TEM***

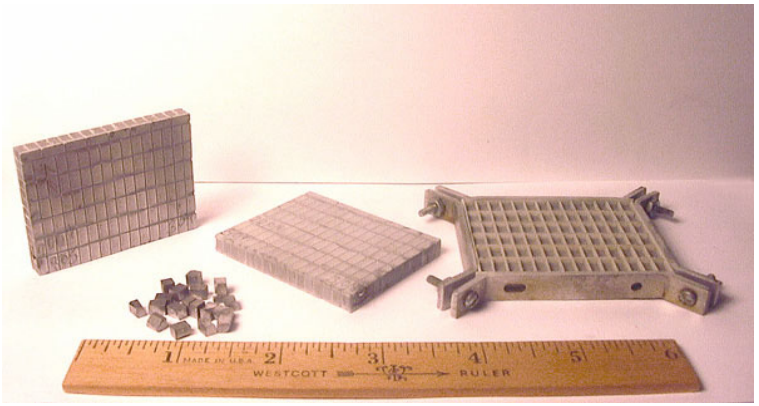
The processes that would be used in the micro-bulk TEM production are used in the semiconductor industry so the production of the TEM has the potential to be very cost effective.

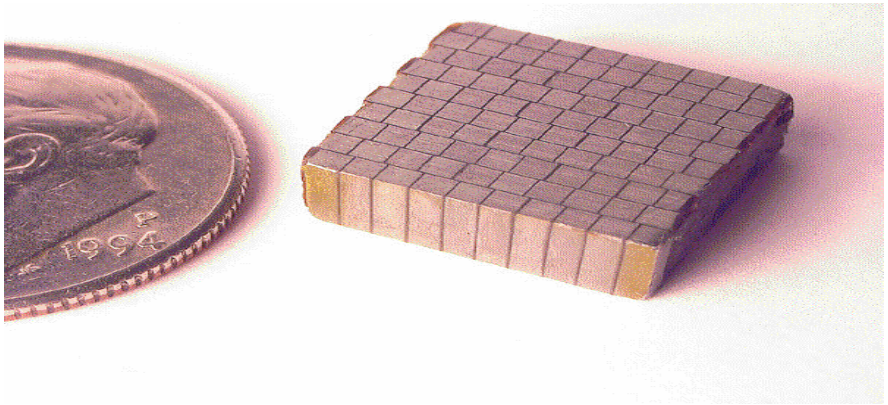
GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Technology Partnerships

Goodrich has also secured a relationship with Industry partners to support the development and prototyping process for the next generation thermo-electric module.

The development parameters for this programs will focus on the development and demonstration of advanced thermoelectric power generators that will deliver higher efficiency and greater reliability.





GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Technology Partnerships

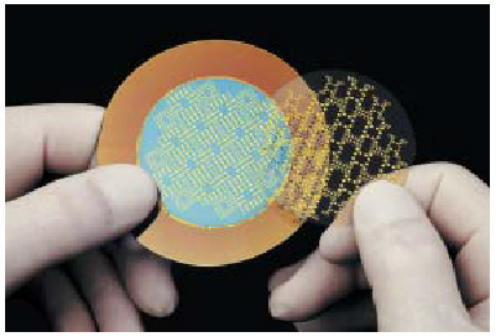
Goodrich has also secured a relationship with a technology developer to support the development and manufacturing process for the next generation thermo-electric materials.

The first significant breakthrough in the field in 40 years is a developed new thermoelectric material that is more than twice as efficient and 23,000 times faster than today's bulk technology which is the existing state of the art material.

High Efficiency

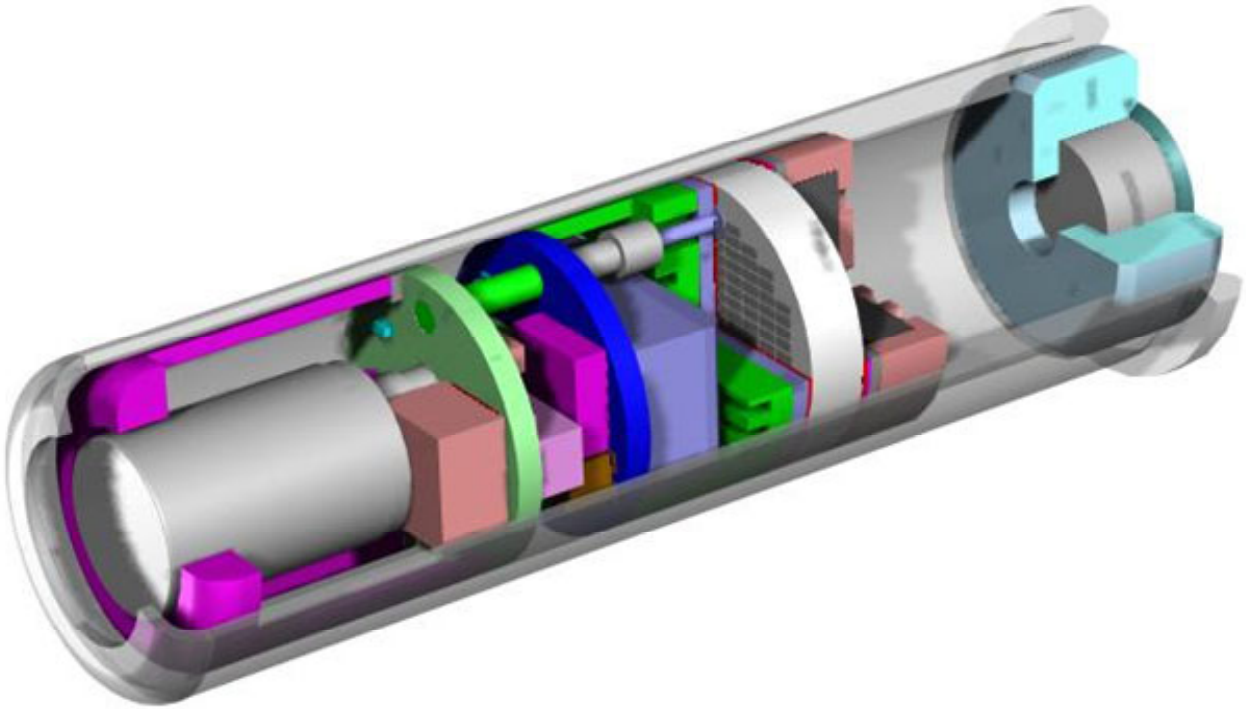
Rapid Temperature Cycling

Space/Weight Premiums



GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Next-Generation Device



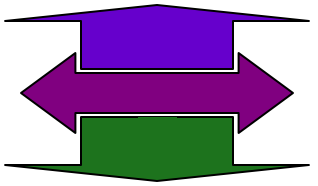
GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Technology Developments

- Goal: to package the technology into a CCU-40 cartridge.
- The CCU-40 cartridge size is .38 in diameter x 1.095 long.
- CCU-40 is the smallest initiator package currently used in the NAVY.
- A circular TEM configuration as show (left) will be used to meet this demand
- The current POC design produced by Goodrich will meet the CCU-35 envelope size.

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Advantages

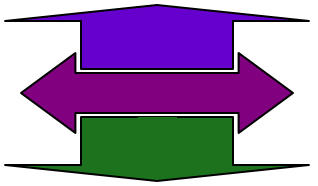


Advantages over current technologies are as follows:

- **Same unit can be programmed for any delay between 0.15 sec to >30 sec**
  - Reduces inventory costs
  - Reduces manufacturing cycle time
- **100% Non-destructive test of time delay components**
- **Removes issues with delay powder column variations, cracks and voids.**
- **Can be configured for other applications:**
  - Field programmable (Manual or electronic)
  - Delay time can be varied based on external stimulus.
  - (I.E. Temperature, pressure, acceleration)

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Envelope Sizes



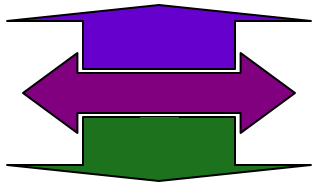
The current design envelope can be easily adapted to many existing fielded delay cartridges.

Examples of current delay cartridge envelope compatibility:

- *CCU-36/A*
- *CCU-38/A (With some modifications)*
- *MU-19*
- *Size reduction Target Envelope: CCU-40A/A*

GOODRICH
Aircraft Interior Products
Propulsion Systems CA

Summary



- A prototype delay cartridge system with less than ±4% timing error over temperature has been demonstrated by the Goodrich Corporation.
- No batteries or external source of power is used.
- Safe, Reliable, Flexible and Long Shelf Life
- Its small physical size allows “drop in replacement” for many existing applications.
- Proof of Concept and First Generation design verification units have already been built, tested and proven the basic concept.
- “Next Generation” cartridge design improvements, size reduction and component cost reduction are now being pursued.
- Same technology can also be used to generate power from other airborne waste heat sources.