Sourcebook on the
Light-Initiated High-Explosives Facility
Sandia National Laboratories,
Albuquerque, New Mexico

Version of 2007-01-29

Additional material for this sourcebook would be welcome. Please send it to thomsona@flash.net

SPACE NUCLEAR POWER, PROPULSION, AND RELATED TECHNOLOGIES

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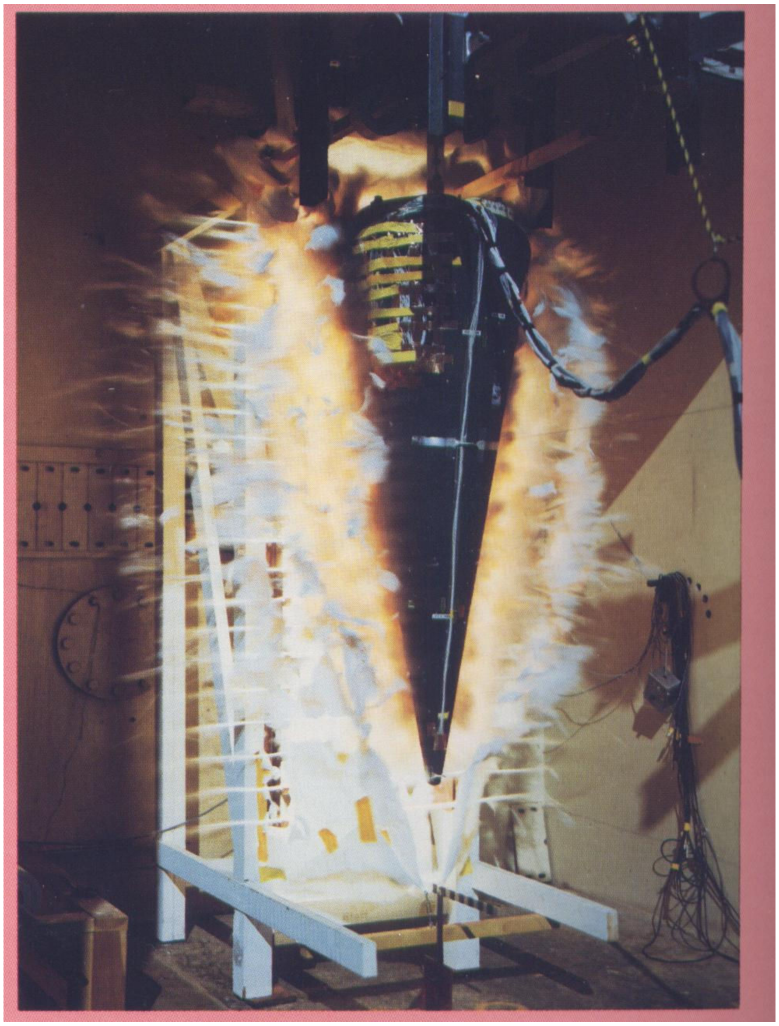
[EXCERPTS]



Remotely sprayed explosive is detonated by a flash of light at Sandia's Light-Initiated High-Explosive (LIHE) Facility

Light-Initiated High-Explosive (LIHE) Test Facility

A technique developed at Sandia permits spraying of explosives onto complex surface shapes and detonating the explosives with a flash of light. The explosive is sprayed with a thickness distribution that is related t the local impulsive load to be simulated. Impulse levels may range from 100 to more than 30,000 taps (1 tap = 0.1 Pa s). Strain, acceleration, displacement, x-ray, high-speed photography, and impulse measurements are obtained.

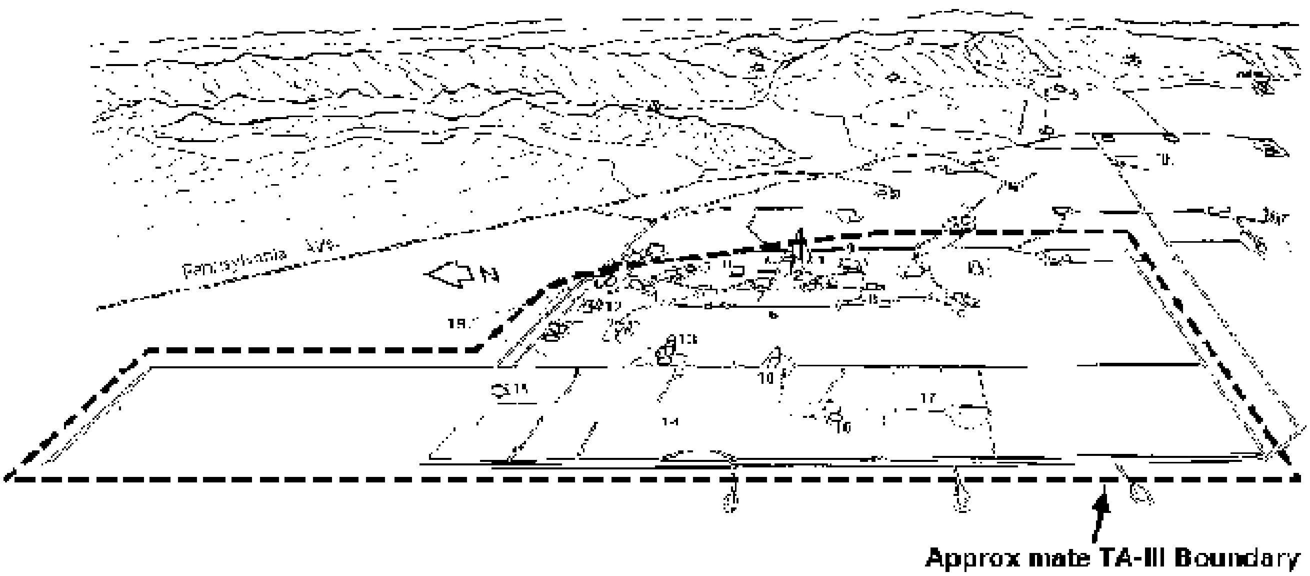
ENVIRONMENTAL ASSESSMENT
OF THE SANDIA NATIONAL LABORATORIES
DESIGN, EVALUATION, and TEST TECHNOLOGY CENTER
at TECHNICAL AREA III
KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

FINAL
U.S. Department of Energy
Albuquerque Operations Office
[EXCERPT]

2. LIGHT-INITIATED HIGH EXPLOSIVE FACILITY

The Light-Initiated High Explosive Facility (LIHE) is shown in Figure 1 as location 12. The LIHE Facility located in Bldg. 6715, is used to prepare and apply a thin coating of silver acetylide-silver nitrate (SASN),which is a sensitive, high-explosive material, to the surfaces of weapons components, subassemblies, and full assemblies. SASN is detonated by an extremely intense flash of light in the test cell area. Explosive force on a test package is measured to evaluate the effect of an external explosion on a weapons system component, a missile, a reentry vehicle, or other space vehicle.

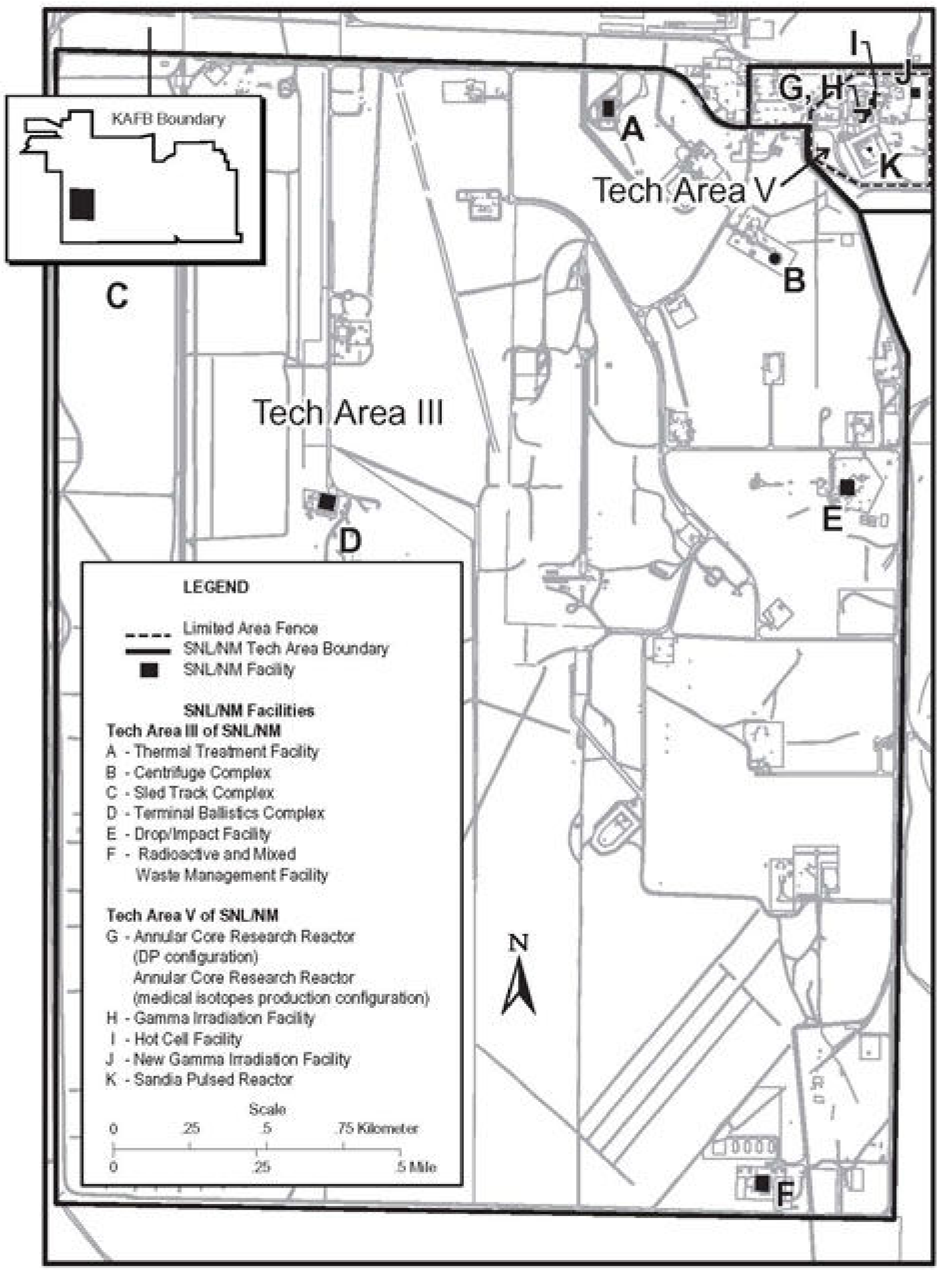
In the LIHE facility, SASN is formulated by remote control and then sprayed onto the test package using a robotic arm. SASN is insensitive when wet, but becomes sensitive to intense light, impacts, or sparks when dry. Test package surfaces are not fragmented by the initiation of the SASN explosive; therefore, the only result of the detonation is a moderate air blast of predictable intensity. These tests are conducted inside the LIHE facility, in a room specially built for this purpose. During a test, there is no fragment or blast hazard outside of the building. The Thermal Treatment Facility, a Resource Conservation and Recovery Act (RCRA)-permitted facility for treating LIHE explosives material, is located at the LIHE. The Thermal Treatment Facility is used at the end of each experiment to clear the facility of SASN explosive materials. Figure 5 is a photograph of an explosives test at the LIHE Facility for a typical reentry weapon.



Key to facilities

1 Drop/Impact Complex (300' Drop Tower)
2 Drop/Impact Complex (185' Drop Tower)
3 Centrifuge Complex
4 Radiant Heat Complex
5 Photometrics Laboratory
6 2,000' Sled Track
7 Vibration/Acoustic Complex
8 Vibration/Acoustic Complex
9 Vibration/Acoustic Complex
10 Radiography Facility
11 Mechanical Shock Complex
12 Light-Initiated High Explosives Facility
13 Force and Pressure Laboratory
14 10,000' Sled Track
15 10,000' Sled Track Control
16 10,000' Sled Track Instrumentation Bunker
17 10,000' Sled Track Impact Area
18 Terminal Ballistics Facility
19 Proposed Locations of the Model Validation and System Certification Test Center

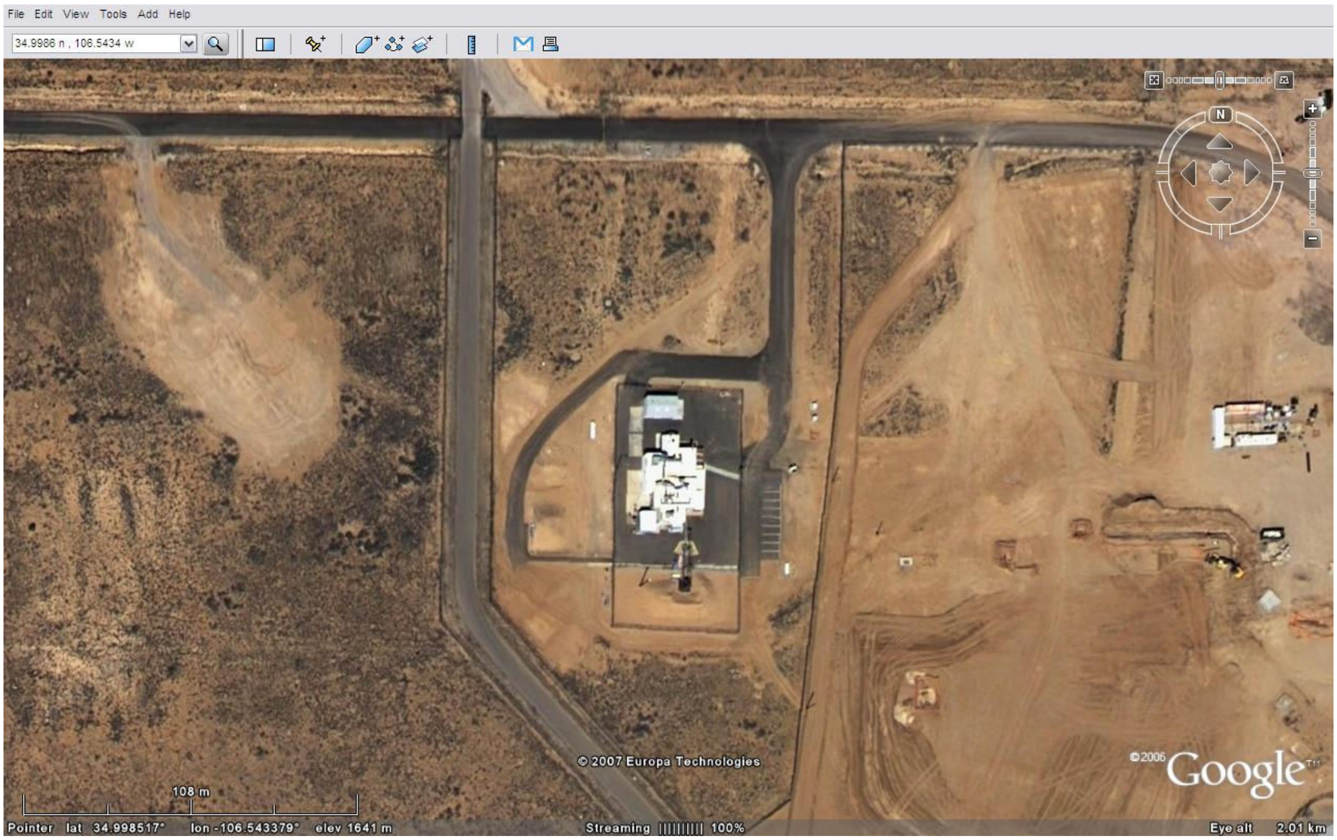
Figure 1



Source: SNL/NM 1997a

Figure 4.3–4. Technical Areas-III and -V

Technical Areas-III and -V are located in the southwest section of KAFB.



LIHE Facility
34.9986 N, 106.5453 W

Application of light-initiated explosive for simulating X-ray blowoff impulse effects on a full scale reentry vehicle

Benham, R. A.; Mathews, F. H.; Higgins, P. B.

Sandia National Labs., Albuquerque, NM.

:
Presented at the 47th Shock and Vibration Symp., Albuquerque, New Mexico, 19 Oct. 1976

Abstract

A lateral impulse test on a full scale reentry vehicle is described which demonstrates that the light-initiated explosive technique can be extended to the lateral loading of very large systems involving load discontinuities. This experiment required the development of a diagnostic method for verifying the applied impulse, and development of a large light source for simultaneously initiating the explosive over the surface of the vehicle. Acceptable comparison between measured strain response and code predictions is obtained. The structural capability and internal response of a vehicle subjected to an X-ray environment were determined from a light-initiated explosive test.

http://www.vxiproducts.com/PR_092203.htm

For Immediate Release
October 28, 2003

Spectral Dynamics Inc., Ships Hybrid, 316-channel Data Acquisition System to Sandia Labs.

San Diego, CA – Spectral Dynamics announced the shipment of a 316-channel data acquisition system. The system was custom designed for the Light Initiated High Explosive (LIHE) facility at Sandia Labs in Albuquerque, New Mexico by Spectral Dynamics' Advanced Research Products Group.

This Spectral Dynamics data acquisition system was tailored to meet the unique LIHE environmental and testing requirements utilizing Spectral Dynamics commercial off the shelf (COTS) Jaguar and VIDAS products supplemented by SD Alliance partner's' (COTS) products'.

"This system is just the beginning of our cutting edge merged technology solutions," stated Mark Remelman, Manager for the Spectral Dynamics' Advanced Research Products Group. "This Hybrid system has 316-channels of data acquisition capability, comprised of 102.4kHz direct to disk acquisition and 2.5MHz, 200Mhz & 500Mhz RAM based capabilities. In addition it incorporates the advanced bridge conditioning and dynamic configuration capabilities offered by Spectral Dynamics' new Smart Interface Panel System (SIPS™)."

After acceptance testing, Tony King, the Instrumentation Engineer facilitating the project for the Sandia LIHE group commented; "The LIHE staff was very impressed with the design, construction, attention to detail and overall performance of the instrumentation system".

This system combines VIDAS, a leading edge fourth generation SD-VXI hardware and field-proven software system from SD's Advanced Research Products Group with SD's Jaguar, a multiple Acquisition Control Peripheral (ACP) system that allows expansion to hundreds of channels without sacrificing signal processing performance. Jaguar incorporates dedicated throughput disks for each ACP providing time streaming to disk at up to the maximum sample rate.

http://www.saviac.org/75th_Symposium/abstracts/U-043.htm

Light Initiated High Explosive Impulse Load Calibration

Mr. W. Gary Rivera, Sandia National Laboratires
[2004]

The Sandia National Laboratories Light Initiated High Explosives (LIHE) Facility, in Albuquerque, New Mexico, has recently undergone a reconstruction and resurrection from mothball status. This new LIHE facility will provide a simulated environment representative of a cold x-ray blowoff impulse generated by an exo-atmospheric hostile nuclear encounter. This above ground simulation generates the proper impulse by initiating a thin layer of a light sensitive primary explosive, spray deposited on the test object. In the past, this facility has conducted numerous full system and component impulse tests for validation and acceptance purposes. The facility is currently being reconstituted to conduct full systems impulse tests for both weapon systems qualifications and computer code validation.

While in operation prior to 1992, an explosive calibration curve had been developed to accurately predict the impulse load delivered by the spray deposited silver acetylide – silver nitrate (SASN) explosive. While procedures for formulation of the SASN explosive remain nearly the same as those in the past, it is desired to understand whether the current explosive product is similar or the same to that produced circa 1992. To achieve this understanding, an explosive calibration test series has been completed using explosive formulated by today’s chemical constituents, processes and procedures, and personnel.

The presented work will detail the current work on a new calibration curve that predicts the impulsive load delivered by a given deposition of SASN explosive.

http://www.sandia.gov/LabNews/LN03-19-04/LA2004/la04/nuclear_story.htm

Sandia Lab News
Vol.56, Special Issue March 2004

Sandia Labs Accomplishments 2004

Nuclear Weapons (including pulsed power and radiation effects)
[EXCERPT]

The Light-Initiated High Explosive (LIHE) Restart project team has successfully completed all of its Phase I milestones: the retraining of personnel; refurbishment of equipment; procurement of state-of-the-art instrumentation and diagnostic systems; and complete renovation of Bldg. 6715. The objective of the project is to reconstitute the Sandia capability that was mothballed in 1992 coincident with the end of the cold war. The main schedule driver for the project is W76-1 qualification testing slated for early 2006. (2500, 10800) http://www.acq.osd.mil/dsb/reports/2005-04-NWE_Report%20_Final.pdf

Report of the Defense Science Board Task Force on Nuclear Weapon Effects Test, Evaluation, and Simulation

April 2005

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

[EXCERPT]

Impulse Simulators

Magnetic Flyer Plates and Light Initiated High Explosive (LIHE) are both methods of simulating the large impulse that X-rays from a nuclear event would introduce into a structure. These are only used for strategic systems where the requirement for nuclear survivability is such that the X-ray environment could cause major structural deformation or damage to the structure.

Flyer plates are the best match for the impulse on the outside of the structure but they are limited in the complexity of the structures that can be matched. There is a DTRA flyer plate facility in Albuquerque. It was in mothballs but resurrected and operated to validate the response of models for the W76 reentry body refurbishment. It is now being put back in mothballs until needed again.

Light initiated explosive tests utilize a thin layer of explosive sprayed on the outside of the structure to be tested. The explosive is initiated simultaneously over the entire surface with a pulse of ultraviolet (UV) light. The spraying technique allows very complex geometries to be tested. This provides a good simulation of shocks transmitted to the internal components of a missile or a reentry system. Sandia is currently reviving its LIHE facility to test the refurbished W76 warhead.

http://www.sandia.gov/LabNews/labs-accomplish/2006/lab_accomplish_2006.pdf

Labs Accomplishments February 2006
[EXCERPT from p. 3]

We have completed a four-year, $10 million project to re-establish the Light Initiated High Explosive (LIHE) facility and test capability at Sandia. Using remotely spray-painted, light-sensitive high-explosive applied directly to a test unit (to simulate an exoatmospheric cold X-ray hostile shock environment) the facility will provide validation data to support the Science Based Engineering & Technology concepts of rigid body mechanics, deformable mechanics, and thermal-structural response. These models will be used in the hostile-environment qualification of nuclear weapons systems. (2500, 2100, 10300, 10800) http://www.ms.northropgrumman.com/PDFs/TRJ/TRJ-2002/SS/02SS_Kendall.pdf

Modeling and Simulation Approach for Reentry Vehicle Aeroshell Structural Assessment
David M. Kendall, Kaz Niemiec, and Richard A. Harrison
TRW Systems, Missile Defense Division
Technology Review Journal · Spring/Summer 2002

[Abstract]

TRW led an Intercontinental Ballistic Missile Prime Integration Contract team in assessing the structural integrity of a reentry vehicle (RV) aeroshell to ensure that Air Force operational requirements would continue to be satisfied after modifications were made to the RV. As a result of the Comprehensive Test Ban Treaty, assessments of RVs necessarily rely significantly on analysis, primarily in the form of computer-based numerical simulations. Accurate structural response simulations of RVs require the integration of analyses from many different engineering disciplines. To have confidence in the simulations, the methodologies and models employed in each of these disciplines must be validated with test data. This paper presents the methods used for the RV aeroshell assessment as a case study to demonstrate how conventional testing methods, data from past nuclear environment simulation tests, and the integration of analyses from several engineering disciplines can be combined to perform high-fidelity simulations of RV responses to critical nuclear environments.

A Modeling and Simulation Approach for Reentry Vehicle Aeroshell Structural Assessment

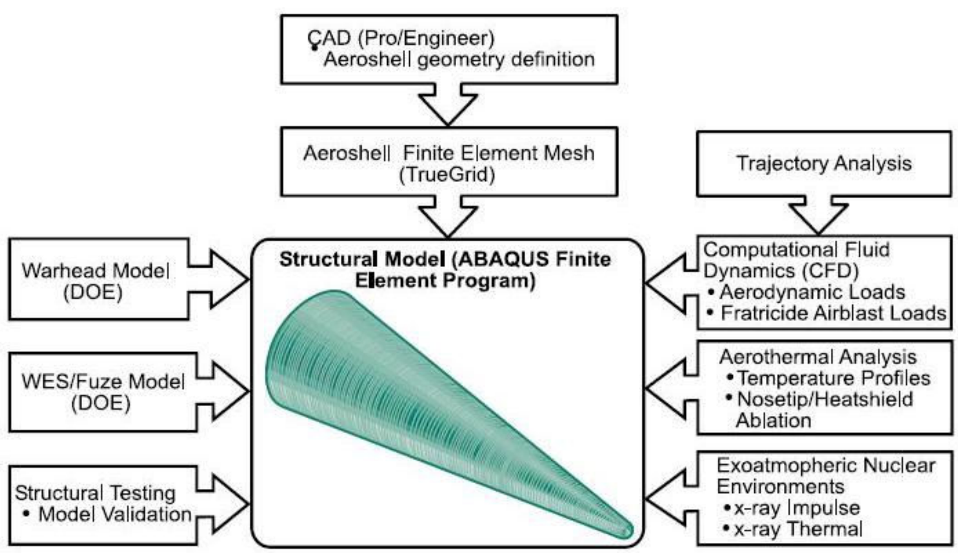


Figure 1. Engineering disciplines

[deletia]

Structural Model Requirements. Before developing the aeroshell structural model, we reviewed aeroshell responses from past tests simulating nuclear environment loadings. In particular, a light-initiated high explosive (LIHE) test performed in the 1980s provided invaluable data for determining requirements for the model. In that test, an explosive material was sprayed on the outer surface of the aeroshell, and detonation was initiated by light. This test imparted an impulse load into the RV representative of an x-ray energy deposition. Several strain gauges were placed on the aeroshell and strain histories were successfully measured. These strain histories were analyzed for frequency content using a Lomb Periodogram.

Figure 3 presents four representative samples from the frequency content analyses—one hoop strain and one axial strain near the forward aeroshell/warhead interface, and one hoop strain and one axial strain near the aft aeroshell/warhead interface. Note that the first peak responses in the axial direction occur at a frequency of about 700 Hz and likely represent a high-order bending mode. The next peak responses occur near the forward support at a frequency of about 3300 Hz. Finally, a peak response in the hoop direction near the aft support occurs at a frequency of about 4100 Hz. Thus, it was determined that the finite element model must be capable of accurately representing structural vibratory modes up to frequencies of at least 4100 Hz. This is a stringent requirement, since finite element models typically do well at capturing lower frequencies and tend to degrade in accuracy for higher frequency responses. A necessary condition for capturing high frequency responses is a refined finite element mesh capable of accurately representing high-order mode shapes.

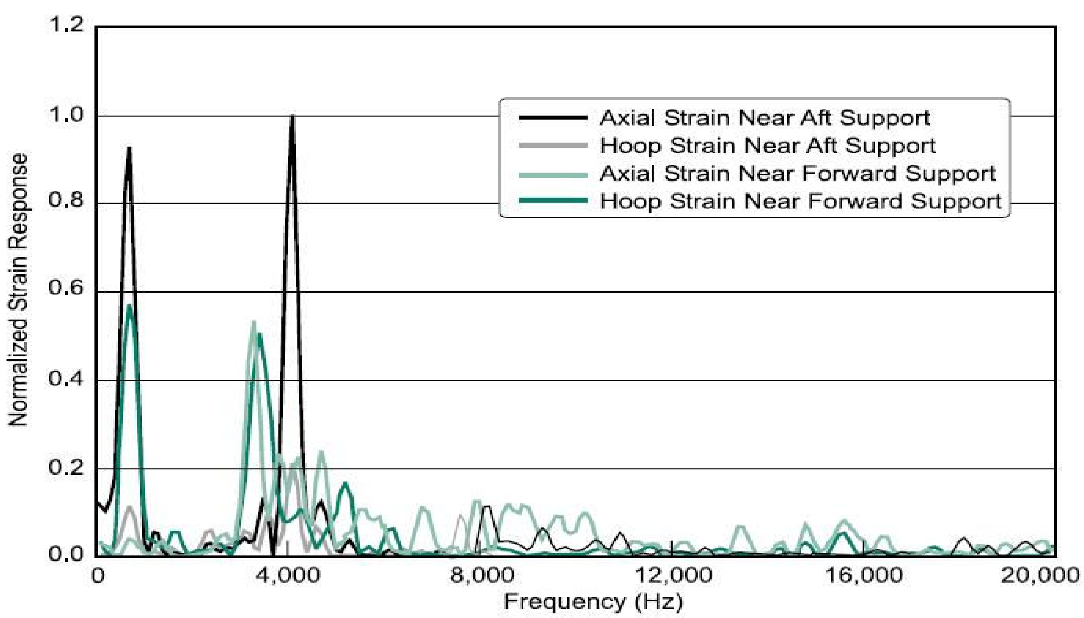


Figure 3. Lomb periodograms of LIHE test strain histories

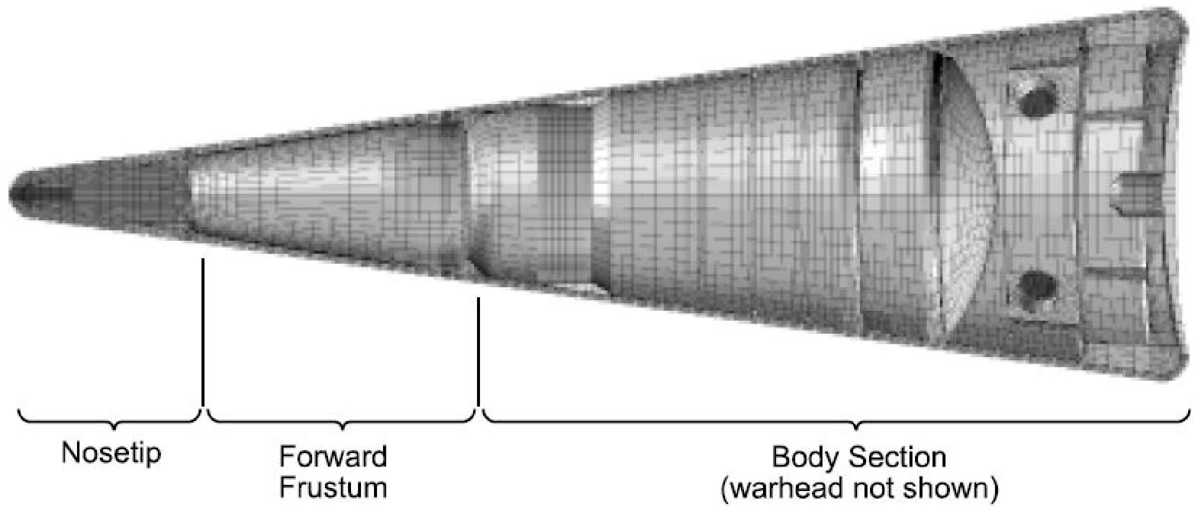


Figure 4. Aeroshell finite element model

http://www.nps.edu/Library/Research/Bibliographies/DEWs/DEWbibTechRptsAB.html

Benham, R.A . "New LIHE (Light Initiated High Explosive) Test Capability for Spherical Targets." Albuquerque, NM: Sandia National Labs., 1987. 2p.
In: Annual SDI Technical Achievements Symposium, Washington, DC, 1 March 1987.

Abstract:

A goal of the Defense Nuclear Agency Lethality and Target Hardening (LTH-3) Program is to assess the lethality of the x-ray laser against the SDI threat entourage of boosters, post-boost vehicles (PBVs), reentry vehicles, and defense suppression weapons (DSWs). A principal characteristic of the effects of the x-ray laser on such threats is the delivery of a cosine distributed impulsive load to exposed curved surfaces of the targets. The LTH-3 program is using test and analysis techniques to investigate the structural response of models of typical targets and target components subjected to impulsive flood loads. A new capability for testing spherical targets using Light Initiated High Explosive (LIHE) is the subject of this paper. Spherical targets are of interest to LTH-3 since vulnerable pressurant, propellant, and chemical reactant storage vessels in PBVs and DSWs are likely to be generally spherical in design.

http://www.nps.edu/Library/Research/Bibliographies/DEWs/DEWbibTechRptsOQ.html

Prantil, V.C. "Response of a Thin Cylindrical Shell Under Lateral Impulse Loads." Albuquerque, NM: Sandia National Labs., March 1988. 78p.

Abstract:

In support of the current directed energy weapons program investigating lethality levels of short pulse width lasers, a combined analytical/experimental program has been underway to predict large deformation response of conceptual ballistic missile designs to impulsive loading. Both unpressurized cylindrical shell models have been analyzed and tested. Such impulsively loaded structures exhibit large scale plastic deformation and local dynamic pulse buckling instability which subsequently influence the loaded surface collapse. Impulse loads were simulated using both lead spray and light initiated high explosive techniques. Finite element calculation using a modified form of the Hughes-Liu shell element verify several characteristics of the structural response observed in experiments. The role of the computational results in identifying lethal impulse levels and response modes is described. In addition, the requirements for initial imperfections and fine mesh discretization for these problems are discussed.

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强度与境
STRUCTURE & ENVIRONMENT ENGINEERING
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强脉冲 X 光射冲量的几模加技

Several Simulation Techniques of Blow-off Impulses by Intense Pulsed Cold X-rays

毛勇建　□宏　何建

摘　要：本文合国内外相文献,□强脉冲 X 光射冲量的片炸加、光敏炸加、柔爆索加、子束加、磁励板加及磁力加等几模技的研究和用情况行了要的介,并要分析和述了各模技的共同点和各自的缺点.

□□□强　脉冲 X 光; □射冲量; 模技
分号：O347.1;O434.14　文献：A
文章号：1006-3919(2003)02-0055-10

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APPENDIX L

FIELD VERIFICATION REPORTSANDIA NATIONAL LABORATORIES, NEW MEXICO

MAY 16-25,1994

Commendable practices identified related to chemical safety at SNIJNM include the following: "just-in-time" procurement system for commonly used chemicals, The Facilities Space Management Program, Deactivation documentation for the Light Initiated High Explosive Facility, The prejob planning process for the Facilities Operations and Maintenance Center,L-5

http://www.eh.doe.gov/docs/chem_vulner/vl3_appo.pdf

APPENDIX O

COMMENDABLE PRACTICES

Documentation Of Facility Dismantling:

The Light Initiated High Explosive Facility at SNUNM was shut down about 2 years ago. After removal of the process equipment, both the equipment and the facility were thoroughly cleaned to remove all traces of explosives. The manner in which the facility was dismantled and cleaned was documented in reports andvideos that demonstrate "before" and "after" conditions and show the techniques used for cleaning. The facility is now in a safe standby mode, awaiting a mission. The extensive documentation of the condition of this facility will provide valuable information to future users of the facility.