**Beneficial Legacies of the Manhattan Project**

A Proposed Initiative

For the

National Park Service

Prepared by the Friends of ORNL

The National Park Service (NPS), in conjunction with the Department of Energy (DOE), is undertaking development of a National Historical Park devoted to the Manhattan Project (MP). The NPS has requested communities where the Park will be located to suggest "themes" for development in communications with Park visitors. The Friends of Oak Ridge National Laboratory (FORNL) is pleased to offer a suggestion for a theme that we feel is essential and needs high visibility for telling the story of the MP.

The suggested theme deals with the large number of "beneficial legacies" that have grown out of the MP from its inception 70 years ago. Most presentations depicting the history of the MP deal with the fascinating story of the Project itself, its people, and its ultimate production of atomic weapons used to hasten the end of World War II. Such an approach is worthy and makes unquestioned good sense. However, the "untold story"—that of the "beneficial legacies" of the MP—are what we propose as a theme for further development. Like the events in the traditional history of the MP, these legacies constitute a compelling and fascinating story that must be told because of the impacts these outcomes have had on our existence today, not only in the United States, but worldwide.

The preliminary list of beneficial legacies that accompanies this introduction covers a multitude of topics and is organized in three categories: Organization/Institutional, Technology Advancement, and Professional Disciplines. Legacy examples are briefly described. The legacies represent events, organizations, technical disciplines, and other initiatives that are **directly** descended (first generation) from the MP, as well as those that have national (or international) impacts. Some, such as nuclear power or nuclear medicine, are fairly well recognized and may come as no surprise to many; others, such as some of the technical discipline examples, are less well recognized, but of significant enough impact to be included on this preliminary list.

It is suggested that after the NPS has had a chance to review and consider this proposed theme of MP legacies, a meeting involving the NPS, DOE, and FORNL be convened locally to determine the next steps. The other two major sites, also part of the National Park (Los Alamos, Hanford), will be interested in contributing to this effort and their involvement is recommended.

FORNL stands ready to work with the NPS in further development of this initiative. Members of FORNL who have prepared this document include: Chuck Coutant, Bob Hightower, Connor Matthews, Bob Olson, Jim Rushton (FORNL President), and Steve Stow.

**Manhattan Project Legacy Examples**

(no relative order implied)

**Organizations/Institutions**

**The National Science Foundation (NSF)**. Following WWII, it was recognized that the Federal Government, having "successfully" managed the Manhattan Project, should undertake support for large-scale science projects, and the NSF was born. While the NSF is not *scientifically* tied to the Project, its origin is. The NSF is recognized throughout the world for the accomplishments in basic science it has funded.

**AEC/DOE.** As a result of the Manhattan Project, the Atomic Energy Commission (and later the present-day Department of Energy and the Nuclear Regulatory Commission), were founded to develop and regulate nuclear technologies in this country; these organizations were emulated throughout the world. The financial impact of this responsibility is immense and a major part of the economy.

**Nuclear Navy**. Well documented is the fact that Hyman Rickover (later Admiral) actively lobbied for nuclear-powered submarines immediately after WWII and was a frequent visitor to Oak Ridge (X-10, ORNL), where naval officers under his command received nuclear training. Our Navy today operates more than 100 nuclear reactors in its fleet of submarines and surface ships. The Oak Ridge Y-12 National Security Complex supplies the enriched uranium (U-235) that powers the fleet.

**ORAU\ORINS.** Immediately after WWII the Federal Government sought to "transfer" nuclear science, learned during the War, to academia to be further developed. Oak Ridge Institute of Nuclear Science (ORINS), which later was renamed Oak Ridge Associated Universities (ORAU), was born and thrives today as a multi-hundred-million-dollar enterprise, affecting virtually every state.

**DOE National Laboratory System.** A U.S. National Laboratory system evolved directly from the Manhattan Project. The MP's laboratory operations in Oak Ridge, Los Alamos, and Hanford (now Pacific Northwest) were continued by the Atomic Energy Commission, and their missions expanded to encompass basic energy-related sciences. Other sites—Argonne, Brookhaven, Berkeley, Livermore, Idaho, Sandia, and Savannah River—were added to the system. Other federal agencies followed with their own laboratories. The national laboratories continue as the bulwark of federal science today. Starting with the Manhattan Project, 115 Nobel Prizes have been awarded to researchers who received DOE funding (mainly at national laboratories and universities).

**Major Industrial Companies**. A number of important companies played significant roles in the MP and achieved major successes in subsequent years. A research economist could undoubtedly be able to show that some of these achievements have contributed to favorable nationwide and worldwide economic conditions..

## Technology Advancement

**Nuclear Medicine**. The first application of nuclear technology to medical needs started at the Graphite Reactor at ORNL, a fact unappreciated by many. For example, in 1946 a carbon radioisotope was delivered from Oak Ridge to a St. Louis hospital to treat a patient's cancer. Today, the nuclear medicine industry in the U.S. is a multi-billion dollar industry and radioactive isotopes are used worldwide to diagnose and treat diseases.

**Nuclear Power.** The development of nuclear reactors for peaceful purposes was an obvious benefit. Nuclear power, which emits no greenhouse gases that threaten unwanted climate change, now accounts for some 20% of electricity produced and used in the U.S. Today, nuclear power is used throughout the world, constituting as much as 50% of the total electricity generated in some nations (even more in France).

**Space Exploration.** The power sources for deep space probes (i.e., Cassini) and for future lunar and Martian exploration are based on thermoelectric generation using heat from radioactive decay of radioisotopes produced in nuclear reactors. This technology evolved from radioisotopes produced during the Manhattan Project. Dozens of radioisotope thermoelectric generators (RTGs) have been deployed to power 25 different U.S. spacecraft, some of which have been operating for more than 20 years. Today, the radioisotope plutonium-238 (Pu-238) is being generated at ORNL's High Flux Isotope Reactor for use in RTGs to power future deep space and planetary missions.

**Nuclear Criticality Safety.** Nuclear criticality safety is a field of nuclear engineering dedicated to prevention of accidents from an inadvertent chain reaction in nuclear materials. This discipline was created as significant amounts of nuclear materials (Pu, enriched U-235) were produced; Oak Ridge, Los Alamos, and Hanford all participated in developing the field. Today, experts in the field are responsible for the safe handling and storage of nuclear materials throughout the world.

**Isotope Separation and Production.** After WWII, facilities at K-25 produced uranium enriched in U-235 in support of U.S. needs during the Cold War. Y-12, where the highly enriched uranium for the first atomic weapon of WWII was produced, began production of stable isotopes with modified calutrons. Some of these isotopes were then irradiated at ORNL for production of radioisotopes for medical, agricultural, industrial, and research purposes. Y-12 also produced lithium-6 and other isotopes for Cold War needs (e.g., developing a more powerful hydrogen bomb). Man-made elements (promethium was produced for the first time in the Graphite Reactor) can also be included in this category. Thus, a world-renowned isotope capability emerged as a legacy of the MP.

**Mammalian Genetics.** From biological studies of the effects of radiation on biological systems came a revolution in mammalian genetics, leading to our present understanding of the human genome and the effects of radiation (and other materials) on the genetic makeup of life. The ORNL research results also led to tightened limits on radiation

exposure to protect the progeny of nuclear workers, pregnant women, and other members of the public.

**Waste Materials Management.** The Manhattan Project left behind large amounts of waste materials generated through research and production activities at its three main locations, as well as elsewhere throughout the U.S. Wastes contained radioactive fission products, uranium and plutonium, heavy and toxic metals, organic compounds, and other hazardous materials. The specific behavior of waste materials in the environment and their impacts on human (and environmental) health were largely unknown. In the decades since the Manhattan Project, the concern about waste has not only been the target of massive cleanup at huge cost, but also the incentive for more fully understanding waste material behavior in the environment and living species.

**Materials Science**. The development of reactors for civilian nuclear power (see above) and for defense purposes ushered in the need to fully understand the behavior of materials (liquid/solid metals, alloys, ceramics, graphite, etc.) under extreme radioactive and thermal conditions, previously not even conceived of. This discipline of materials science fostered reactor development, ultimately leading to enhanced power production, materials for the Cold War, and the present-day recognition of world-class materials research at Oak Ridge.

**Robotics.** Because of the extremely high radiation fields associated with separation of plutonium from irradiated fuel, isotope production, routine examination and maintenance of cladding and reactors, and handling of waste materials, it became necessary to develop remote means for handling virtually all associated materials. Shielded hot cells were developed and the capability for safely undertaking processing and maintenance operations evolved with the development of increasingly sophisticated remote handling and robotics equipment. Such technology was critical in working with chemical and thermonuclear weapons by creating isolated environments with capability to perform remote operations in their production. Today, this robotics technology remains the cornerstone for handling hazardous materials in isolated environments.

**Neutron Science.** Although neutron science started in the early 1930s, the presence of nuclear reactors at Oak Ridge and Argonne national labs provided an abundant source of neutrons, enabling this new discipline to thrive and evolve. In development of the science, physicists used reactor neutron beams as a means of studying the behavior of the atomic nucleus, as well as deciphering the atomic structure of materials. Development of this discipline in Oak Ridge, which led to a Nobel Prize, culminated in world-class leadership at Oak Ridge this century with the operation of the Spallation Neutron Source and the High Flux Isotope Reactor

**High-speed Computing**

Nuclear weapons design and research have from the beginning provided the impetus for advances in large-scale computation. The first atomic bombs were designed only with desktop calculators and punched-card equipment, but continued work on nuclear weapons provided some of the earliest applications for the new electronic machines as

they evolved. The first computation job run on the ENIAC in 1945 was an early calculation for the hydrogen bomb project "Super." In the late 1940s, the Los Alamos National Laboratory built its own computer MANIAC, based on von Neumann's design for the Institute for Advanced Study computer at Princeton, and the Atomic Energy Commission funded similar machines at Argonne National Laboratory and Oak Ridge National Laboratory. Although nuclear weapons applications were not the only driver for high-speed computing and perhaps not even the biggest incentive, they were certainly significant and large, especially in the 15 or so years following WWII.

## Professional Disciplines

**Nuclear Engineering.** The Oak Ridge School of Reactor Technology (ORSORT) was established after WWII to train people in the new nuclear technologies. By the mid-1950s, establishment of nuclear engineering departments at major universities had begun, and as nuclear facilities (research and power reactors) emerged throughout the United States, nuclear engineering became a major academic and industrial discipline.

**Radioecology.** The discipline of using radioactive elements to understand the movement of elements in the environment was pioneered at ORNL and other Manhattan Project nuclear sites for monitoring the spread of radioactivity associated with production and testing. Radioecology, which now includes stable isotopes as tracers, is an accepted major field of research today.

**Health Physics/Dosimetry.** The discipline of determining and reducing the risk of radiation exposure to humans and other organisms arose from the Manhattan Project. The field includes the development of accurate radiation detection technologies and methods of measuring radiation doses to living organisms. Sophisticated instruments and dose estimates are used worldwide for regulating radiation exposures for the protection of human health and the environment, as well as for nuclear medicine.

# Friends of ORNL

Friends of ORNL (FORNL) is a non-profit organization, founded in 1991, with the following goals:

- Provide members with a way to keep in touch with co-workers, retirees, and current activities at the Oak Ridge National Laboratory

- Provide ORNL with a resource of knowledgeable volunteers

- Provide community interactions through presentations on technical topics of community interest

Membership is open to ORNL retirees, former and current employees of ORNL and any person or organization with an interest in ORNL and its programs. FORNL is operated by an elected Board of Directors.

Ongoing Activities:

- Monthly luncheon lecture series on ORNL science and technology
- Dick Smyser Community Lecture Series with invited international and national speakers
- Volunteer guides for the DOE Facilities Bus Tours
- Manhattan Project historical preservation
- Alvin Weinberg Memorials
- Science fair judges and volunteers
- ORNL history volunteers

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