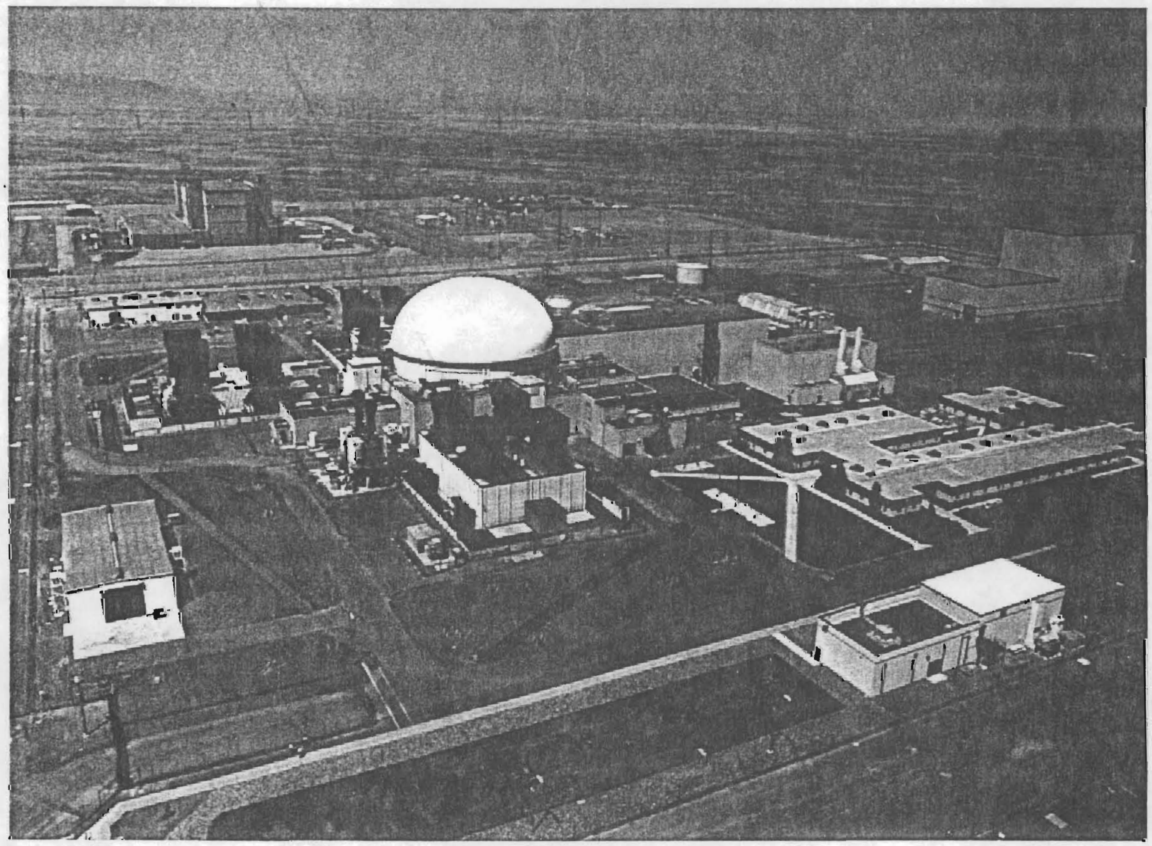
FAST FLUX TEST FACILITY (FFTF)

BRIEFING BOOK 1

SUMMARY

Technical and Economic Viability of Future FFTF Operation



U.S. Department of Energy
Office of Nuclear Energy,
Science and Technology
Dr. Terry Lash, Director

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PREDECISIONAL

Abstract

This report documents the results of evaluations performed during 1997 to determine what, if any, future role the Fast Flux Test Facility (FFTF) might have in support of the Department of Energy's tritium production strategy. An evaluation was also conducted to assess the potential for the FFTF to produce medical isotopes.

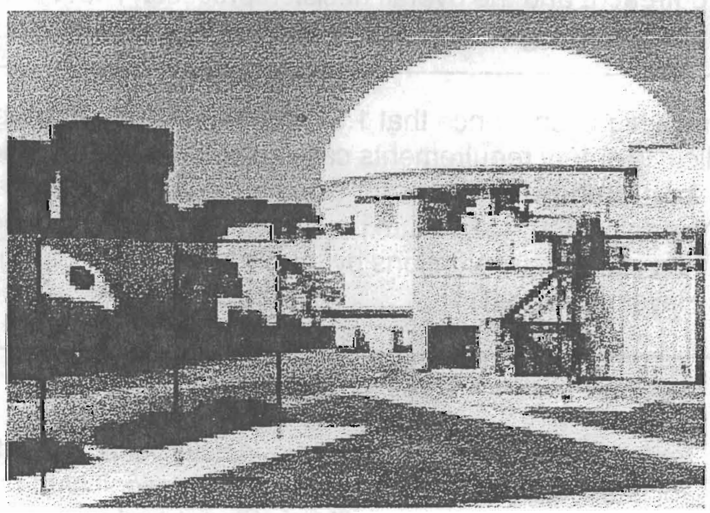
No safety, environmental, or technical issues associated with producing 1.5 kilograms of tritium per year in the FFTF have been identified that would change the previous evaluations by the Department of Energy, the JASON panel, or Putnam, Hayes & Bartlett. The FFTF can be refitted and restarted by July 2002 for a total expenditure of $371 million, with an additional $64 million of startup expense necessary to incorporate the production of medical isotopes.

Therapeutic and diagnostic applications of reactor-generated medical isotopes will increase dramatically over the next decade. Essential medical isotopes can be produced in the FFTF simultaneously with tritium production, and while a stand-alone medical isotope mission for the facility cannot be economically justified given current market conditions, conservative estimates based on a report by Frost & Sullivan indicate that 60% of the annual operational costs (reactor and fuel supply) could be offset by revenues from medical isotope production within 10 years of restart.

The recommendation of this report is for the Department of Energy to continue to maintain the FFTF in standby and proceed with preparation of appropriate National Environmental Policy Act documentation in full consultation with the public to consider the FFTF as an interim tritium production option (1.5 kilograms/year) with a secondary mission of producing medical isotopes.

Executive Summary

In January 1997 the Secretary of Energy directed that the Fast Flux Test Facility (FFTF) be maintained in a standby condition while an evaluation was conducted of any future role the facility might have in support of the nation's tritium production strategy. The purpose was to maintain the FFTF as near-term "insurance," given uncertainties associated with the dual-track approach and future stockpile requirements. To safely maintain the FFTF and perform the required evaluation, the Office of Nuclear Energy, Science and Technology established a Standby Project Office, reporting to the Department's Richland Operations Manager. The Standby Project Office has completed the safety and environmental analyses that will be needed for nuclear safety and National Environmental Policy Act (NEPA) documentation before startup for tritium production. The Standby Project Office has also evaluated the use of the FFTF for medical isotope production. This report describes the current status of the facility, results of the evaluations performed, communications outreach activities, key annotated references, and a recommendation for a future role for the facility.



Current Status of the FFTF

The Fast Flux Test Facility is in standby with the reactor completely defueled. The Main Heat Transport System is being operated at approximately 400°F. Essential systems, staffing, and support services are being maintained. Standby surveillance and maintenance activities are being performed to ensure that there is (1) no degradation of key plant systems; (2) retention of the authorization basis and configuration control; (3) maintenance of key staffing, qualifications, and training; and (4) full compliance with federal and state safety requirements.

Results of Evaluations Performed

The following studies and analyses, focused on five major sub-tasks, were conducted during 1997; the complete results are presented in the *Studies & Analyses Results Summary* section that follows this *Executive Summary*. Critical conclusions for each of the sub-task studies are presented below.

Task 1

Any restart of the FFTF will involve important environmental and safety issues which need to be identified and addressed. This evaluation prepared a Technical Information Document (TID) to capture and address those issues, as well as to provide a roadmap for resolving them as part of a formal NEPA process.

Conclusion: No environmental or safety issues have been identified that would compromise the safe operation of these facilities for the proposed mission.

Task 2

As part of the overall evaluation it was essential to confirm previous production estimates for the FFTF to ensure that the facility could produce the design goal of 1.5 kilograms of tritium per year. In addition, internal and external reviews and stakeholder interactions identified policy and technical questions that needed to be answered to support any final recommendation, communications outreach, and the overall decision process. That activity resulted in a detailed production report and the generation of a technical questions database.

Conclusion: There is high confidence that 1.5 kilograms of tritium can be produced annually, and applicable safety requirements can be met for full production reactor core loading as well as for all intermediate reactor core loadings. No technical issues associated with producing 1.5 kilograms of tritium per year in the FFTF have been identified that would change the previous evaluations by the Department of Energy, the JASON panel, or Putnam, Hayes & Bartlett.

Task 3

Having addressed the environmental and safety impacts of FFTF restart, as well as the technical questions associated with production assurance and significant stakeholder issues, it was important to review and confirm restart and life-cycle cost and schedule estimates.

Conclusion: The FFTF can be refitted and restarted by July 2002 for a total expenditure of $371 million, with an additional $64 million of startup expense necessary to incorporate the production of medical isotopes.

Task 4

Any restart of the FFTF will require extensive interactions with and impact to ongoing programs and supporting services. As part of the evaluation, a Systems Engineering

Management Plan was prepared to address fuel and target supply, long-lead-time procurements, transport of irradiated materials, integration with the Hanford Strategic Plan, tritium storage and processing, regulatory requirements, and staffing needs. In addition, the possible role of the FFTF as an interim supplier of tritium was reviewed using formal decision analysis to establish its appropriate relationship to the "dual-track strategy" described in the existing *Final Programmatic Environmental Impact Statement (PEIS) for Tritium Supply and Recycle* (DOE/EIS-0161).

Conclusion: There are no known technical issues associated with interfacing and supporting programs and services that would preclude a restart of the FFTF for tritium and medical isotope production. However, if the FFTF is to remain a viable tritium and medical isotope production option, the Department of Energy's Offices of Fissile Material Disposition and Defense Programs will need to integrate the FFTF alternative into their NEPA review process, as well as into design documentation for surplus plutonium disposition and the Tritium Extraction Facility.

In supporting the dual-track strategy as an interim supplier of tritium, the major advantages of the FFTF are that (a) its restart allows for a reduction in near-term Departmental funding of up to $1.5 billion (Putnam, Hayes & Bartlett); and (b) the FFTF is an existing facility that can produce a significant percentage of the tritium requirement starting in 2002. Interim operation of the FFTF would delay the need date for a new production source, providing additional time for the Department to resolve technical, cost, and institutional issues associated with the dual-track strategy. Once the issues are resolved and the long-term primary source is established, the FFTF could serve as a backup tritium source while continuing to produce medical isotopes or be shut down if the market is inadequate. Operation of the FFTF for tritium production would also allow the Department to respond to changes in the stockpile requirements resulting from future arms control negotiations.

Task 5

Restart of the FFTF for tritium production has the potential to provide a mechanism by which an important secondary mission can be achieved: the production of medical isotopes needed for therapeutic and diagnostic applications. This evaluation examined both the current and projected demand for isotopes, as well as the cost and technical feasibility of producing those needed isotopes in the FFTF.

Conclusion: Therapeutic and diagnostic applications of reactor-generated medical isotopes will increase dramatically over the next decade. Essential medical isotopes can be produced in the FFTF simultaneously with tritium production, and while a stand-alone medical isotope mission for the facility cannot be economically justified given current market conditions, conservative estimates based on a report by Frost & Sullivan indicate that 60% of the annual FFTF operational costs (reactor and fuel supply) could be offset by revenues from medical isotope production within 10 years of restart.

Communications Outreach Activities

An extensive communications outreach program was performed during 1997 and the results of that program are presented in the *Public Outreach* section that follows this *Executive Summary*. One of the important features of that program was the development of an interactive electronic homepage (http://www.fftf.org), which enabled high-volume communications (the page recorded over 10,000 "hits" in the most recent month).

Conclusion: Generally stakeholders including those represented on the Hanford Advisory Board, have a favorable impression of the FFTF's prior operating history (1982-1992) and a neutral-to-favorable reaction to the possibility of medical isotope production. There is little support for operation of the FFTF solely as a tritium producer.

Stakeholders are concerned that restarting the FFTF may take away cleanup funds for other activities at Hanford, as well as dilute management focus on Hanford cleanup.

Stakeholders have also expressed the opinion that the decision process for the FFTF's future would benefit greatly from the Department of Energy's initiating a NEPA process to more formally obtain public review and participation.

The groups and individuals contacted as part of the outreach program had the same recurring concerns and questions, which are documented in the *Technical Questions* section of the *Studies & Analyses Summary*.

General Conclusions and Recommendation

The results of the evaluations performed to date support the following general conclusions about the role of the Fast Flux Test Facility:

The FFTF can produce 1.5 kilograms per year of tritium while also producing a valuable supply of medical isotopes.

The FFTF can be restarted safely, in a relatively short time, and at a reasonable cost that provides overall savings to the Department of Energy.

Proceeding with preparation of appropriate National Environmental Policy Act documentation that augments the existing *Final Programmatic Environmental Impact Statement (PEIS) for Tritium Supply and Recycle* (DOE/EIS-0161), starting in January 1998, would ensure that further consideration of the Fast Flux Test Facility is consistent with the overall schedule for a decision on future tritium production.

These general conclusions support the following recommendation:

***Recommendation:** Continue to maintain the FFTF in standby, and proceed with preparation of appropriate NEPA documentation, in full consultation with the public, that considers the FFTF as an interim tritium production option (1.5 kilograms/year) with a secondary mission of producing medical isotopes.*

Task 1 - Environmental Impact

Extensive studies were completed to analyze impacts on human health and the environment associated with producing tritium and medical isotopes at the FFTF and related Hanford support facilities. Impacts associated with routine operations, postulated bounding accident scenarios, and transportation of materials were included in the analyses. The results indicate that there are no technical or safety issues that would compromise safe operation of these facilities for the proposed mission. Furthermore, a solid safety basis is provided for a decision by the Department of Energy to proceed with evaluation of the FFTF for an interim role in the nation's tritium supply strategy and as a long-term supplier of medical isotopes. The data are compiled in a *Technical Information Document* (HNF-SD-FF-TA-043, November 1997) and would support preparation of a draft environmental impact statement should the National Environmental Policy Act (NEPA) process be initiated.

... there are no technical or safety issues that would compromise safe operation ...

The proposed FFTF mission comprises the following key activities: reactor operations (FFTF); fuel and tritium target fabrication (Fuels and Materials Examination Facility, FMEF); medical isotope target fabrication (FMEF, 306-E and 325 Buildings at Hanford); spent fuel management (Hanford Site); irradiated tritium target management (FFTF); irradiated medical isotope processing (325 Building); and transportation of raw materials to the Hanford Site, irradiated tritium targets to Savannah River Site, and medical isotope products to one of three distribution centers. All areas of operation were extensively evaluated using the best available information. The accidents and source terms selected were chosen to provide bounding worst-case results. Routine operations could be assessed with a high confidence in accuracy, as existing data are available from current operations within the facilities and historic information on previous operations (e.g., reactor operations, fuel fabrication).

A brief summary of the conclusions is provided below:

... operations would be essentially the same as conducted during the highly successful 10 years of previous reactor operation.

- FFTF tritium and medical isotope production operations would be essentially the same as those conducted during the highly successful 10 years of previous reactor operation. The main difference would be the reactor core configuration. For tritium production, the reflectors and approximately sixteen in-core assemblies would be replaced by tritium target assemblies. Because these targets parasitically absorb neutrons, the enrichment of the fuel must be increased from a nominal 26 weight percent plutonium oxide to

42 weight percent. Detailed analyses of this core were completed, including re-analysis of the most limiting design basis and beyond-design-basis events that are identified in the FFTF Final Safety Analysis Report (FSAR). The results show that for the postulated design basis events, the Reactor Shutdown System prevents fuel cladding failure and no radiological releases occur.

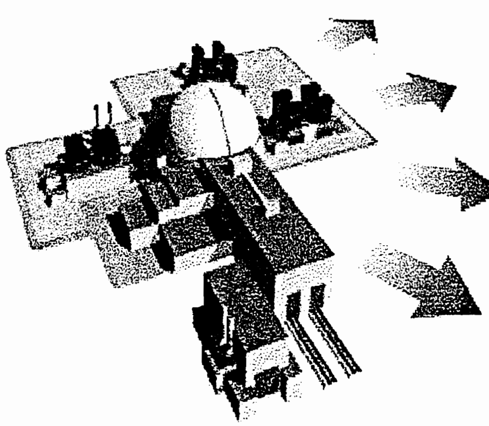
... consequences of FFTF operation still fall well below Hanford Site risk guidelines as well as the current U.S. Nuclear Regulatory Commission requirements ...

- The consequences of postulated beyond-design-basis accidents (e.g., hypothetical core disruptive accident) also were assessed to evaluate and demonstrate safety margins in the plant design. Results indicate that the degree of core damage and resulting energetics are bounded by the current FSAR events; the reactor, primary heat transport system, and containment boundaries would remain intact. The radiological and toxicological consequences are higher than stated in the current FSAR, primarily due to the difference in source terms as a result of the 42 weight percent fuel enrichment, tritium inventory, and additional sodium that is postulated to be expelled into containment. However, these consequences of FFTF operation still fall well below Hanford Site risk guidelines as well as the U.S. Nuclear Regulatory Commission requirements (10 CFR 100 reactor siting guidelines).
- Postulated accident scenarios were evaluated for all other major activities involved in the proposed mission. The radiological and toxicological consequences for these analyses fall well below Hanford Site risk guidelines.
- Other important activities occurring at the FFTF include spent fuel and irradiated tritium target management. Spent fuel generated as a result of operating the reactor would be similar to current fuel offload activities. If the FFTF operated for an additional 30 years, approximately 60 metric tons of spent nuclear fuel would be added to the Department of Energy inventory. This inventory would be stored at the Hanford Site pending final repository emplacement. Preparation of irradiated tritium targets for transportation to the Savannah River Site would be conducted in essentially the same way that other reactor core components are handled at the FFTF. No unresolved issues were identified with either spent fuel or irradiated tritium target handling and transport activities.
- Fuel fabrication activities were routinely conducted in the Hanford 300 Area from the early 1970s. Based on

this process knowledge and the protective features that are expected to be provided by the state-of-the-art FMEF facility, minimal airborne releases would occur as a result of mixed oxide fuel fabrication. Tritium and medical isotope targets (with the singular exception of the medical isotope, radium-226) are fabricated from nonradiological materials, and thus do not result in an environmental or safety impact.

- Medical isotope processing would be similar to previous and current activities conducted in the 325 Building. The addition of the proposed medical isotope processing represents a small contribution to the source term and activities currently conducted within the 325 Building.
- Waste generated from the proposed activity is small, especially when compared to annual average quantities of waste similarly handled on the Hanford Site. Existing Hanford waste management facilities can readily accommodate this incremental increase in waste production. Nonradioactive waste streams associated with FFTF operation would include solid hazardous waste, process waste water, and solid and liquid wastes. Approximately four cubic yards of hazardous waste is projected annually. Process waste water is a nonhazardous waste stream that would be controlled by an existing state waste discharge permit. Liquid sanitary waste would be discharged to the Washington Public Power Supply System treatment facility, and solid sanitary waste (office waste) would be

Disposition of wastes would conform to state and federal requirements ...



disposed of at the Richland municipal landfill. Disposition of wastes would conform to state and federal regulations and would not result in significant impacts to the environment.

- In conclusion, the results of the safety and environmental studies have shown that routine and accident impacts to the onsite worker, the public, and the environment as a result of tritium and medical isotope production at the FFTF and related support facilities are small. No technical or safety issues have been identified that would compromise the safe operation of these facilities for the proposed mission. Based on the data and analyses that have been completed, the impacts associated with this proposed mission are similar to current or previous operational impacts and are not substantial. For perspective, the impacts presented in the *Technical Information Document*, and summarized above, appear to be less than or comparable to the impacts analyzed for the tritium production alternatives presented in the *Tritium Supply and Recycling Programmatic Environmental Impact Statement* (DOE/EIS-0161, October 1995) and the Record of Decision issued December 1995.

Task 2 - Technical Questions

To confirm previous production estimates for the FFTF, specifically the capability to produce the design goal of 1.5 kilograms of tritium per year and a viable supply of medical isotopes, core scoping analyses were performed and a technical question database was prepared.

Production Assurance

Prior FFTF operation provides a basis for the validation of reactor core performance models and methods used to evaluate tritium production and to calculate reactor coefficients important to safety. A full discussion of FFTF reactor core physics methods and confirming comparison with actual reactor core performance has been documented previously; the same computer programs, data, and methods were used in this analysis, the results of which are available for review.

For the proposed tritium production mission, only the reactor core configuration (the core loading) will be modified. Other features of the facility remain unchanged from the original authorized configuration. The plant will operate at its rated power level of 400 megawatts (MW) of thermal power and reactor core components will operate within the bounds prescribed by the FFTF Final Safety Analysis Report (FSAR). A reference reactor core loading plan was defined as the basis for production analysis. It was selected as a representative or typical reactor core arrangement capable of producing 1.5 kilograms of tritium per year assuming a plant capacity factor of 0.75 and an operating power level of 400 MW. The reference core loading contains 16 in-core tritium target assemblies and up to 90 tritium target assemblies located peripherally around the fueled in-core region. Both in-core and peripheral tritium target assemblies are the same design; based on the light-water reactor tritium target materials and design, the FFTF target design has been modified to take advantage of the higher-energy neutron spectrum found in a fast reactor.

Physics analysis of the reference core loading confirmed that at least 1.5 kilograms of tritium per year can be produced and contained in the target pins. The analysis accounted for bounding permeation losses and burnout of lithium-6 atoms in the target pin.

The reference core loading plan includes medical isotope production concurrent with tritium production, and analyses have demonstrated that the design production goal of

1.5 kilograms of tritium can be achieved. In addition to available reflector region sites, three in-core locations for the production of medical and/or industrial isotopes are provided. Depending on market demand, the number of isotope production assemblies can be increased or decreased with a reciprocal effect on tritium production.

... the design production goal of 1.5 kilograms of tritium per year can be achieved.

While the number of driver fuel assemblies is about the same for both missions, the feed fuel plutonium enrichment is higher for the tritium mission (up to 42 versus 26 weight percent). This enrichment increase is needed to compensate for the large number of in-core and peripheral target assemblies in the tritium mission core. Although the fuel plutonium enrichment is roughly 50% higher than in earlier fuel, the performance of the tritium core fuel assemblies will be reliable and comparable to the historical mission fuel (40 weight percent fuel was successfully tested in Experimental Breeder Reactor II). The second difference is the impact of exchanging the previous mission radial reflector assemblies for tritium target assemblies. Tritium target assemblies are much better absorbers of neutrons; consequently, they greatly reduce the neutron flux at the inner radial shield of the reactor. The inner radial shield has been the lifetime limiting component for the FFTF. By reducing the neutron flux at the inner shield, reactor lifetime can actually be increased.

Production Safety

The safety coefficients for the reference core loading for the tritium production mission were calculated. Three safety coefficients have changed significantly: the Doppler effect coefficient, the axial expansion coefficient, and the sodium void worth.

... three safety coefficients have changed significantly ...

The Doppler effect is a feedback effect that tends to mitigate a power excursion. As nuclear fuel heats up, some fuel isotopes increase their absorption of neutrons, thus reducing the neutron population growth and slowing the power excursion. The Doppler effect coefficient is nearly an order of magnitude smaller in the tritium mission reference core than it was in the historical mission core loading. The reduction is almost entirely due to the presence of in-core tritium targets. The in-core targets preferentially absorb neutrons from the lower-energy part of the neutron spectrum. The lower-energy neutrons are also the neutrons that have the strongest impact on the Doppler feedback. Because tritium target assemblies get most of these neutrons, the Doppler effect coefficient is considerably smaller.

The axial expansion coefficient is another feedback effect that mitigates a power excursion. As the power level increases, the driver fuel assemblies increase in length. This growth causes the concentration of fissile material near the core mid-plane to decrease, thus reducing core reactivity. The axial expansion coefficient is almost twice as large in the tritium mission reference core as it was in the historical mission core. The increase is due to the higher fissile material concentration in the tritium mission core and the greater importance of axial neutron leakage from the core. The changes in the Doppler effect and axial expansion coefficients offset each other somewhat.

The total sodium void worth is the change in reactivity if all the sodium in the core disappeared. While such an event is extremely unlikely, the total sodium void worth is viewed as a safety metric which should always be negative. This is still the case for the tritium mission core loading, though the worth is not as negative as it was for the historical mission core.

The impact of the changes in these important safety coefficients has been evaluated. Several important conclusions have been identified.

1. For accidents that are terminated by a reactor scram, limiting temperatures in the core remain at or below the FSAR limiting values. This occurs because the FFTF trip settings are appropriate for shutting the reactor down at the "critical" point even if reactor kinetic characteristics are somewhat different.
2. For an unprotected loss of flow accident (which assumes the scram system fails), results are better than those reported in the FSAR. This accident is less serious because the Doppler effect, which adds reactivity in this event, is significantly smaller in the tritium mission core.
3. For an unprotected transient overpower accident (which assumes the scram system fails), limiting core temperatures remain at the same values as the FSAR limiting values. For this event, although Doppler effect feedback is less mitigating than it was in the historical mission core (FSAR), axial expansion is much stronger and compensates, the accident terminates when a few fuel assemblies fail and fuel is washed out of the core region. For the tritium mission core and the historical mission core, fuel failure occurs at very similar thermal conditions.

... safety envelope for the reference core loading for the tritium mission remains bounded by the existing FSAR analyses.

Thus, for the most limiting reactor accidents analyzed in the FSAR, the safety envelope for the reference core loading for the tritium mission remains bounded by the existing FSAR analyses.

Technical Questions Database

Internal and external reviews as well as stakeholder interactions identified technical questions which needed to be addressed to support any final recommendation, communications outreach, and the overall decision process. External reviewers included the prior Director of K-Reactor restart, prior Technical Director of the Department of Energy's New Production Reactor Program, and the Chairman of the Nuclear Engineering Department of Oregon State University. The resultant technical question database identified no unresolvable policy, production, operations, processing, safety, or environmental impact issues. The fifteen most recurring questions are listed in Table 1.

Table 1. Recurring Questions About the FFTF

Question	Answer
1. Does the United States really need more tritium right now?	Tritium is an essential component in weapons on which this country relies as the foundation of its nuclear deterrent strategic defense. The amount of tritium required is established in the *Nuclear Weapons Stockpile Plan* and approved by the President. Current projections require additions to the stockpile on or before 2005.
2. Why haven't DOE's decisions relative to the FFTF involved formal public meetings? When will formal public involvement start in the consideration process?	The FFTF is in standby awaiting a decision by the Department on whether the facility will be considered for restart. During this time, tours and status briefings by the FFTF Standby Project Office have been made upon request. If the FFTF merits further consideration, a full National Environmental Policy Act (NEPA) process will begin that will include extensive formal public involvement.
3. Does maintaining FFTF in standby take dollars away from Hanford cleanup? Won't adding an FFTF production mission divert attention from the cleanup mission?	Hanford cleanup is funded by DOE's Office of the Assistant Secretary for Environmental Management (EM). FFTF deactivation activities such as fuel wash and storage are also funded by EM. FFTF standby activities such as studies and analyses for tritium and medical isotope production are being funded and managed by the Office of Nuclear Energy, Science and Technology.
4. Why is DOE considering any production mission for Hanford when we thought that Hanford's only mission is cleanup?	The DOE has adopted a dual-track strategy for tritium production; Accelerator Production of Tritium (APT) and Commercial Light Water Reactor (CLWR). The DOE has not selected either of these options as the primary, long-term source because of unresolved technical, cost, and institutional issues. Until these issues are resolved, the FFTF represents an inexpensive "insurance policy" for the DOE's tritium production responsibility.
5. Is DOE committed to medical isotope production, or is this a ruse to get the FFTF started for tritium production?	If it is decided that the FFTF has a role in the national tritium supply strategy, and the FFTF site-specific Environmental Impact Statement (EIS) results in a favorable Record of Decision (ROD), the DOE is committed to concurrent, early production of medical isotopes.
6. What is the market (current and projected) for medical isotopes? Why do you need tritium production as a prerequisite to medical isotope production?	Medical isotopes are a growing component of the United States health care system and, based on a 1997 Frost & Sullivan study, demand is expected to grow by 7 - 15% per year over the coming decade. The evaluations that have been conducted to date indicate that the near-term revenue stream from the sale of medical isotopes would be insufficient to offset the costs to operate the FFTF.
7. Will changes in the FFTF core, necessary to allow tritium and medical isotope production, compromise safety or result in environmental releases that impact the Columbia River?	The FFTF and all reactors are required to be built, tested, and operated to established safety standards. These standards will not change for the new mission. The evaluations performed to date indicate that even with the proposed changes, the core will operate within limits of the original FSAR. The FFTF is located approximately four miles from the Columbia River. There are no liquid radiological or hazardous effluent pathways from the FFTF to the environment.
8. Does the use of a higher fraction of plutonium in the FFTF core to produce tritium and medical isotopes introduce a potential catastrophic safety risk for the facility (e.g., meltdown or explosion)?	Use of higher enriched plutonium fuel at the FFTF does not introduce or contribute to the risk of a catastrophic accident. The Secretarial decision to place the FFTF in standby included direction to conduct safety and environmental analyses that could support nuclear safety or NEPA documents. The results indicate that the consequences of some previously analyzed beyond-design-basis accidents are less severe than those analyzed under the original mission.

Table 1. Cont'd

Question	Answer
9. Will the FFTF generate additional waste, spent fuel, and releases at Hanford?	Yes, the operation of the FFTF will generate additional waste. However, the quantities are very low and the releases well below any legal limits. The FFTF does not release hazardous or radioactive material to the environment. Operation of the FFTF is expected to generate up to 60 spent fuel assemblies annually. Current plans involve cleaning the components and placing them into interim above-ground dry storage until a national repository is completed.
10. Since Russia and the United States are attempting to negotiate a joint agreement to dispose of surplus weapons-grade plutonium, won't there be potential policy issues if the United States says it is disposing of the plutonium by burning it in a reactor as MOX fuel to produce another material needed for nuclear weapons; i.e., tritium?	The agreement stated that, "The United States will not use this material for nuclear weapons or for any other nuclear explosive devices." The policy statement is unambiguously clear in reference to use of the excess material for weapons or nuclear explosives. This can only be interpreted as prohibiting any further use of the fissile material within an explosive device. A second point of U.S. policy is the stated desire to not encourage the civilian use of plutonium. The disposition of surplus weapons plutonium in the FFTF would not challenge this policy. A third point of U.S. policy is to work cooperatively with Russia to move forward on the disposition of surplus fissile materials. Clearly the inclusion of plutonium disposition as part of the FFTF tritium production mission would support this aspect of policy.
11. Will FFTF's need for MOX fuel require so much of the existing plutonium inventory that it wiill "starve" the commercial MOX program as well as require an FFTF stand-alone MOX plant at Hanford?	The FFTF could consume more than one-half of the plutonium considered excess in the U.S. nuclear weapons stockpile if it operated for 20-plus years. A decision to operate the FFTF for tritium production would result in a re-examination of how best to implement the commercial MOX fuel option for plutonium disposition.
12. Are there any significant safety issues associated with the transport of plutonium fuel or fuel material to Hanford or with the transport of irradiated tritium targets from the FFTF at Hanford to Savannah River for eventual extraction?	No. Analysis has been performed on the safety impact of transporting plutonium and uranium oxides and irradiated tritium targets. Both routine and accident scenarios indicate that there are no significant safety issues associated with the transport of plutonium fuel or fuel material shipped to Hanford or with the transport of irradiated tritium targets from the FFTF at Hanford to Savannah River.
13. If the FFTF is involved in the defense production mission, won't the public access to design and safety documents be restricted (i.e., CLASSIFIED), limiting stakeholder access to this important information (reinstituting the same cloak of secrecy that existed at Hanford during the defense production days)?	Because a tritium mission would involve some national security issues, certain aspects of the FFTF operation would be of significant value to a nuclear proliferant and will be classified in some way. At this time, we would expect only a very small portion of the information dealing with safety or environmental issues to be classified. The safe operating envelope for the facility would not be classified, only the precise amount of tritium produced at any one time.
14. Would a restarted FFTF be required to meet current commercial standards and, based on that decision, what regulatory group would oversee the FFTF's startup and operation?	Throughout the design and construction of the FFTF, the siting and design calculations were reviewed by the NRC with subsequent review by the Advisory Committee for Reactor Safeguards. To document their review, the NRC issued a Safety Evaluation Report. Before loading of fuel and any reactor operations, the FFTF would be reviewed to commercial or equivalent standards by a fully independent, qualified safety oversight organization who would insist on the same level of safety assurance to which commercial reactors are held.
15. Would any portion of the FFTF startup and operations be privatized?	It is premature to commit to any aspect of privatization at this time. Medical isotope processing has been privatized in the past, and the opportunity exists for privatization of that portion at the FFTF.

Task 3 - Cost and Schedule

The Fast Flux Test Facility can be refitted and restarted by July 2002 for a total year-of-expenditure (YOE) cost of $371 million with an additional $64 million startup expense necessary to incorporate the production of medical isotopes.

The cost and schedule estimates for the restart and operation of the FFTF, initially prepared by FFTF staff in late 1995, have been extensively reviewed by several independent groups, with general agreement on the magnitude and profile of the required expense. The latest revision of the tritium production cost estimate was formally submitted as part of the *1998 Field Work Proposal for FFTF*, shown below.

FFTF Restart Budget Estimate

FY	1999	2000	2001	2002	2003	2004	2005
FY96$	$55M	$90M	$90M	$123M	$99M	$90M	$90M
YOE$	$62M	$103M	$106M	$154M	$129M	$116M	$119M

Note: An additional $64 million of startup expense (YOE) would be incurred to incorporate medical isotope production capability (FY 99 - $7M, FY 00 - $13M, FY 01 - $26M, FY 02 - $18M).

Confidence in these estimates is based on historical data and experience, including the following:

- The FFTF is an existing facility with established costs for engineering and operation.
- For cost and schedule estimation, fuel manufacture is proposed in the Fuels and Materials Examination Facility (FMEF), an existing facility in the FFTF complex. The FMEF was originally designed and constructed as a mixed oxide (MOX) fuel manufacturing facility for the Liquid Metal Reactor (LMR) program.
- Functional design criteria and conceptual design requirements for installation of an FFTF fuel fabrication line in the FMEF were prepared in 1991.
- The FFTF fuel is a proven design with prior manufacturing and operational experience. Existing fuel is available for the first eighteen months of operation.
- The FFTF tritium target design is based on proven light-water reactor target and performance data.
- Technical review by the JASON panel in 1996 concluded with reasonable confidence that the FFTF can

... FFTF is an existing facility with established costs for engineering and operation.

achieve a production rate of 1.5 kilograms of tritium per year with minimal technical development. Operation at significantly higher production rates was deemed to be feasible but would require significant additional time and cost.

A March 1996 review by a Defense Programs Review Team used Burns & Roe for the review of the FFTF restart cost and schedule estimate. This assessment concluded, with medium to high confidence, that the FFTF could be restarted to produce 1.5 kilograms of tritium per year within four to five years from authorization to initial criticality.

...present restart cost estimates lie between the high and low estimate values used in the 1997 Putnam, Hayes & Bartlett report.

In September 1996, an "Independent Assessment of Cost and Schedule Estimates for the Production of Tritium at the Fast Flux Test Facility" provided a detailed cost estimate. The independent review team included experienced consultants from Integrated Resources Group, Inc., GE Nuclear Energy, Dames & Moore, Babcock & Wilcox, Pacific Northwest National Laboratory, and SGN Eurisys. The team's experience, particularly in the cost of fuel cycle facilities, adds confidence to the overall project estimates. The high-confidence restart costs from this assessment were less than $458 million from authorization to initial operation.

In January 1997 the consulting firm, Putnam, Hayes & Bartlett, Inc., conducted a comprehensive analysis of the cost impacts of using the FFTF to produce tritium and provided their conclusions and recommendations to DOE. Even given the conservative assumptions of their analysis, Putnam, Hayes & Bartlett concluded that keeping the FFTF as an option had positive value. The present restart cost estimates lie between the high and low estimate values used in the 1997 Putnam, Hayes & Bartlett report.

The proposed baseline schedule conservatively assumes that the NEPA process does not start until December 1998 and that formal project authorization (positive Record of Decision) occurs in December 1999; reactor criticality would be achieved two and one-half years later. There is a risk of schedule delay due to potential inability to initiate schedule-critical activities until the EIS Record of Decision is issued.

From a cost standpoint, it would be beneficial to begin the EIS process sooner (January 1998) rather than later. The present facility estimates for restart activities are scheduled for review during the preparation of the *FY 1999 Field Work Proposal.* Assuming that authorization is received in January 1998 to proceed with the EIS process, a parallel program will be initiated to provide a detailed resource-loaded project cost estimate and schedule in support of a possible positive decision upon receipt of the EIS Record of Decision.

Task 4 - Systems Engineering

Restart of the FFTF will require extensive interactions with and impact to ongoing programs and supporting services. As part of the restart evaluation, three primary activities related to systems engineering were conducted:

Restart of the FFTF will require extensive interactions with and impact to ongoing programs and supporting services.

- Preparation of a Systems Engineering Management Plan to ensure that a systematic process is in place so that overall requirements are identified and well understood.
- A decision analysis of the FFTF's possible role in the nation's tritium production strategy.
- An examination of the primary system interfaces with FFTF restart (reactor fuel and tritium target supply, long-lead-time procurements, transportation of irradiated materials, integration with the Hanford Strategic Plan, tritium storage and processing, regulatory requirements, and staffing needs).

Systems Engineering Management Plan

A Systems Engineering Management Plan was developed to describe the systems engineering activities supporting any FFTF restart. The emphasis in this plan is on those life cycle, physical, and programmatic activities essential for the successful accomplishment of the FFTF's tritium and medical isotope production missions.

The requirements for applying systems engineering to the FFTF Standby Project are derived from DOE policies, directives, and implementing documents. The hierarchy of documents providing guidance for systems engineering at Hanford flows from DOE Order 430.1, Life Cycle Asset Management (LCAM). DOE Order 430.1 and the LCAM Project Management Good Practices Guides, which were issued in August 1995, provide the minimum performance requirements for DOE's physical assets, including those for project management. The LCAM Project Management Good Practices Guides are based on techniques used in industry and other federal agencies, and address the application of systems engineering principles to DOE-sponsored projects.

Systems engineering is used in complex projects to increase the likelihood of success, and implemented as a process that has been customized to the needs of the project. The systems engineering process is iterative. It begins with the mission and the top-level functions and progresses downward into increasing levels of detail, until it reaches sufficient detail to provide assurance of the success of the system.

Decision Analysis

... decision analysis examined alternative FFTF options for interim tritium production, plutonium burning, and medical isotope production.

The decision analysis examined alternative FFTF options for interim tritium production, plutonium burning, and medical isotope production. The options considered were whether to shut down the FFTF in 1998 or to keep it in standby and, in case of a standby decision, whether to initiate the National Environmental Policy Act (NEPA) process which could potentially lead to developing an environmental impact statement (EIS) during 1998. Using a scenario approach, the analysis examined the following uncertainties:

- whether the outcome of the EIS would be favorable or unfavorable for an FFTF restart
- whether the accelerator or the commercial light-water reactor option is selected as the prime tritium producer in the dual track
- whether START II is ratified.

Depending on the specific scenario, the FFTF is assumed to either be shut down or be restarted in 2002 or 2003. If the FFTF is restarted for interim production, it would produce tritium until the dual-track alternative comes on line. This start date for the dual-track alternative also varies by scenario, ranging from 2005 to 2030.

The combinations of decisions and scenarios were evaluated against four criteria:

- the year when the dual-track tritium source is needed
- the amount of excess plutonium burned
- the revenues from the production of medical isotopes
- the total life-cycle cost for the tritium mission.

There were several conclusions from the evaluation:

... conducting an EIS for FFTF restart in 1998 is better than conducting it later ...

- For all scenarios considered, conducting an EIS for FFTF restart in 1998 is better than conducting it later, since if the Record of Decision (ROD) is in favor of continuing shutdown, there are fewer standby costs, and if the ROD favors startup, then the need for a new production source is delayed by an additional year and there is an additional year of burning plutonium and producing medical isotopes.
- Restarting the FFTF for interim production accrues the following benefits: a delay in the need for the new production source, burning of several tons of plutonium, and revenues from medical isotope production.

- FFTF restart supports enhancements to the dual-track strategy as an interim supplier of tritium. FFTF restart allows for a reduction in near-term Departmental funding of up to $1.5 billion (Putnam, Hayes & Bartlett). FFTF restart provides flexibility — the FFTF is an existing facility which can produce a significant percentage of the tritium requirement starting in 2002. Interim operation of the FFTF would delay the need date for a new source, providing additional time for the Department to resolve technical, cost, and institutional issues associated with the dual-track strategy. Once the issues are resolved and the long-term primary source is established, the FFTF could serve as a backup tritium source while continuing to produce medical isotopes. Operation of the FFTF for tritium production would allow the Department to respond to changes in the stockpile requirements resulting from future arms control negotiations.

FFTF restart supports enhancements to the dual-track strategy as an interim supplier of tritium.

Primary System Interfaces

The following table shows the status of primary system interfaces associated with FFTF restart.

FFTF System	Status
Nuclear Fuel Supply	Adequate fuel on-site for startup and 18-month operation; fuel fabrication capability development has been incorporated into this evaluation. Critical issue - the ability to obtain surplus plutonium for MOX fuel fabrication.
Tritium Target Supply	Use of light-water reactor target facilitates meeting schedule. Critical issue - potential need to develop advanced target for enhanced production or meeting design goal if forced to use highly enriched uranium fuel instead of historical MOX fuel.
Long-Lead-Time Materials Procurement	1 year EIS and 3.5 years startup schedule means that the critical path acquisition is the full-scope simulator that would be used for operator training and verification of qualification.
Transportation	No issues with transport of materials to Hanford; transport of irradiated targets to Savannah River and spent fuel to repository well within acceptable regulatory limits.

... need to integrate the FFTF interim production alternative into ongoing NEPA review processes ...

Hanford Integration	FFTF restart is fully compatible with the existing Hanford Strategic Plan's emphasis on applying site assets to new missions. Public hearings on the change to the Tri-Party Agreement related to not shutting down FFTF are scheduled for January 1998.
Tritium Storage & Processing	The irradiated tritium target rods will be transferred to Savannah River for storage and processing; no processing of the targets will be done at Hanford.
Regulation	Ten years of previous operation, design emphasis on meeting commercial licensing standards, fully permitted status, as well as existing S/RIDS and FSAR base should facilitate startup with Defense Nuclear Facilities Safety Board oversight, potentially transitioning to external regulation if determined appropriate by the Department of Energy.
Staffing	Existing operations and engineering staff base would facilitate ramping up to startup and production levels.

Conclusion

There are no known technical issues associated with interfacing and supporting programs and services which would preclude a restart of the FFTF for tritium and medical isotope production. However, if the FFTF is to remain a viable tritium and medical isotope option, the Department of Energy's Offices of Fissile Material Disposition and Defense Programs will need to integrate the FFTF interim production alternative into ongoing NEPA review processes, as well as into the design documentation for surplus plutonium disposition and the Tritium Extraction Facility.

Task 5 - Medical Isotopes

National Need for New Sources of Medical Isotopes

Medical isotopes are a growing component of the United States health care system. Based on a 1997 market survey by Frost & Sullivan, the demand for radiopharmaceuticals used in medical diagnostic and therapeutic applications is expected to grow by 7% to 15% per year over the coming decade. The revenues from sales of diagnostic agents are projected to increase from $530 million in 1996 to around $17 billion in 2020; for therapeutic agents, which have a much smaller share of the current radiopharmaceutical market, the growth in sales revenues is expected to occur at an even more rapid pace, from $48 million in 1996 to about $6 billion in 2020.

At present, only a few reactor-produced radioisotopes are widely used in medical procedures for the detection and treatment of cancer, cardiovascular disease, neurological disorders, and other major health problems. Among the most commonly used isotopes are technetium-99m, which is used in more than 70% of all diagnostic imaging procedures; iodine-131, used for the treatment of thyroid disease; xenon-133, used for lung imaging; phosphorus-32, used for the treatment of leukemia, arthritis and polycythemia rubra vera (a hematological disease involving the overproduction of red blood cells); and strontium-89, used for the relief of pain associated with advanced cases of metastatic bone cancer. Two of these isotopes, technetium-99m and iodine-131, are available only from sources outside the United States. Overall, more than 90% of the radioisotopes used in medical applications are imported from Canadian or European suppliers, and the existing sources are not expected to be able to meet the rapid growth in demand for medical isotopes over the coming two decades.

... existing sources are not expected to be able to meet the rapid growth in demand for medical isotopes ...

Medical Isotopes to Be Produced in FFTF

The FFTF's operating characteristics make it an ideal reactor for the production of large quantities of radioisotopes to meet the growing U.S. demand for both diagnostic and therapeutic applications. It has a fast neutron spectrum, with energies up to 1 MeV, that can be moderated to lower energies in the epithermal range. Because the production of large quantities of radioisotopes with the high specific activities required for many medical applications is dependent on the neutron energy used for target irradiation, the FFTF offers significant advantages over other U.S. reactors currently producing medical isotopes. This capability is enhanced by

... 20 medical isotopes have been identified as primary candidates for production ...

the fact that the FFTF has a substantially larger target volume than other U.S. isotope production reactors.

Based on the Frost & Sullivan market survey and an in-depth evaluation of the production capability for more than 70 radioisotopes, a candidate list of 30 medical isotopes has been developed for future FFTF isotope production activities. For each of these isotopes, detailed calculations have been made of the quantity that can be produced and the specific activity that can be achieved in FFTF target irradiation cycles ranging from 10 to 300 days.

Of the 30 medical isotopes that have been studied, 20 medical isotopes have been identified as primary candidates for production at the time of FFTF startup in 2002. This selection has been based on the market demand projected from the Frost & Sullivan survey, and the cost of production relative to the anticipated revenues from isotope sales. These 20 isotopes, and the various disease states for which they have diagnostic and therapeutic applications, are summarized in Table 1.

Infrastructure Requirements and Costs

The Hanford Site has a broad array of capabilities for support of an FFTF medical isotopes mission. Many of the facilities required for preparation of isotope targets and the radiochemical processing of isotope products were used in the production of nearly 40 different medical isotopes during the decade of FFTF operations from 1982 to 1992.

The major laboratories involved in this work are located in the Hanford 300 Area and would be the 306 Building and the Fuels and Materials Examination Facility (FMEF) for the processing and assembly of irradiation targets, and the 325 Building for target processing to obtain the final medical isotope products. Upgrades of these facilities will make them suitable for carrying out medical isotope production under the rigid quality assurance requirements of current Good Manufacturing Practices, which is essential for providing medical-grade isotopes suitable for direct clinical use in diagnostic and therapeutic procedures.

Implementation of the full medical isotopes mission at the FFTF would require expenditures to upgrade laboratory facilities and to design and fabricate critical equipment items. Based on preliminary estimates, the largest expenditures for implementing an FFTF medical isotopes mission are the following:

(1) construction of two rapid radioisotope retrieval systems for the production of short-lived medical isotopes in 10- to 25-day irradiation cycles: $15 to $20 million,

Table 1. Diagnostic and Therapeutic Isotope Candidates for FFTF Production Beginning in 2002, and Related Disease Indications

Isotope	Disease Indication
Ac-227 (parent of Ra-223)	Bone pain palliation, breast cancer, lung cancer, prostate cancer, melanoma, ovarian cancer, colorectal cancer
Cd-109	Heart disease
Cu-67	Lymphoma, breast cancer, rheumatoid arthritis, colorectal cancer
Gd-153	Osteoporosis
Ho-166	Rheumatoid arthritis
I-125	Heart disease, prostate cancer
I-131	Brain cancer, head & neck cancers, breast cancer, liver cancer, colorectal cancer, melanoma, Hodgkin's lymphoma, leukemia, neuroendocrine tumors, neuroblastoma, non-Hodgkin's lymphoma, arthritis, heart disease (restenosis), ovarian cancer, pancreatic cancer, thyroid cancer, hyperthyroidism
Ir-192	Breast cancer, prostate cancer, ovarian cancer, brain tumors, uterine tumors, heart disease (restenosis)
Lu-177	Bone pain palliation, heart disease (restenosis)
P-32	Leukemia, polycythernia vera, bone pain palliation, rheumatoid arthritis, pancreatic cancer, head & neck tumors, hepatocarcinomas, ovarian cancer
Pd-103	Prostate cancer, brain cancer, breast cancer, heart disease
Re-186	Prostate cancer, thyroid cancer, bone pain palliation, breast cancer, rheumatoid arthritis, lung cancer, colorectal cancer, ovarian cancer
Re-188	Heart disease (restenosis), bone pain palliation, thyroid cancer, ovarian cancer, lung cancer, colorectal cancer, breast cancer
Sc-47	Bone pain palliation
Sm-145	Eye cancer
Sm-153	Leukemia, spinal cord tumors, bone pain palliation
Sr-85	Bone pain palliation, bone disease
Sr-89	Prostate cancer, multiple myeloma, bone metastases, bone pain palliation, heart disease (restenosis)
Th-229 (parent of Ac-225/Bi-213)	Leukemia, prostate cancer, melanoma, breast cancer, colorectal cancer, lung cancer, lymphoma, ovarian cancer
Y-91	Leukemia, lymphoma, breast cancer, colorectal cancer, Hodgkin's lymphoma, non-Hodgkin's lymphoma

... annual cost of medical isotope production should be fully recoverable at the onset of FFTF operations ...

(2) upgrades of facilities for target preparation at the 306 Building and FMEF, and for the radiochemical processing of isotope products at the 325 Building: $25 to $30 million.

In addition, an initial expenditure of $5 to $15 million is needed to purchase target material for FFTF medical isotope production. Many of these stable target isotopes can be recycled following irradiation, thereby reducing the requirement for procuring additional target materials in later years.

An isotopes mission would also entail additional staffing requirements for FFTF medical isotope production, packaging, distribution, marketing, and sales. These activities are prime candidates for privatization. The combined annual cost of the FFTF medical isotopes mission, the procurement of target materials, and the maintenance of facilities such as hot cells is estimated to be $15 to $20 million annually.

Revenues Generated from FFTF's Isotope Mission

Based on conservative estimates of the market demand for FFTF medical isotopes, the annual cost of isotope production should be fully recoverable from the onset of FFTF operations in 2002. In addition, the market demand is expected to progressively grow and reach a level at which 60% of the total cost of operating the FFTF may be recovered from isotope sales revenues by the year 2012. If the demand for diagnostic and therapeutic medical isotopes reaches the extent of market penetration projected by Frost & Sullivan, full cost recovery for both FFTF operations and medical isotope production could possibly occur in the 2015 to 2020 time frame.

Public Outreach

The goal for the Public Outreach Program is to build stakeholder confidence and trust through timely and honest information, and to provide a forum for identifying key issues and questions. The FFTF Standby Project Office worked with the Office of External Affairs, Richland Operations Office, to write a communications plan to address a number of mechanisms for public outreach that could meet the needs of a variety of audiences. The communications plan was implemented during calendar year 1997 and the following activities were performed.

Status briefings were made upon request. Fifty-three groups received briefings between January and November 1997. These groups included:

Tribal Nations - the Yakama Indian Nation, the Confederated Tribes of the Umatilla, and the Nez Perce

Defense Nuclear Facilities Safety Board

Nuclear Regulatory Commission

Hanford Advisory Board

Oregon Hanford Waste Board

Hanford Education Action League

Environmental Protection Agency

Washington State Department of Ecology

Oregon Office of Energy

Professional Societies - Hanford Technical Exchange, Nuclear Medicine Research Council Symposium: "Accelerating Nuclear Medicine Treatments and Techniques," Conference: "Future Role of the Fast Flux Test Facility (FFTF) as a Supplier of Diagnostic and Therapeutic Medical Isotopes," American Nuclear Society regional and annual meetings

Media - Los Angeles Channel 1 News, *Tri-City Herald* (Richland, WA), *Los Angeles Times*, *Chicago Tribune*, Prosser *Record-Bulletin,* editorial board for the Hermiston, OR newspaper

State and Federal Elected Officials - Washington, Oregon, and Alaska

... to provide a forum for identifying key issues and questions.

Stakeholders have expressed the opinion that the decision process for the FFTF's future would benefit greatly from a more formal public review and participation process.

Interested Citizens - Service clubs such as Chambers of Commerce, Rotary, Toastmasters

Other Department of Energy organizations - Materials Disposition, Savannah River, INEEL, PNL, and LANL.

Plant tours were given upon request. Twenty-two groups received a tour between January and November 1997.

A letter was sent to an additional sixty-eight stakeholders, elected officials, and interested parties in August and September 1997, offering plant tours, discussions, and meeting participation.

Public meetings have been scheduled in January 1998 to review proposed changes in the Tri-Party Agreement milestones as a result of not shutting down and deactivating the FFTF.

A brochure was published in September 1997.

A web page, http://www.fftf.org, was upgraded on the internet in October 1997 to provide enhanced public interaction. There were 10,294 hits to the page in the first month.

Responses have been provided to all of the limited number of inquiries the SPO has received. Input from the public outreach activities has been used in the formulation of a technical questions database.

Generally the stakeholders, including those represented on the Hanford Advisory Board, have a favorable impression of the FFTF's prior operating history (1982-1992) and a neutral-to-favorable reaction to the possibility of medical isotope production at the FFTF. Many stakeholders are concerned that restarting the FFTF would take away cleanup funds for other activities at Hanford, as well as dilute management focus on Hanford cleanup. Other stakeholders have expressed a generic opposition to all nuclear weapons programs, and therefore oppose FFTF restart for tritium production. Stakeholders have expressed the opinion that the decision process for the FFTF's future would benefit greatly from a more formal public review and participation process.

The medical community has expressed great concern over the limited availability and high cost of medical isotopes. The FFTF is viewed as an existing facility that could provide these needed and projected-to-be-needed isotopes.

Reference List

Date	Title/Preparer / *Conclusion(s)*
December 1995	Record of Decision: Tritium Supply and Recycling Programmatic Environmental Impact Statement, U.S. Department of Energy *"The Department needs a capability that can produce tritium to meet the requirements set forth in the 1994 Nuclear Weapons Stockpile Plan."*
March 1996	Technical Assessment of Tritium Production Capability of the Fast Flux Test Facility, Defense Programs Tritium Office, U.S. Department of Energy *"FFTF...could be brought to an operational condition ready to start partial tritium production by...2002...for about $460M...medium to high confidence in the ability to produce 1.5 kilograms per year."*
July 1996	Technical Assessment of Tritium Production Capability at the Fast Flux Test Facility, Argonne National Laboratory *FFTF "is a feasible technical alternative."*
October 1996	Potential Role of the Fast Flux Test Facility and the Advanced Test Reactor in the U.S. Tritium Production System, Office of Nuclear Energy, Science and Technology, U.S. Department of Energy *"FFTF could produce radioisotopes for medical use while producing 1.5 kg/year of tritium" and FFTF has the potential to reduce "near-term expenditures...for the accelerator or CLWR purchase options."*
October 1996	Use of the Fast Flux Test Facility for Tritium Production, The JASON Panel, The Mitre Corporation *"...confident that FFTF can achieve a 1.5 kg per year T production rate..." which will "contribute substantially to but cannot fully meet U.S. T needs."*
January 1997	Record of Decision for the Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement, U.S. Department of Energy *FFTF "...could also use surplus plutonium as reactor fuel if it were shown to be useful for tritium production....This ROD does not preclude...potential use of surplus plutonium as fuel for the FFTF."*

January 1997	DOE Tritium Production: FFTF and ATR Cost Analysis, Putnam, Hayes & Bartlett *"FFTF near-term tritium production allows delays in the primary tritium production sources, with associated cost savings....FFTF tritium production may be able to replace production from primary tritium source, with savings resulting if FFTF tritium production costs are lower than primary tritium source costs....FFTF may be able to replace current programs as the backup or even the primary tritium source, with associated cancellation savings."*
November 1997	FFTF Medical Isotopes Market Study (2001-2020), Frost & Sullivan, PNNL-11774 *...Study supports conclusion that 60% of the annual FFTF operational costs (reactor and fuel supply) could be offset by revenues from medical isotope production within 10 years of restart.*
November 1997	Interim Tritium/Long-Term Medical Isotope Production Mission at the Fast Flux Test Facility, FFTF Standby Project Office *"No technical or safety issues have been identified that would compromise the safe operation of these facilities for the proposed mission."*