Laser Pyro System Standardization and Man Rating

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Agenda

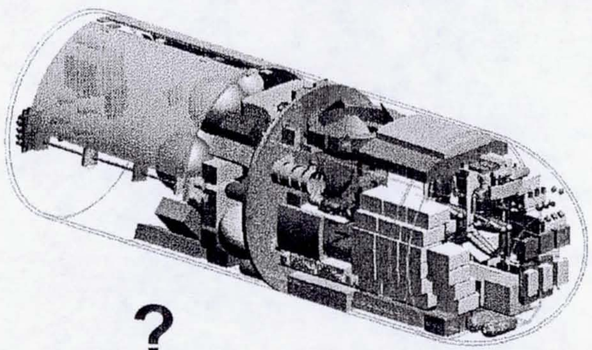
- Objective
- What NASA Johnson Space Center is Doing
- Future Pyro Specification
- Laser Firing System Requirements
- Standardization of Laser Initiators and Detonators
- Qual Plan – Laser Firing System
- Lessons Learned

Objective

- To share ideas on a plan to approve a laser initiation system for man rated vehicles.
- Plans presented will reflect the evolution of the X-38 laser initiation system and beyond.
- The following charts are only ideas and not firm requirements signed off by any program office.

What is NASA Johnson Space Center Doing?

- Preparing for a new manned rated program – Moon … Mars….
- As of now, one concept is called the Crew Exploration Vehicle.
- Other vehicles to complete final objectives are not yet defined.



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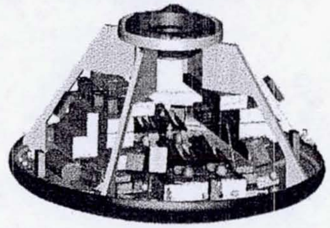

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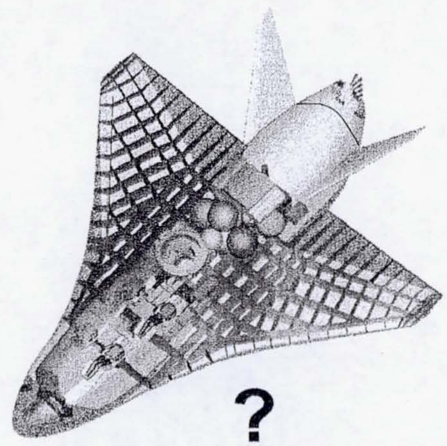

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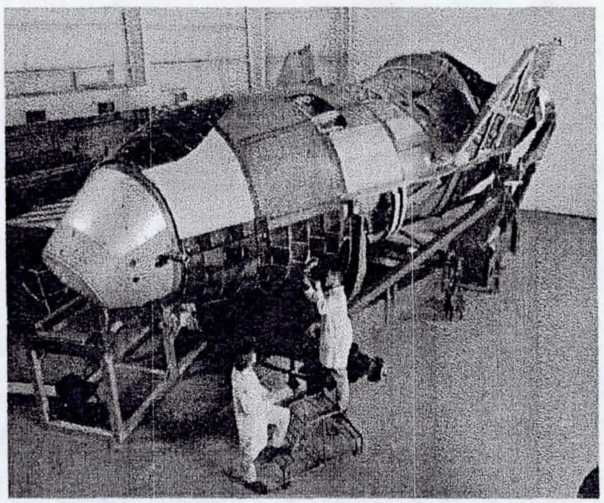
What is NASA Johnson Space Center Doing? (Cont.)

- The X-38 Program has been mothballed.
  - Vehicle V201, demonstration space vehicle, was 85% complete.
  - All vehicles are stored at a JSC and open for display.



Future Pyro Specification

- The NSTS 08060 Space Shuttle System Pyrotechnic Specification was originally established for the Space Shuttle pyrotechnics.
- The 08060 has been applied to other programs such as the X-38 and Orbital Space Plane.
- Work has begun to create a pyro specification for future manned rated space vehicles.
- The new spec will be open to new technology developed after the start of the Shuttle program.
- The new spec will allow for the acceptance of "alternate ignition systems" upon approval of a man rating qualification plan.
- Specifications pertaining a certain vehicle will be developed and follow the guidelines from the upper tier.

Laser Firing System Requirements

System requirements are in 3 parts that are based on the lessons learned and the evolution of the X-38 Program along with other laser initiation experience gathered throughout the 1990's and early 2000's:

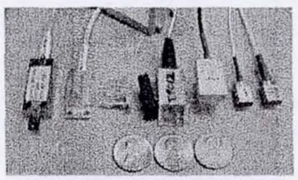
- Firing Unit
- Fiber optic lines
- Initiators/Detonators.

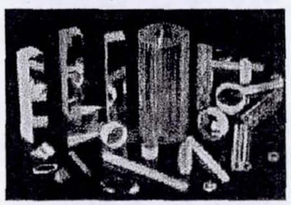
To date, no laser initiation system has been standardized.

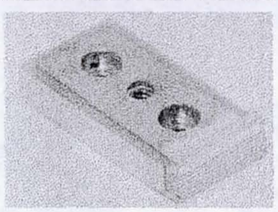
Designs and processes are to be owned by the U.S. Government and have a minimum amount of proprietary information to facilitate the qualification of multiple vendor sources.

Laser Firing System Requirements
Firing Unit

- As technology is being enhanced, the idea of an ideal laser firing unit progresses.
- Unlike the Shuttle's Pyro Initiator Controller, there is not a standard firing unit that has been developed.
- Several sources of laser power exist, and each has pros and cons.



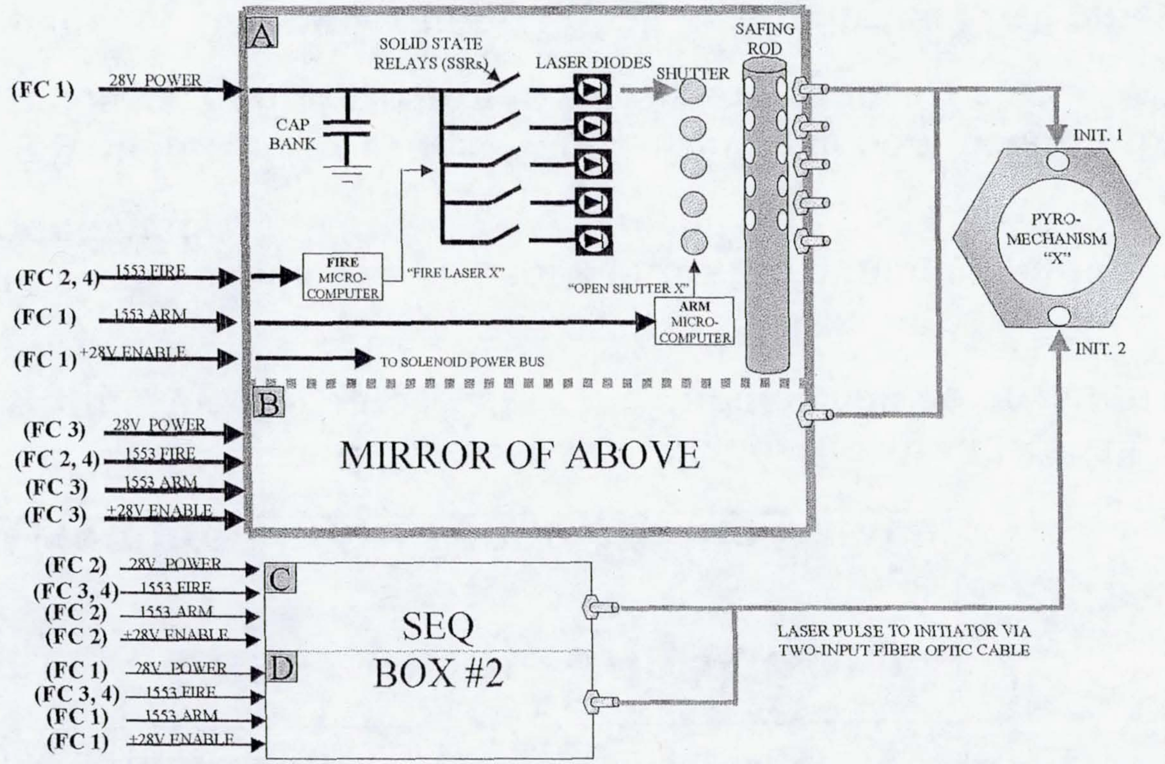




Energy Source	Pros	Cons
Laser Diode w/ Pigtail	• High Power Efficiency	• Single Strand Output • Low Efficiency of Diode/Fiber Interface
Laser Rods	• High Energy Output • Able to energize a Bundle of Fibers • Mechanical Shutter	• Low Power Efficiency • Difficult Optical Alignment • Inconsistant Output
Diode/Bundle	• High Power Efficiency • High Energy Output • Able to Energize a Bundle of Fibers • Mechanical Shutter	• Do They Exist??? • How Much Will They Cost? • Optical Alignment

Laser Firing Unit (Cont.)

Sequencer Block Diagram



Laser Firing Unit (Cont.)

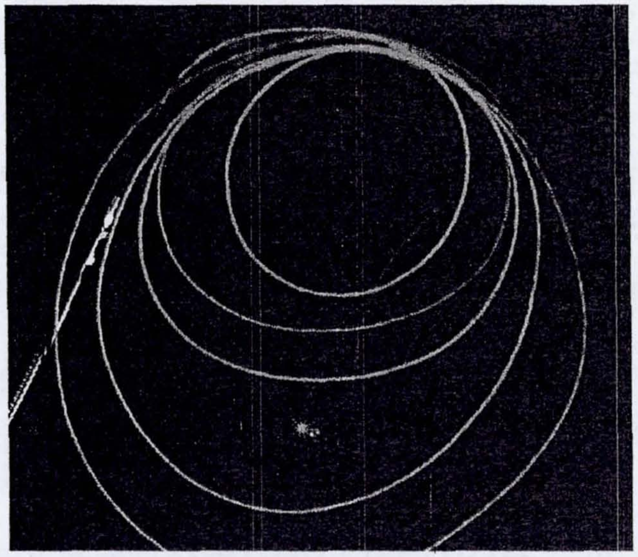
Preferred Requirements. These are the basics:

- A minimum of 6 fiber strands per initiator. Half of the strands shall come from one power source and the other half of the bundle shall be powered from a redundant source i.e.
- Each output strand shall have at least 2 times the minimum all-fire level of the initiator/detonator.
- Post mating built in test for every strand through all connections. Testing availability times vs. inhibit closure to be worked later.
- Three independent inhibits for firing. Shall be monitored at all times. “Pre Arm”, “Arm”, and “Fire”. A computer is considered to be one inhibit.
- Wavelength to fit absorption levels of ignition mix.
- Firing pulse less than 2 ms to avoid fiber tip burning.

Laser Firing System Requirements
Fibers

Fiber optic lines from the firing source to the initiator have been the weakest link, and fiber bundles are no exception.

Incorrect fiber selection and construction can lead to system failure.



Fiber Lines Requirements (Cont.)

•SMA 905 – Pinned or keyed to prevent incorrect connections.

•Fiber Material – Radiation hardened. Low OH – for best wavelength transmission. Core- Pure Silica; Clad – Doped Silica; Buffer – Polyimide.

•Coating – Dry lubricant coating to prevent stress on strands while bending. Material to be vacuum stable.

•Lining – To protect bundle from rubbing on inner jacket wall. Must keep strands loose from rubbing against each other. Material to be vacuum stable.

•Jacket – SST spiral tubing – does not stretch in tension. Metallic strain releases swedged to the SMA's

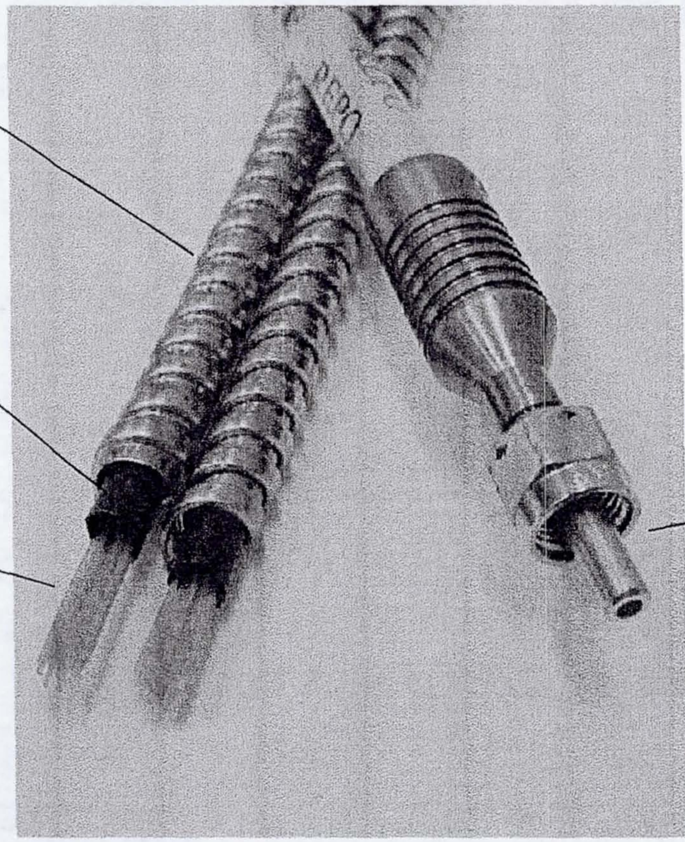
•Epoxy – High temp

•Bend Radius – Two inch radius minimum.

•Temperature limits TBD.

•No Splicing or connectors between firing unit and initiator/detonator.

Fiber Lines Requirement (Cont.)



Standardization of Laser Initiators and Detonators

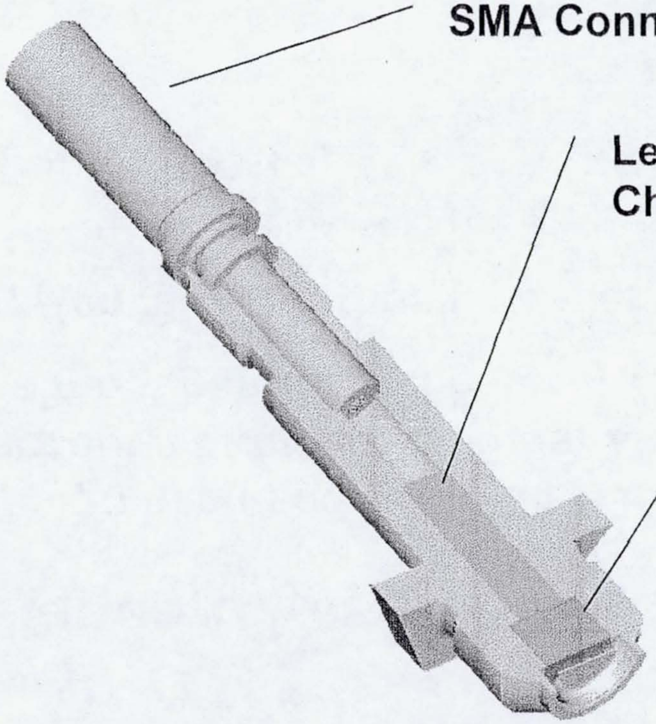
Many laser pyro systems have been developed but none have been narrowed down to a standard.

The Plan:

•NASA to control the design, development, fabrication, and distribution of a standard laser initiator the same way the NASA Standard Initiator is controlled.

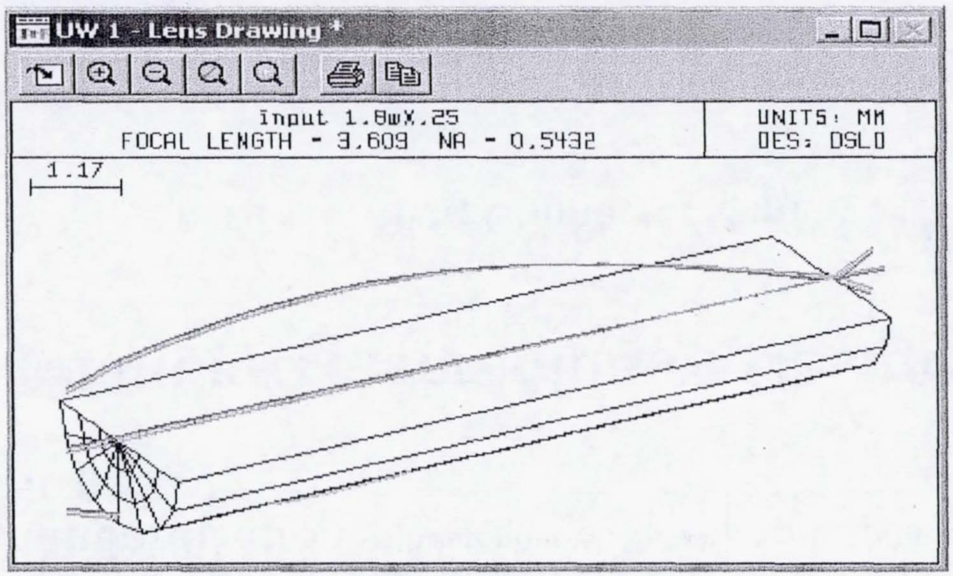
•A standard must have minimal proprietary designs and processes to allow multiple vendors to fabricate.

Standard laser Initiator Design



Standard Laser Initiator Design (Cont.)

- Latest design has used 3 mm dia. GRIN lenses sized over a third pitch to accept a bundle of 19 fiber strands that concentrate the image to almost half the diameter.
- A lens system simpler than GRIN lenses could be considered.



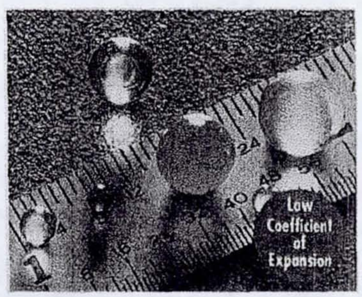
Standard Laser Initiator Design (Cont.)

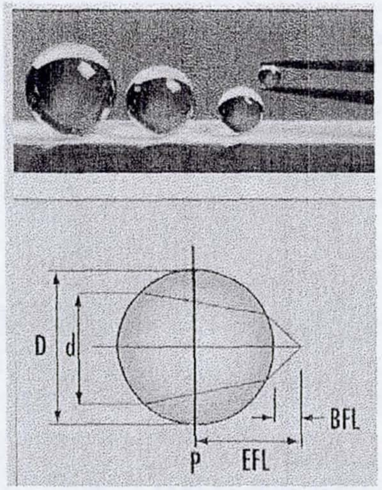
Lenses other that GRIN could be:

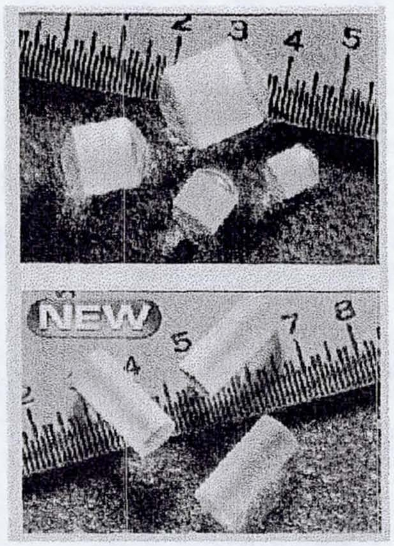
Easier to Produce

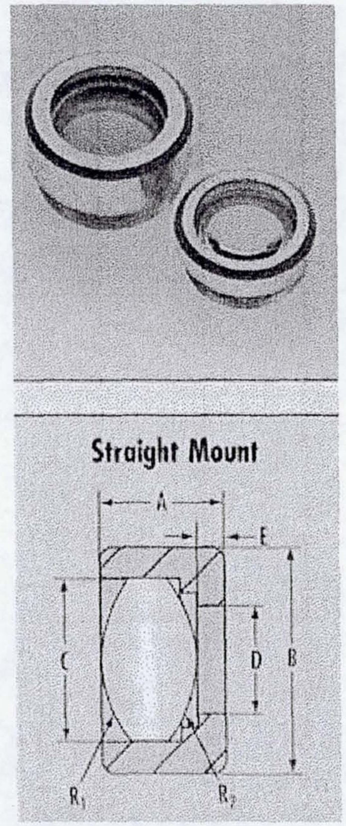
Less Expensive

More Tolerant to Radiation





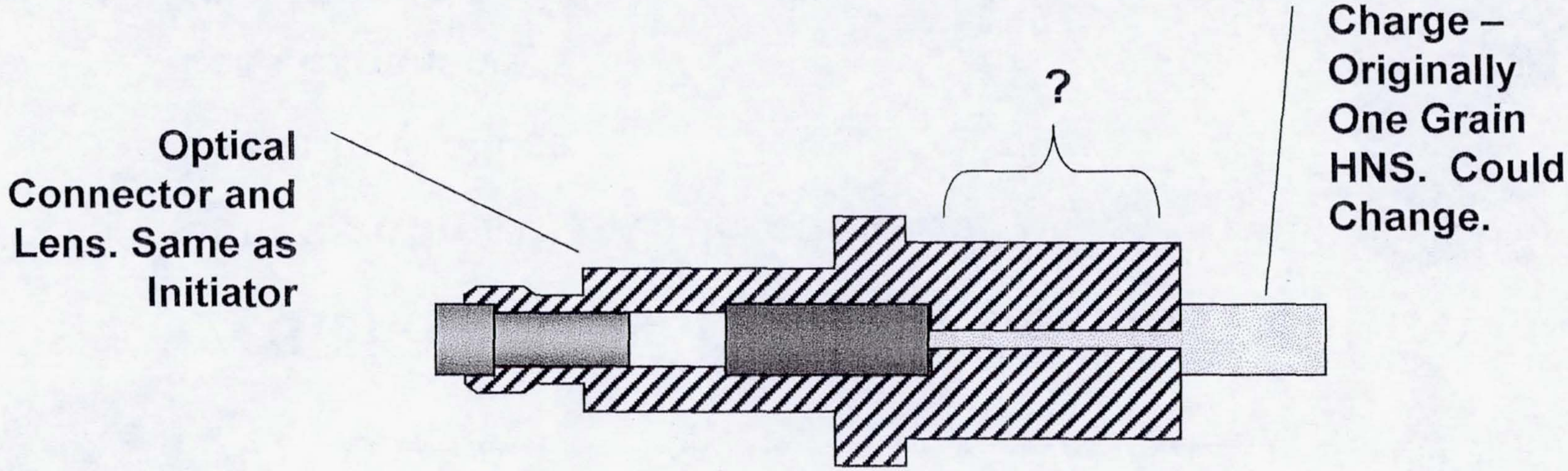




Standard laser Detonator Design

The plan for a standard laser detonator will consist of the same mechanical/optical interface as the initiator and an output tip having the power equivalent to one grain of HNS.

The middle section is to be determined.



Standard Laser Detonator Design (Cont.)

Deflagration to detonation (DDT) area not yet settled

DDT Source	Pros	Cons
BNCP	• Low Sensitivity • Safe to handle	• Proprietary Packing Process • Not available to many vendors • More qual testing required
Lead Azide	• Available to many vendors • Simple packing process • Less qual testing due to similarity.	• Sensitive to Shock • Hazardous to handle
Desired Material	• Low Sensitivity • Safe to handle • Available to many vendors • Simple packing process	• Does is exist? • More qual testing required for unfamiliar mixes.

Qualification Plan

The qual plan for laser initiators and laser detonators will implement the MIL-STD-1576 as a foundation and will be tailored.

Laser initiators and laser detonators will be excluded from electrical tests used for bridge wire initiators; however, other hazards that might come with laser systems will be considered.

Even though laser initiators from other programs have been subjected to considerable testing, a new configuration or design will require full qualification testing.

Sensitivity will follow the latest Likelihood Ratio approach.

Qualification of the System

The system, as a whole, shall be fully qualified at levels meeting or exceeding flight environments.

System tests shall take place after component qualification test – i.e. firing unit, fiber, initiators/detonators.

System tests shall consist of a flight firing unit, fiber lines of the same length routed in a flight like matter, and initiators/detonators (with containment vessels) all in one setup with full functioning to be performed.

Laser Firing System Requirements – Acceptance Tests

- An objective of the NSTS 08060 that will carry on will be the control of traceability and pedigree.
- New processes will be implemented to assure all material, I.e. fiber, lenses, rods, diodes...etc, will be thoroughly checked at the earliest stage before fabrication and assembly.
- These processes will require 100% test and inspection points throughout the assembly process just like Shuttle pyrotechnic devices.

Conclusion

- The evolution of the X-38 laser pyro systems created a large data base of lessons learned.
- Special thanks to Indian Head's and other laser programs for a great deal of knowledge used to create what NASA has baselined today.
- Before having a NASA vehicle with human crew and a laser pyrotechnic system, there is still lots of work to be completed.