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1 EXECUTIVE SUMMARY

For more than 30 years the Department of Energy (DOE) and its predecessor agencies have conducted research and development aimed at beneficial uses of products derived from its nuclear activities. This program has sought to identify, perfect, and extend the practical use of by-products derived from nuclear fission and other nuclear reactions for both civilian and military applications. Nuclear materials and processes have been used successfully to produce heat, light, electricity, and process food in practical demonstrations. In some instances, it has made some uniquely complex endeavors possible. For example, the heat of decay from radioactive materials has been used to provide a reliable supply of power to operate deep space exploration vehicles for many years. Currently new opportunities have developed which promise to accelerate the application of nuclear by-products to beneficial uses.

A program of Advanced Radiation Technology (ART) has emerged. Management responsibility for this effort has been shifted from the Office of Defence Programs to the Office of Nuclear Energy where it is undergoing a revitalization as a result of the specific guidance and support of Congress.

An important and promising element of radiation technology is the Program for Radioluminescent (RL) development. For years simple RL devices, such as aircraft *exit* signs, have served necessary functions in society. Electrons exciting phosphors and producing light is a fundamental concept to which the layman can immediately relate, while gaining a balanced perspective concerning risk and safety. DOE's RL lighting development program has advanced the technology with infrared RL markers for helipads which are not detectable without the aid of special viewers. These devices were used to aid in the evacuation of wounded from Grenada. Visible RL airfield lighting has been used to promote aviation safety in remote Eskimo communities in Alaska, and non-electric taxiway signs and markers in the corrosive saline soils of Florida airports. The current plan is to consolidate past accomplishments and develop RL devices and systems using advanced technology for new applications.

The potential for improved performance that solid-matrix RL techniques offer has stimulated interest in a variety of innovative applications for which electric lighting has long been the only practical alternative. The program described in this document is intended to provide for an optimum development and application of RL technology while supporting the transfer of this technology to the private sector and providing an institutional perspective from which the longer range applications and ramifications of this technology can be anticipated.

2 INTRODUCTION

2.1 RL TECHNOLOGY

In this document the acronym RL refers to the physical phenomenon of radioluminescence, which is defined below.

> **Radioluminescence: The process by which light is emitted from a material at relatively low temperature where the material has been excited by energy resulting from a radiological decay.**

RL occurs naturally in the environment, as in the Aurora Borealis. It also occurs in some materials when it's exposed to emanations from radioactive materials. This property has been used for many years in instrumentation to detect and measure the level of activity present in radioactive materials. More recently the RL effect has been employed for area lighting. The program is mainly concerned with exploiting this latter application.

To date most RL devices for area lighting applications have used an electron emitting isotope (tritium) to excite a phosphor coating on the inside of a glass tube. This is usually referred to as gas-tube technology and has had commercial application for over twenty years. Advanced applications of gas tube technology have been the focus of the DOE RL program thus far. Successful applications have been in aviation lighting and signage for both military and civilian applications. It is assumed that significant technological advances can be achieved that will greatly increase the applicability of RL technology.

Using existing gas-tube technology the overall energy conversion efficiency from energetic electron to visible photon is between 1% and 5%; there are some mechanical limitations as well. Radioactive tritium gas is safely contained by relatively few materials and in the typical device a glass tube has been the only practical alternative. If a method could be found to increase the overall efficiency and at the same time develop more mechanically convenient packaging, a vast range of new applications would be open to RL technology. It is the intent of this program to vigorously pursue the concepts leading to this objective.

Calculations have indicated that chemically binding tritium in a solid matrix under correct conditions could yield an RL source with at least the equivalent conversion efficiency of gas-tubes. Hydride or carbon polymer based tritium confinement opens up new possibilities for packaging by increasing stability. Polycarbonate sheets bearing RL lights brighter than gas-tubes, and only a millimeter thick may be possible. This approach will be referred to as solid matrix technology.

2.2 PURPOSE

This program description is intended to define the RL research and development activities under the sponsorship of DOE and other cooperating agencies and organizations within DOD. It also serves as an informational document for DOE management, program sponsors, other program participants and interested parties. It is anticipated that this document will be revised periodically as the program evolves.

2.3 SCOPE

The DOE RL research and development program encompasses research, development, dissemination, and implementation of RL technology. The program is especially concerned with RL technology and its application where radioactive materials contained in devices and systems have originated within DOE sponsored programs. The life cycle of these materials, including their safe use and disposal will be the subject of special attention. This description provides a comprehensive support structure for all aspects of the program and will address both the physical/technical and social/institutional issues.

2.4 AUTHORITY

The authority for this program was initially provided by Congress prior to 1984 and recently reaffirmed in the Conference report on Continuing Resolution (H. J. Res. 738, Senate Report 99-441, Page 103) approved the 99th Congress on October 18, 1986.

The Department of Energy, Nuclear Energy, Office of Remedial Action and Waste Technology (NE-24) has been assigned the responsibility to conduct the RL program as an adjunct to the Advanced Radiation Technology Program. Program responsibility is addressed in a memorandum of understanding between NE-24 and DP-12.

2.5 CONTENTS

This program description contains eight sections which provide the operating guidelines for the conduct of the RL program within DOE.

3 GOALS & STRUCTURE

3.1 GOALS

The RL program has three fundamental goals:

- o To improve significantly RL lighting technology for civilian and military applications.
- o To stimulate an emerging RL lighting industry by technology transfer.
- o To develop a stable institutional base that will meet the long term needs of the RL lighting industry.

3.2 PROGRAM ELEMENTS

Within the context of the program goals there are four structural program elements. These are:

MANAGEMENT: To develop and implement a comprehensive RL Program management structure within DOE that will coordinate existing activities and focus research and development efforts on significant new applications.

RESEARCH AND DEVELOPMENT: To formulate and direct the research and development activities of the RL Program in support of the goals of the program.

DEMONSTRATION, TEST, AND EVALUATION: To conduct test, demonstration, and evaluation activities to prove the performance and safety of newly developed RL lighting concepts and systems.

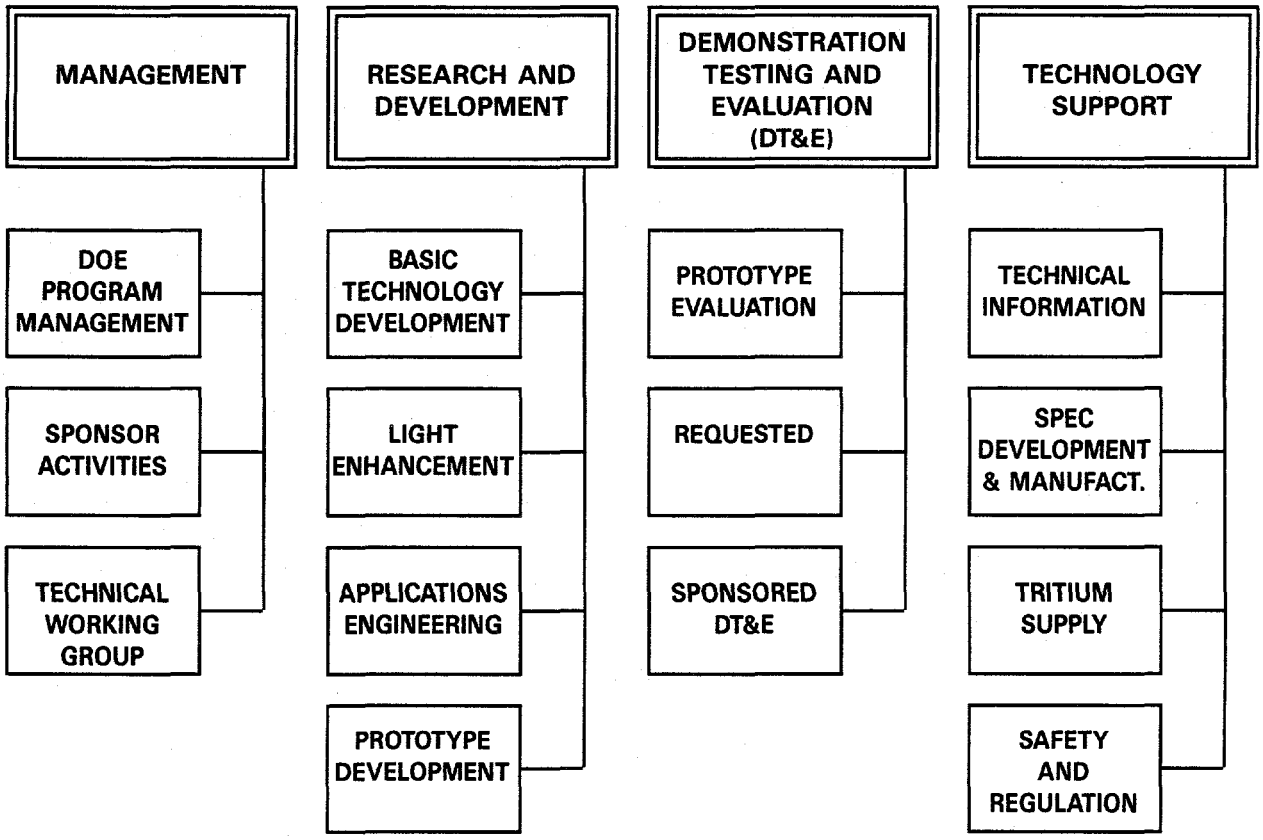
TECHNOLOGY SUPPORT: To develop and implement a comprehensive RL technology support program that addresses the health and safety, institutional, technological and environmental considerations associated with the various applications for RL lighting systems.

4 ACTIVITIES

4.1 GENERAL

Attached to each of the four program elements described above are a number of activities required to implement the RL Program. While the goals and program elements are not expected to change significantly, the activities can be expected to change as the program develops. Program structure is presented as Figure 4.1. The activities are briefly described in the following sections. From these activities, a specific work plan will be formulated annually.

FIGURE 4.1



4.2 ACTIVITY DESCRIPTIONS

4.2.1 DOE PROGRAM MANAGEMENT

Active DOE program management at the headquarters level is necessary to achieve the goals and objectives of the program.

DOE has provided complete program management staffing at DOE Headquarters. Details of DOE's management plan are addressed under Section 6, Implementation.

4.2.2 SPONSOR PARTICIPATION

In the past outside sponsors have contributed to the program in a number of ways. They have provided funding, technical expertise, logistics support, and other assistance without which this program would not be possible. It is anticipated that interaction with sponsors at the management level will continue to be an activity crucial to this program. Section 5.2.3, RL Sponsors, provides additional detail.

4.2.3 TECHNICAL WORKING GROUP

The Technical Working Group (TWG) will support the program management activity and will bring together the diverse interests of RL program participants. Additional information concerning the TWG is contained in Section 6.4.

4.2.4 BASIC TECHNOLOGY DEVELOPMENT

This activity includes all R&D to ensure safety, reliability and improved energy conversion efficiency of the RL process. Investigations will include phosphors, solid-matrix RL technology and enhanced gas-tube technology.

4.2.5 LIGHT ENHANCEMENT

This activity includes all R&D work directed toward improving the optical performance of RL devices and systems. Light sources employing gas-tube, solid-matrix and other concepts will be investigated to strive for more efficient light production and improved transmission of light to an intended use. Lenses, reflectors, light pipes, and other optical enhancements will be examined under this activity. Underlying consideration for all applications will be a careful attention to health and safety considerations.

4.2.6 APPLICATIONS ENGINEERING

This activity consists of matching basic RL light sources to practical applications. Under the program specific emphasis will be placed on design to assure all foreseeable engineering criteria have been addressed prior to prototype development and field testing.

4.2.7 PROTOTYPE DEVELOPMENT

When an application for an RL device or system has been identified and prototypical demonstration is desirable to assess the capabilities, an effort will be made to conduct the work in cooperation with the RL industry.

4.2.8 PROTOTYPE EVALUATION

When a prototype RL device or system has been developed and built to serve a specific application, thorough testing under operational conditions will be conducted. This activity will normally precede production of a large number of units.

4.2.9 REQUESTED DEMONSTRATION TEST & EVALUATION

When prototypes are available in sufficient quantity and quality to support a field demonstration, test, or evaluation (DT&E) requests for such testing will be considered. Normally such DT&E would be of short-term duration. In addition a prerequisite of the DT&E will require that:

- o Adequate funds are available to support the activity and,
- o It would be of mutual benefit to the user and the program.

While this activity is expected to continue under the program there will be an attempt to minimize such DT&E activities in the field by substituting other forms of presentation using video, photographic, graphic, or written material.

4.2.10 SPONSORED DEMONSTRATION TEST & EVALUATION

Requests for a test, evaluation, or demonstration of a RL prototype system which would require a substantial commitment of program resources or the manufacture of additional devices or systems will not generally be considered unless they are specifically programed as part of the RL Program or unless sponsorship is available. In general, it shall be the practice to request sponsorship for efforts of this type. Sponsorship may

consist of organizational support with sponsor assets and/or direct monetary funding of all or part of the DT&E effort.

4.2.11 TECHNICAL INFORMATION

The development of technical material concerning RL technology and its applications will be a major activity of this program. Information will be prepared using a variety of media, in a form suitable for a variety of audiences. Examples of this activity include:

- o Academic papers and journal articles;
- o Engineering papers and articles;
- o Technology transfer seminars and workshops;
- o Educational materials for users, and
- o Educational materials for the public.

4.2.12 SPECIFICATIONS DEVELOPMENT & MANUFACTURING

Under this activity the conditions necessary for the safe and responsible growth of the RL industry will be established. As part of this element, the DOE RL Program will assure that new and improved RL technology and applications are properly utilized by manufacturers and users. Issues considered under this program may include:

- o Development of procurement specifications to assist users in the selection of RL products.
- o Development of testing procedures for the RL industry, users, and regulatory agencies.
- o Development of Quality Control and Quality Assurance procedures for the manufacture of RL products.
- o Development, testing, and evaluation of manufacturing processes under controlled conditions.

4.2.13 TRITIUM CYCLE

This activity is primarily institutional in nature. Work will address the policies of the various organizations which may have impact on the RL program and the present and future use of RL technology. Issues to be considered under this activity may include:

- o The present and future sources of tritium.
- o Price stability and availability of isotopes.

- o Recycling RL products at the end of useful life and,

- o The disposal of RL products past the end of useful life, especially large-source products and systems such as airport lights.

4.2.14 REGULATION AND SAFETY

As large-source RL products become dispersed throughout the environment and as new and perhaps complex RL technologies and applications emerge (many as the result of this program) it will be necessary to interface with the NRC and perhaps other regulatory agencies with regard to the impact of RL technology on public health and safety. Technical assistance may be necessary to substantiate a valid test for licensing of a particular product or, assess health physics. Other issues in this area could include safety response capability, a safety training course for major users of RL products, or assistance to state, local, or military radiological control personnel.

Since DOE is currently the source of most isotopic material currently employed in RL devices, and because it appears this condition will continue for the foreseeable future, a vigorous health and safety activity will be a high priority of the DOE RL Program.

5 ORGANIZATION

The functional relationships among the entities involved in implementing the program are shown in Figure. 5.1.

RL PROGRAM ORGANIZATIONAL CHART

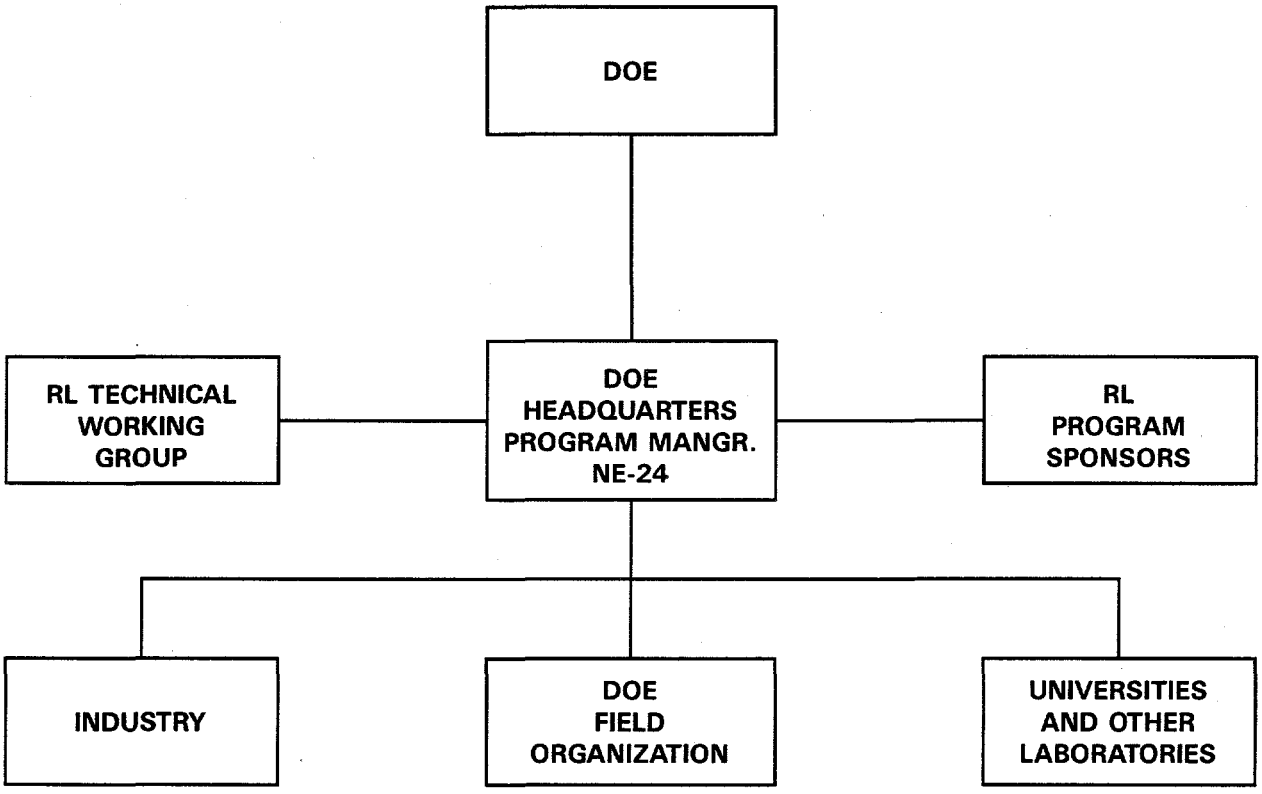


FIGURE 5.1

Each of the organizational entities is briefly described in the following section. DOE will coordinate and manage at the headquarters level. The TWG and Program Sponsors provide program resources and guidance to the Program Manager. The Program Manager pursues the objectives of the program through assignment of work consistent with the program elements shown in Figure 4.1.

6 FUNCTIONAL DESCRIPTIONS

6.1 DOE

DOE is responsible for the direction of this program under the DOE organizational structure. The DOE Headquarters Office of Remedial Action and Waste Technology, by the authority described in section 2.4, is responsible for interpretation and modification of this program. A program manager from this office will implement the program consistent with this document.

6.2 DOE HEADQUARTERS PROGRAM MANAGER

All management functions required to implement this program will be the responsibility of the DOE headquarters program manager. Specific examples of the DOE headquarters program manager's responsibilities are:

- Act as the primary interface with program sponsors.
- Interface with DOE management on program matters.
- Modify as appropriate from time to time, this program document and prepare the additional documents necessary to implement and plan program activities.
- Manage and direct program resources.
- Assign and coordinate program activities among program participants.

6.3 PROGRAM SPONSORS

Sponsors external to DOE have been a major part of the RL Program and are encouraged to take a decisive role in the future. Currently various State and Federal agencies are active program sponsors contributing various resources including substantial funding. DOE has a fundamental obligation to support the needs of these sponsors. As financial contributors, pooling resources with a federal agency they must receive special consideration and quite correctly expect to share in management decisions which may affect the fulfillment of their specific missions. To accommodate this, two options are open to sponsors under this program. The first is an invitation to participate in the TWG process (See TWG below), and, second, sponsors are encouraged to interact directly with DOE program management at the headquarters level.

6.4 TECHNICAL WORKING GROUP

The TWG will be the formal process by which DOE program management receives guidance and direction on the conduct of the program. The TWG provides an open forum in which the needs of the entire program can be discussed and addressed. The TWG process is especially effective in identifying the most efficient allocations of available resources, and stimulating close interaction of participants.

6.5 DOE FIELD ORGANIZATION

Two DOE Field Operations Offices have had primary involvement in the RL Program: Oak Ridge Operations Office and Richland Operations Office. It is anticipated that in the future these two offices will continue to participate and others may be included as the program evolves. The DOE headquarters program manger will seek the cooperation and assistance of the field offices to administratively support the program by interfacing program resources with National Laboratory project activities.

6.6 INDUSTRY

It is anticipated that the program will involve private industry in appropriate aspects of work described in the program elements. This will be an evolving relationship which is not yet developed. However, it is clear that the future development of RL technology will require the active participation of industry.

6.7 UNIVERSITIES AND OTHER LABORATORIES

It is anticipated that in the future the RL Program will involve Universities and other laboratory resources more fully than has been the case in the past. Specific tasks associated with various program elements may be most appropriately undertaken by University researchers or other special laboratory facilities run by government or nonprofit organizations.

7 IMPLEMENTATION SCHEDULE

This program is currently being implemented. Upon the approval of the final draft of this document work was begun to formulate all aspects of program continuation by the designated RL Program manager. Follow-on work will develop and maintain:

- o A RL Program working budget showing all identified sources of funds for use by the program and proposed allocations of those funds to support program objectives and elements.
- o A headquarters staff and support personnel description for all current and projected activities.
- o A Work Breakdown Structure matching program participants with specific activities.

These materials will serve as working documentation and will be used to direct program activities, and will be reviewed and revised as necessary to meet program objectives.

DOE HEADQUARTERS STAFF

RL Program management authority is assigned to:

Richard B. Chitwood, Manager
Advanced Radiation Technology Program - (301) 353-5254
Office of Remedial Action and Waste Technology, NE-24
U.S. Department of Energy
Washington, D.C. 20545

RL Program activities will be supervised by:

Leroy E. Leonard, Coordinator
Radioluminescent Lighting Program - (301) 353-6520
Office of Remedial Action and Waste Technology, NE-24
U.S. Department of Energy
Washington, D.C. 20545

8 FINANCIAL PLAN

The RL Program manager is responsible for planning, programing and allocating RL Program funds and resources. It is the intent to the extent practicable the funds and resources contributed by the DOE, the program sponsors, and other program participants will be combined and used as required to meet planned program objectives. A detailed program budget will be prepared as described earlier which addresses each program element. This will be done as described in Section 7.

Table 8.1 presents a preliminary projection of the RL Program Budget for FY 88-92. This will be further refined in detail and certainty as the program is implemented.

RL PROGRAM BUDGET
FY 1988-1992
(Amounts Shown in Thousands of Dollars)

PROGRAM OBJECTIVE	ALLOCATION BY YEAR				
	FY88	FY89	FY90	FY91	FY92
Program Management	$ 500	$ 600	$ 500	$ 500	$ 400
Research & Development	1200	2000	1200	600	400
Demonstration, Test & Evaluation	600	600	1000	900	800
Technical Support	300	400	500	600	400
Totals	$2,600	$3,600	$3,200	$2,600	$2,000

Table 8.1