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# Los Alamos Studies of Nevada Test Site Facilities for the Testing of Nuclear Rockets

## Nuclear Propulsion Technical Interchange Meeting

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## NASA-Lewis Research Center
## Plum Brook Station

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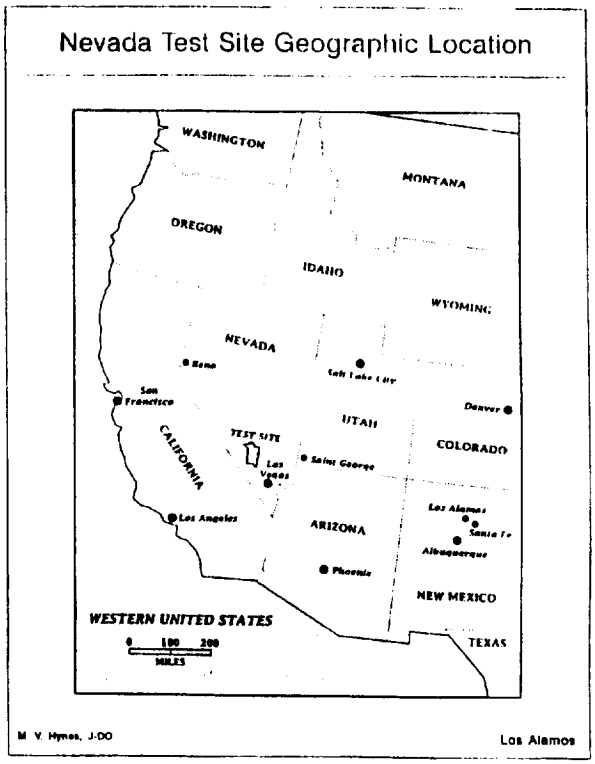
Recent NASA/DOE studies for the Space Exploration Initiative have demonstrated a critical need for the ground-based testing of nuclear rocket engines. Experience in the ROVER/NERVA Program, experience in the Nuclear Weapons Testing Program, and involvement in the new nuclear rocket program has motivated our detailed assessment of the facilities used for the ROVER/NERVA Program and other facilities located at the Nevada Test Site (NTS). The ROVER/NERVA facilities are located in the Nevada Research & Development Area (NRDA) on Jackass Flats at NTS, approximately 85 miles northwest of Las Vegas. To guide our assessment of facilities for an engine testing program we have defined a program goal, scope, and process. In particular we have assumed that the program goal will be to certify a full engine system design as flight test ready. All nuclear and non-nuclear components will be individually certified as ready for such a test at sites remote from the NRDA facilities, the components transported to NRDA, and the engine assembled. We also assume that engines of 25,000-100,000 lb thrust levels will be tested with burn times of 1 hour or longer. After a test, the engine will be disassembled, time critical inspections will be executed, and a selection of components will be transported to remote inspection sites. The majority of the components will be stored for future inspection at Jackass Flats. To execute this program scope and process will require ten facilities. We considered the use of all relevant facilities at NTS including existing and new tunnels as well as the facilities at NRDA. Aside from the facilities located at remote sites and the inter-site transportation system, all of the required facilities are available at NRDA. In particular we have studied the refurbishment of E-MAD, ETS-1, R-MAD, and the interconnecting railroad. The total cost for such a refurbishment we estimate to be about $253M which includes additional contractor fees related to indirect, construction management, profit, contingency, and management reserves. This figure also includes the cost of the required NEPA, safety, and security documentation.


Nevada Test Site Geographic Location
WASHINGTON
MONTANA
OREGON
IDAHO
WYOMING
NEVADA
Reno
Salt Lake City
San Francisco
Denver
UTAH
TEST SITE
COLORADO
CALIFORNIA
Las Vegas
Saint George
Los Alamos
Santa Fe
Los Angeles
ARIZONA
Albuquerque
Phoenix
NEW MEXICO
WESTERN UNITED STATES
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MILES
TEXAS
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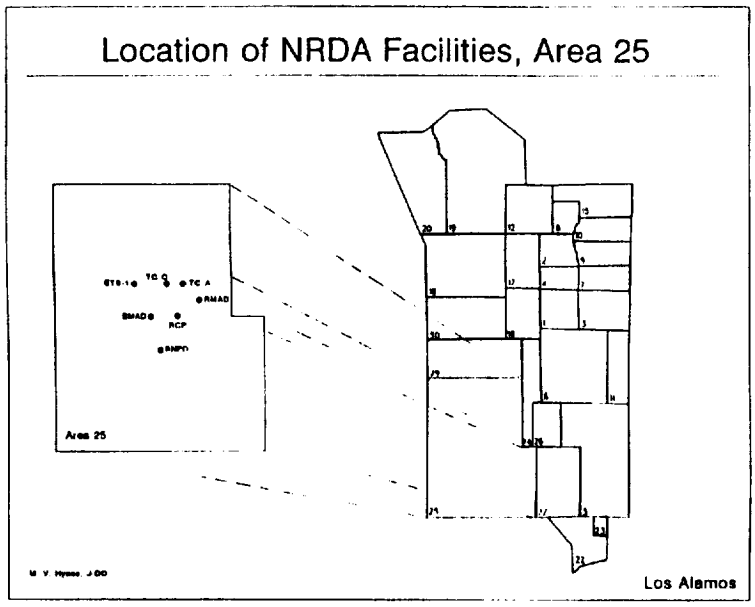
Location of NRDA Facilities, Area 25
TC A
RMAD
RCP
Area 25
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# Assessment Program Plan

- Phase 0: Preliminaries
  - Formal charter from Jay Norman, Field Test Division Leader
  - Notification of N. Aquilina, NVOO
  - Notification of J. Stewart, NTSO
- Phase 1: Testing Program Design
  - Define testing program goal, scope, and process
  - Determine facilities required to execute testing program
- Phase 2: Facilities Overview
  - Survey of all relevant facilities at NTS
  - Existing and new tunnels
  - Vertical bore holes
  - ROVER/NERVA facilities on Jackass Flats
- Phase 3: Facilities Assessment
  - Determination of most cost effective facilities
  - Detailed functional assessment
  - Detailed cost estimating
- Phase 4: Operational Considerations
  - Infrastructure and support facilities
  - Impact on other users of NTS and Area 25
  - NEPA, safety, and security issues

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# Program Goal, Scope, and Process
## The New Nuclear Rocket Program

- Program Goal:
  - Flight Test Certify Design of Full Nuclear Rocket Engine System
- Program Scope:
  - Test fire up to 100,000 LbF Thrust engines for up to 1 hour
  - Testing capability for up to 6 tests annually
- Program Process:
  - Mission profile and flight systems specifications determined.
  - Develop engine system design
  - Develop and certify non-nuclear components at sites remote from Engine Test Stand
  - Develop and certify nuclear components at sites remote from Engine Test Stand
  - Transport all components for full engine system test to Engine Assembly/Disassembly Facility
  - Assemble engine
  - Transport engine to Engine Test Stand Facility
  - Conduct all needed tests
  - Transport engine to Engine Assembly/Disassembly Facility
  - Disassemble engine
  - Conduct time critical inspections
  - Package and ship components to remote inspection sites.
  - Analyze results and determine engine performance.
  - Store engine components for future reference near Assembly/Disassembly Facility.

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# Nuclear Rocket Engine Test Facilities
## Program Goal: Flight Test Certify Full Engine System

| | | |
|---|---|---|
| 1. | Transportation facilities for components | DOT Casks |
| 2. | Non-Nuclear assembly facility | EMAD |
| 3. | Nuclear assembly/disassembly facility | EMAD |
| 4. | Rocket engine test stand facility | ETS-1 |
| 5. | $LH_2/LN_2$ & HP gas storage facility/tank farm | ETS-1 |
| 6. | Transportation facilities between NTS sites | NRDA RR |
| 7. | Time-critical inspection facilities | EMAD |
| 8. | Storage facility for reference components | RMAD |
| 9. | Storage facility for SNM components | EMAD |
| 10. | Transportation facilities between remote inspection sites | DOT Casks |

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# EMAD Facility
## Engine Maintenance, Assembly, and Disassembly Building

- General Description:
  - Built in 1964 for the assembly and preparation of NERVA engines for testing, refurbishment of radioactively hot engines for additional testing, and disassembly and detailed post mortem inspection of tested engines and components.
  - T-Plan multi-storied structure, 280 ft by 350 ft.
  - Divided into 7 separate sections according to specific functions and material traffic flow.
    - Cold assembly area; Hot maintenance and disassembly area; Post mortem cells; High and low level cells; Operating galleries; Shop and service area; Office area
- Functional Capabilities:
  - Cold and hot assembly and disassembly of major engine components and full size engines
  - Assembly line techniques applied due to heavy work load.
  - Special remote operated equipment installed to enable rapid disassembly.
- Cold Assembly Area:
  - Used for receipt and assembly of engines
  - Three major sections all 43 ft high:
    - Core receiving area --- 64 ft by 72 ft
    - Engine receiving area --- 72 ft by 36 ft
    - Cold engine assembly area --- 72 ft by 144 ft
- Hot Maintenance and Disassembly Area:
  - Five major sections all equipped with rectilinear and master-slave manipulators, overhead cranes, specially shielded viewing windows, etc.
    - Main hot bay --- 66 ft by 144 ft by 77 ft high
      5-8 ft thick concrete walls for shielding, rectilinear and master slave manipulators,
    - Core disassembly and examination cell --- 46 ft by 28 ft
    - Engine disassembly and examination cell --- 46 ft by 28 ft
    - Crane maintenance balcony
    - Hot and cold transfer tunnel
- Post Mortem Area.
  - Twelve independently shielded cells with shielded door openings to a common cell service area
  - Each cell equipped with special viewing windows, master slave manipulators, transfer carts, and specialized inspection equipment

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# Summary of Final Assessment Results
## J-Division Review of Nuclear Rocket Facilities at NTS NRDA, Jackass Flats, Nevada

- Determined general program goals, scope, and process for full engine system test.
- Surveyed all possible facilities at NTS for application to program requirements.
  - Tunnels, existing and new
  - Existing ROVER/NERVA facilities
- Determined that existing facilities on Jackass Flats have the most potential for meeting program requirements in a cost driven assessment.
- Cost estimated upgrade of existing facilities for New Nuclear Rocket Program to be about $253M.
  - Richardson and Means Formalism
  - All additional fees included
- Recommend pursuing upgrade of existing facilities out of operating budget with NEPA and Safety Analysis concurrent.
- Estimated time to completion = 3 years.
- Recommend feasibility study of scrubber design alternatives and optimization in FY93.
  - Estimated cost = $350K
- Recommend full conceptual design study in FY93.
  - Estimated cost = $1M

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# ETS-1 Facility
## Engine Test Stand Number 1

- General Description:
  - Built in 1966 for the ground development testing of a downward firing NERVA-type engine in a flight simulated environment.
  - Originally designed for the test of a 50,000 LbF, 1 GW engine with a 300 s run time
  - Upgrade to 75,000 LbF engine not completed.
- Physical Description of ETS-1 Complex:
  - Test stand connected to an underground control point building by a 1150 ft tunnel.
  - Cryogenic dewar and High Pressure gas vessel tank farm
  - Interconnecting process piping
  - Engine compartment radiation shield
  - Diffuser/Ejector exhaust duct
  - 2.5 Mgal demineralized deluge and cooling water storage tank.
  - Cooling water drainage ditch
  - Instrumentation and Controls, general utilities and support systems.
- The Test Stand consists of:
  - 160 ft, 100 ton aluminum structure supporting a 77,000 gal 50 psig LH2 vacuum jacketed run tank, instrumentation and Controls terminations, and an elevator.
  - Below grade pipe chase
  - Exhaust gas duct vault
  - Mechanical and electrical equipment room
  - 3 ft wide by 40 ft high by 100 ft long concrete shadow shield
  - Process piping and distribution system
- The Control Point Building consists of:
  - Underground structure partitioned for control and recording data reduction
  - 2000 channels of data available
  - Above ground equipment room
  - HV & AC capability for all of ETS-1
  - I & C cabling, steam lines, and AC ducts in shielded tunnel

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# Facilities Cost Summary ($M)

| Cost Item | E-MAD | ETS-1 | R-MAD | Railroad | Subtotal |
|---|---|---|---|---|---|
| Basic Facility | 17.574 | 50.930 | 2.473 | 0.624 | 71.601 |
| Indirect | 8.435 | 25.000 | 1.187 | 0.299 | 34.921 |
| Home Office | 6.502 | 22.500 | 0.915 | 0.231 | 30.148 |
| NEPA Documentation | 1.500 | 1.000 | 0.250 | 0.250 | 3.000 |
| Safety Analysis | 2.000 | 4.200 | 0.085 | 0.500 | 6.785 |
| Security Plan | 0.500 | 0.000 | 0.000 | 0.000 | 0.500 |
| Construction Management | 3.576 | 9.800 | 0.503 | 0.127 | 14.006 |
| Inspection | 0.000 | 3.800 | 0.000 | 0.000 | 3.800 |
| Profit | 3.251 | 9.800 | 0.458 | 0.115 | 13.624 |
| Contingency | 5.364 | 51.000 | 1.258 | 0.190 | 57.812 |
| Management Reserve | 3.576 | 13.000 | 0.503 | 0.127 | 17.206 |
| Subtotal | 52.278 | 191.030 | 7.632 | 2.463 | 253.403 |

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