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SEISMIC SAFETY MARGINS RESEARCH PROGRAM (Phase II)

PROGRESS REPORT NO. 10

March 31, 1981

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by
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for the U. S. Department of Energy

FOREWORD

Progress Report number 10 of SSMRP is the sixth to be issued as a NUREG report. The first five in this series are available from Lawrence Livermore National Laboratory under the numbers ME79-206 through ME79-210. Progress Report number 10 initiates the reporting of Phase II of SSMRP.

CONTENTS

ABSTRACT

This document is a progress report on the Seismic Safety Margins Research Program (SSMRP) covering the period January 1, 1981 through March 31, 1981. The report gives a general description of the program, together with financial summaries and individual project details. Each project is summarized to show accomplishments, schedules, milestones and completion dates, budget and expenditures, and any concerns that may affect the project.

SEISMIC SAFETY MARGINS RESEARCH PROGRAM (PHASE II)
FIN A0126 and A0130

GENERAL DESCRIPTION

Personnel

NRC Program Manager: C. W. Burger
Contractor: Lawrence Livermore National Laboratory (LLNL)
LLNL Program Manager: P. D. Smith
LLNL Deputy Program Manager: R. G. Dong

Program Dates and Cost

Starting date: February 1978
Ending date: September 1984

Justification

NRR User Request No. 76-5, dated June 16, 1977

Objectives

The objectives of the Seismic Safety Margins Research Program (SSMRP) are to:

1. Estimate the degree of conservatism of the present Standard Review Plan (SRP) seismic safety requirements.
2. Develop improved requirements and methods for safety assessment.

Approach

The approach toward achieving the program objectives is to develop probabilistic methodology that more realistically estimates the behavior of nuclear power plants during an earthquake. This methodology will be tested against experimental data wherever possible. The work of the program is being performed in three phases:

1. In Phase I, the methodology is developed. Models for seismic input, soil-structure interaction, dynamic response of structures and subsystems, and fragility are developed and combined using a probabilistic computational procedure. Sensitivity studies to gain engineering insight into seismic safety requirements have been started. The results will help determine priorities for the Phase II effort.
2. In Phase II, additional models and probabilistic procedures will be developed. These include selected subsystems, components, and structures not included in Phase I. Sensitivity studies started in Phase I will be completed. The methodology will be used to estimate the degree of conservatism of the SRP seismic safety requirements and to develop improved methods for safety assessment. The probability of failure of systems, components, and structures, and the probability of radioactive releases from a range of earthquake levels will be used to define needed improvements in the methodology. Necessary validation improvements will be carried out and the validated methodology will be used to refine estimates of conservatism and define the seismic contribution to reactor risk.
3. In Phase III, the validated methodology from Phase II will be used to recommend changes in the SRP seismic safety requirements, if needed, to obtain improved deterministic requirements.

Prior Year Completions

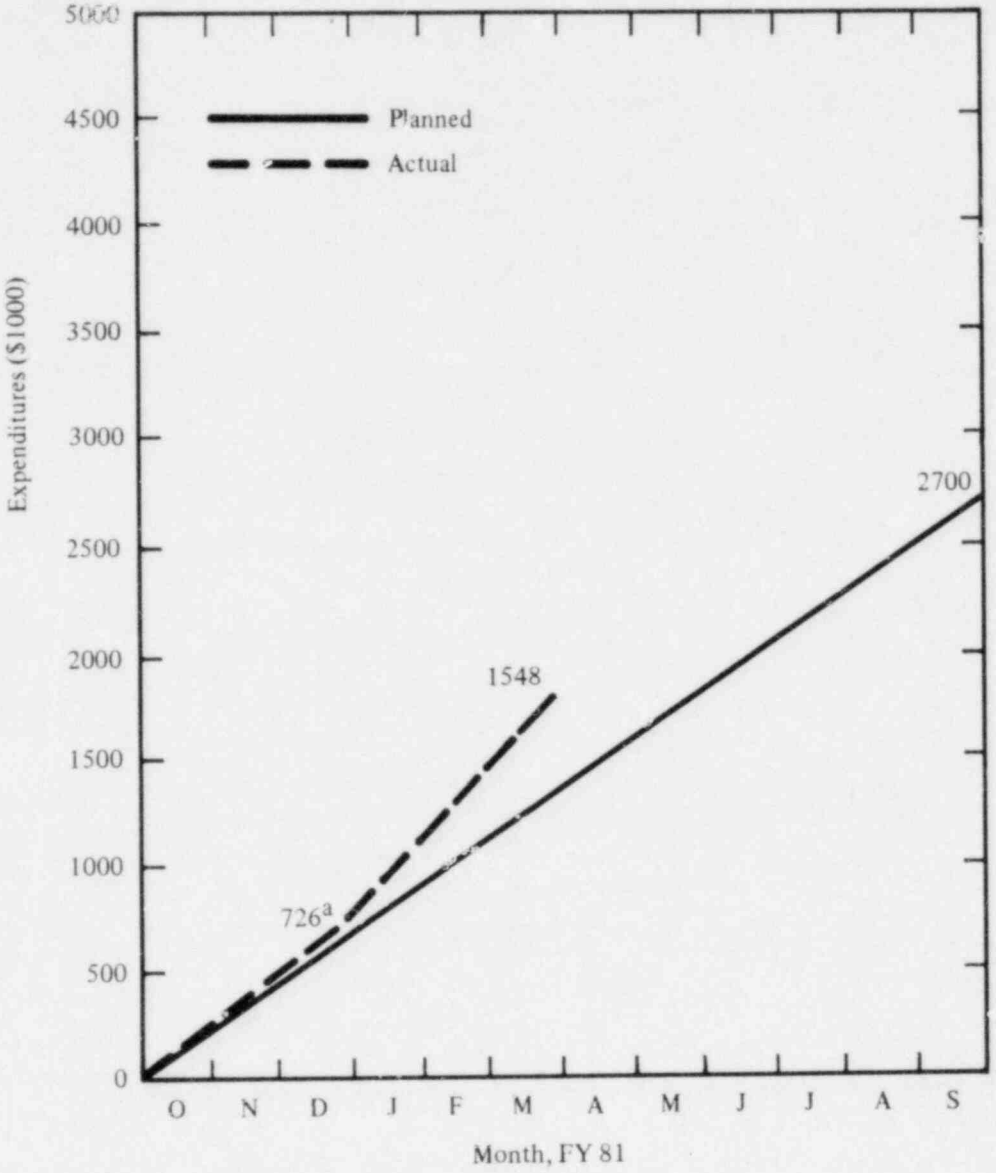
Seismic Safety Margins Research Program – Program Plan, Revisions 0, I, and II

Current Year Scope

The scope of Phase II will include work on the following projects:

I. San Onofre Nuclear Generating Station Auxiliary Feedwater System
II. Seismic Input
III. Soil-Structure Interaction
IV. Major Structure Response
V. Subsystem Response
VI. Fragilities
VII. Systems Analysis
VIII. SMACS and BE-EMS

Expenditures for FY 81, Grand Totals (FIN A0126 and A0130)



a. End of Phase I

Phase I Budget Summary, Grand Totals
(FIN A0126 and A0130)

Segment	Budgeted Amounts ($1000)		
	Operating	Equipment	Total
Prior year (FY 78)	244	0	244
Prior year (FY 79)	2062	0	2062
Last year (FY 80)	3075	0	3075
Current year (FY 81)	726	0	726
Totals	6107	0	6107

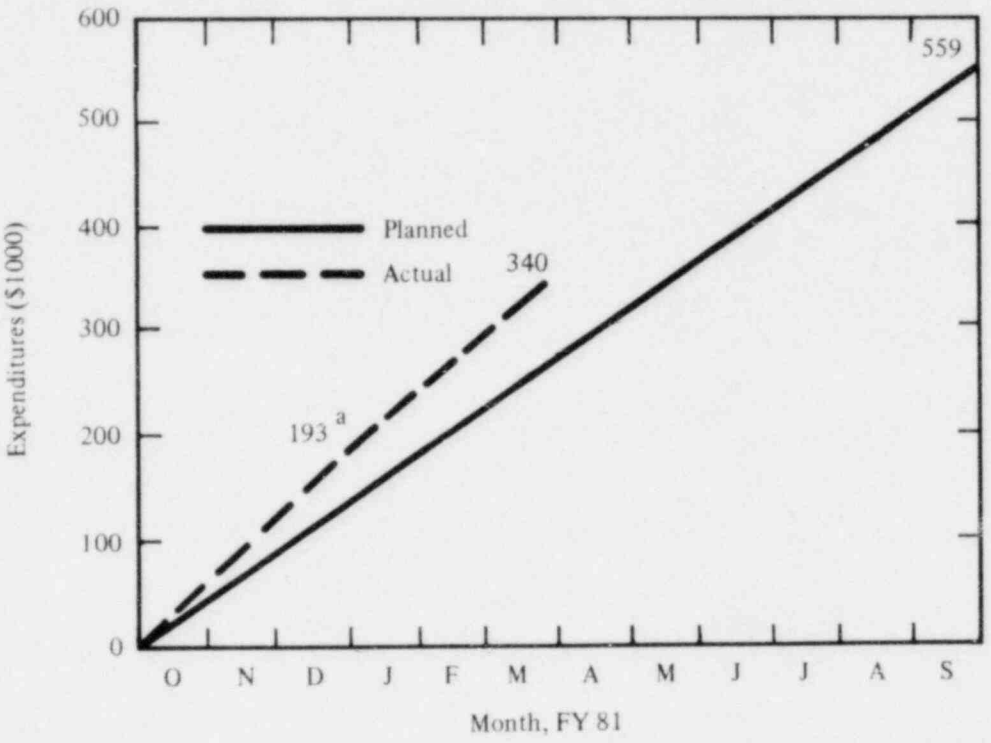
Phase II Budget Summary, Grand Totals
(FIN A0126 and A0130)

Segment	Budgeted Amounts ($1000)		
	Operating	Equipment	Total
Current year (FY 81)	1974	50[a]	2024[a]
Totals	1974	50[a]	2024[a]

a. No equipment funding authorization.

GENERAL PROGRAM MANAGEMENT
FIN A0126

Expenditures for FY 81, General Program Management (FIN A0126)



Phase I Budget Summary, General Program Management (FIN A0126)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	121
Prior year (FY 79)	447
Last year (FY 80)	550
Current year (FY 81)	193
Total	1311

a. End of Phase I.

Phase II Budget Summary, General Program Management (FIN A0126)

Year	Budgeted Amount ($1000)
Current year (FY 81)	366
Total	366

GENERAL PROGRAM MANAGEMENT

A. Accomplishments

During the quarter, computations for Phase I of the SSMRP have been completed and documentation of the Phase I results is under way. The overview and summary for Phase I, "Seismic Safety Margins Research Program, Phase I Final Report – Overview," UCRL-53021, Vol. 1, NUREG/CR-2015, Vol. 1, March 6, 1981, has been completed and a camera-ready copy transmitted to the NRC. Subsequent volumes of the Phase I Final Report will provide detailed descriptions of the Phase I technical effort.

A review of the SSMRP and Phase I results was presented to the Advisory Committee on Reactor Safeguards (ACRS), Subcommittee on Extreme Phenomena, on January 29 and 30, 1981. The presentation was well received and the meeting marks the close of Phase I of the program.

Before the ACRS meeting, a meeting with the Senior Research Review Group (SRRG) was held at LLNL on January 28, 1981. The purpose of the meeting was to go over the Phase I results with the SRRG members and with the NRC/RES and NRC/NRR members in attendance.

A work plan for a study of the San Onofre Nuclear Generating Station (SONGS) Unit 1 Auxiliary Feedwater System ("Seismic Safety Margins Research Program, Project I SONGS 1 AFWS Project," UCID-18959, February 24, 1981) was written and transmitted to the NRC. This document reflects numerous discussions with NRC/RES and NRC/NRR personnel on the subject. This study will be the first application of the SSMRP methodology to a licensing issue. The proposed budget for this study is $900,000, spread between FY 81 and FY 82. An agreement has been reached with Southern California Edison Company to provide the necessary design information and drawings for SONGS Unit 1. The SONGS Unit 1 study will be managed under Project I of the SSMRP. Although the technical work will spread over all projects of the SSMRP, progress will be reported principally by Project I to maintain a cohesive picture of the effort.

Due to the addition of the SONGS Unit 1 study to FY 81, and the magnitude of the effort, the work scope for FY 81 needs to be revised. This revision is not yet firm; therefore, the tasks, milestones, schedule, and cost per task conveyed in this report are subject to change. For the sake of consistency in format with past progress reports, we chose to relate our progress with respect to the tasks, milestones, schedules, and cost per task as we see these items today. The tasks are generally quite different from those in past progress reports.

A proposed work scope for the SSMRP in FY 82, dated March 18, 1981, was transmitted to the NRC as FIN/189A No. A0126 and FIN/189A No. A0130, B&R 60 19 10 06.

Eleven papers based on SSMRP Phase I results were written for the Sixth International Conference on Structural Mechanics in Reactor Technology. All eleven were accepted and were transmitted to the Commission of the European Communities, Brussels, Belgium, in early March 1981.

For Project I, SONGS 1 AFWS, work on the SONGS Unit 1 study will begin as soon as the NRC's endorsement of the proposed work plan is received. In Project II, Seismic Input, the effects of changes in zonation and earthquake occurrence models are being studied, and considerable progress is being made in transferring contractor developed computer codes to the LLNL system. A comparison of structural response as computed by the FLUSH and CLASSI codes is nearing completion in Project III, Soil-Structure Interaction. Studies on soil amplification and three-dimensional nonlinear soil-structure interaction are continuing. In Project IV, Major Structure Response, the study to quantify the variation in structural dynamic response introduced by model assumptions is being documented. A draft of the Phase I final report for Project IV has been completed. Response computations necessary for Phase I for Project V, Subsystem Response, were completed. In the SMACS Sensitivity Study, which resides in Project V, 22 time histories were determined to be an insufficient number for a good statistical sampling for subsystem response whereas 30 time histories were found to suffice. The uncertainties in subsystem modeling was found to be the most important contributor to subsystem response compared with major structure modeling, soil-structure interaction modeling, and one particular characterization of seismic input. A draft of the Phase I documentation of Project V has been completed. In Project VI, Fragilities,

component and structural failure probabilities were hand calculated to provide analytical validation for the SEISIM code being developed by Project VII, Systems Analysis. In Project VII, the user's manual for Option 1 of SEISIM has been completed. Analysis of Zion 1 fault trees for Phase I is complete, as is the construction of accident sequences. Conversion of SMACS from the CDC 7600 to the CRAY computer has been completed in Project VIII, SMACS and BE-EMS.

B. **Next Quarter**

Efforts planned for the next quarter are as follows:

1. Upon receiving NRC endorsement, begin the SONGS Unit 1 study.
2. Complete the documentation of technical work and results of Phase I.
3. Complete Task III.3.2 (comparative linear analysis of Zion multistructure configuration) of the soil-structure interaction study.
4. Complete the planned SMACS sensitivity study, which assesses the contribution to subsystem response uncertainty due to seismic input, soil-structure interaction modeling, major structure modeling, and subsystem modeling.
5. Prepare handbook on fragilities.
6. Begin the sensitivity studies planned for Phase II.
7. Refine the SEISIM code.
8. Propose a schedule for transfer of SMACS analytical capability to the NRC.

C. **Concerns**

1. **Technical**

   None.

2. **Schedule**

   None.

3. **Cost**

   Because of the relatively high rate of spending during the first half of FY 81 to complete Phase I in a timely manner and to document the Phase I work and results, the funds for the remainder of FY 81 are disproportionately low. The projected SONGS 1 effort will consume a major portion of the remaining FY 81 budget. Consequently, the Phase II effort, other than SONGS 1, will be minimal in FY 81.

PROJECT I
SAN ONOFRE NUCLEAR GENERATING STATION
AUXILIARY FEEDWATER SYSTEM[a]

Personnel

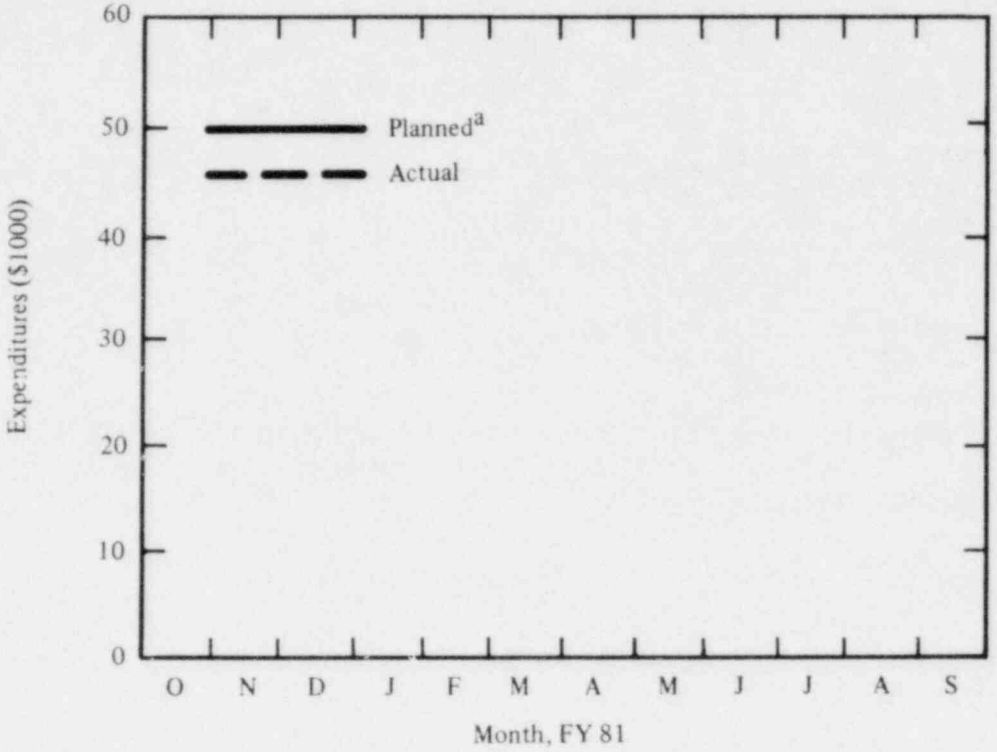
NRC Program Manager: C. W. Burger
NRC Project Manager: C. W. Burger
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: T. Y. Chuang

Objectives

1. Identify the weak links in the auxiliary feedwater system (AFWS) of the San Onofre Nuclear Generating Station (SONGS) Unit 1.
2. Compare the probabilities of failure of the AFWS for Zion Unit 1 and SONGS Unit 1.
3. Compare the seismic responses of structures and piping systems of AFWS due to different input spectra and design values.

a. FIN unknown at present.

Expenditures for FY 81, Project I, San Onofre Nuclear Generating Station
Auxiliary Feedwater System[b]



Phase II Budget Summary, Project I, San Onofre Nuclear Generating Station
Auxiliary Feedwater System

Year	Budgeted Amount ($1000)
Current year (FY 81)	Note a
Total	0

a. Planned expenditure for FY 81 not yet established.

b. FIN unknown at present.

PROJECT I, SAN ONOFRE NUCLEAR GENERATING STATION AUXILIARY FEEDWATER SYSTEM

A. Accomplishments

The final work plan has been developed and published as an LLNL document (UCID-18959). This work plan was submitted to the NRC on February 24, 1981 for approval.

B. Next Quarter

Upon NRC approval, the project will be executed.

C. Concerns

1. **Technical**
   None.
2. **Schedule**
   None.
3. **Cost**
   None.

PROJECT II
SEISMIC INPUT
FIN A0126

Personnel

NRC Program Manager: C. W. Burger
NRC Project Manager: C. W. Burger
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: D. L. Bernreuter

Objectives

1. Refine and document Phase I results.
2. Generalize and complete transfer of computer programs developed by TERA under LLNL direction to LLNL system.

Task Description

Task II.1 – Refinement of Phase I Results

The objective of this task is to make additional sensitivity runs to better understand the importance of certain parameters and assumptions made. In particular, our sensitivity studies will illustrate the importance of: (1) alternative seismic zonation; (2) the manner in which the largest earthquake for a given seismic zone is treated; (3) the effect of the ground motion model on the hazard; and (4) variations in the parameters of the earthquake occurrence model. Also under this task, we want to assess the effect of the changes in the zonation and earthquake occurrence models resulting from the feedback meetings with our panel of experts. Also included in this task is the completion of the generation of time histories.

Task II.2 – Transfer of Technology

The objective of this task is to cover the transfer of the computer program developed by TERA in Phase I to the LLNL system from the Berkeley system and to ensure that LLNL personnel understand all facets of the various computer programs developed by TERA for Phase I of the SSMRP. Three computer codes are involved: (1) DOALL, which is used to develop the earthquake occurrence model for each source zone; (2) HAZARD, which is used to develop the hazard curve; and (3) HAZARD-MC which is the Monte Carlo code developed from HAZARD and used to generate the spectra from which the time histories are generated.

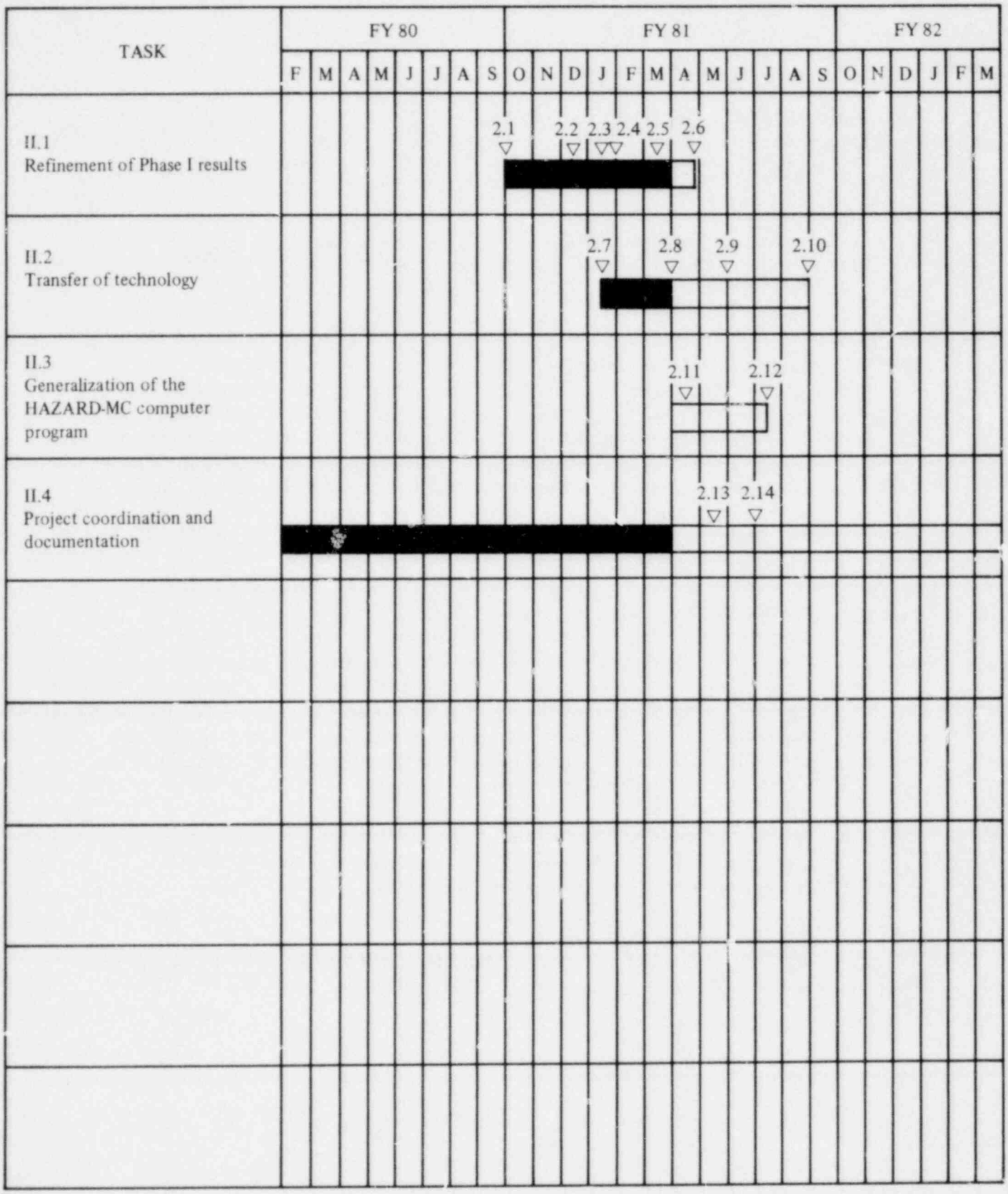
Task II.3 – Generalization of the HAZARD-MC Computer Program

The objective of this task is to modify the Monte Carlo version of HAZARD to efficiently handle narrow fault zones typical of the western United States.

Task II.4 – Project Coordination and Documentation

The objectives of this task are to coordinate the activity of the project and to develop the final report and presentations.

Project II Schedule



Project II Milestone Dates

	Milestone	Original Target Date	Revised Target Date	Completed Date
2.1	Initiate additional sensitivity studies and complete development of all time histories	10-1-80		10-1-80
2.2	Complete development of all boxes of time histories for Phase I	12-15-80		12-15-80
2.3	Begin assessment of feedback data	1-15-81		1-15-81
2.4	Start drafting final report	2-1-81		2-1-81
2.5	Complete assessment of feedback results	3-15-81		3-15-81
2.6	Complete all sensitivity runs	5-1-81		
2.7	Start transfer of technology (DOALL and HAZARD)	1-15-81		1-15-81
2.8	Start transfer of HAZARD-MC	4-1-81		
2.9	Completion of internal User Manual for DOALL and HAZARD	6-1-81		
2.10	Completion of internal User Manual for HAZARD-MC	9-1-81		
2.11	Initiate changes in HAZARD-MC	4-15-81		
2.12	Completion of changes in HAZARD-MC	7-15-81		
2.13	Documentation of Phase I results – draft report transmitted to NRC	5-15-81		
2.14	Documentation of Phase I results – camera-ready copy transmitted to NRC	7-1-81		

Project II Topical Reports

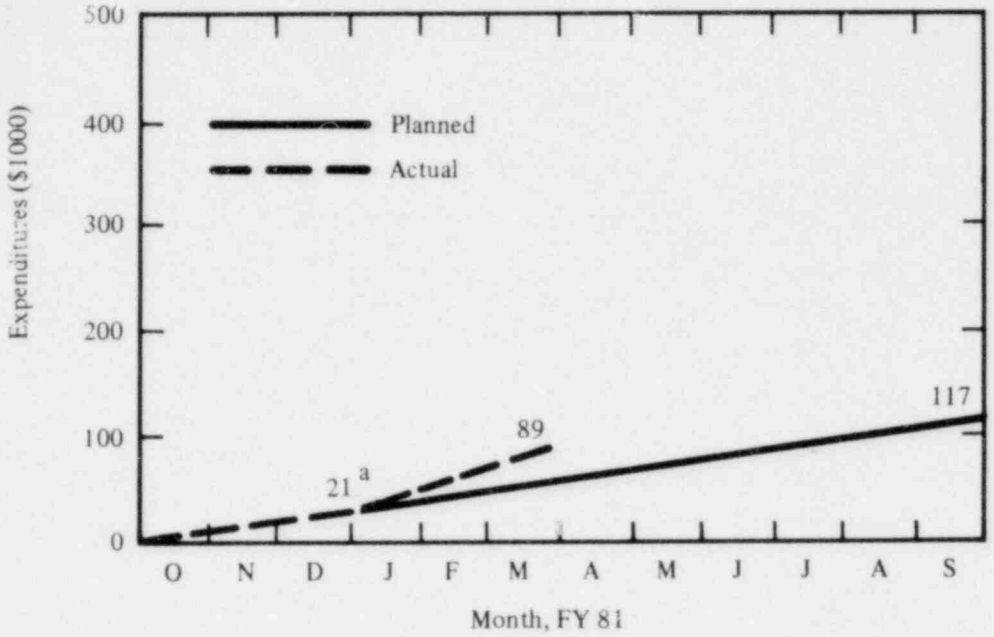
	Report*	Original Target Date	Revised Target Date	Completed Date
SI-1.	Feasibility of using ARMA models to simulate earthquake time histories.	9-79		7-79
SI-2.	Simulation of time histories parameterized by magnitude, epicentral distance and site conditions using ARMA models.	12-80		9-80
SI-3.	Differences between body wave magnitude in the Eastern and Western U.S. and the interrelation between local body and surface wave magnitudes.	4-80		4-80
SI-4.	Assessment and expansion of the strong ground motion data base.	4-80		4-80
SI-5.	Relative effect of Q on the strong ground motion from earthquakes between the Eastern and Western U.S.	7-80		7-80
SI-6.	Improved Bayesian methodology for development of site dependent spectra.	12-80	5-81	

*Published reports are listed under Reports Generated by the SSMRP, following the Project VIII progress report.

Subcontractors

1. Dr. O. Nuttli (consultant)
2. Dr. N. Toksoz (consultant)
3. Dr. M. Sbar (consultant)
4. Dr. A. Cornell (consultant)
5. Dr. T. McEvilly (consultant)
6. TERA Corporation, Berkeley, CA (Tasks II.2 and II.3)
7. Dr. D. Veneziano (consultant)

Expenditures for FY 81, Project II, Seismic Input (FIN A0126)



Phase I Budget Summary, Project II, Seismic Input (FIN A0126)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	23
Prior year (FY 79)	249
Last year (FY 80)	319
Current year (FY 81)	21
Total	612

a. End of Phase I.

Phase II, Budget Summary, Project II, Seismic Input (FIN A0126)

Year	Budgeted Amount ($1000)
Current year (FY 81)	96
Total	96

Project II, FY 81 Cost Breakdown

	Task	Amounts ($1000) FY 81 Budget[a]	YTD Spent[b]
II.1	Refinement of Phase I results	35	35
II.2	Transfer of technology	25	25
II.3	Generalization of HAZARD-MC computer program	25	0
II.4	Project coordination and documentation	32	29
	Totals	117	89

a. Proposed
b. As of March 31, 1981

PROJECT II, SEISMIC INPUT

A. Accomplishments

Task II.1, Refinement of Phase I Results – We evaluated (in conjunction with the site specific spectra project) the effect of the changes in zonation and earthquake occurrence models resulting from our feedback meetings with our expert-panel members. Additional sensitivity runs have been made, using the HAZARD code, to better understand the influence of the key input parameters on the hazard at low (order of 10^{-5} to 10^{-7}) probabilities of exceedence.

Task II.2, Transfer of Technology – Considerable progress has been made in transfering the codes to LLNL system and in understanding the internal workings of both DOALL and HAZARD. Both codes are now running on the LLNL system, but we still need to improve the plotting capabilities of both codes.

Task II.3, Generalization of the HAZARD-MC Computer Program – This task is not scheduled to begin until next quarter.

Task II.4, Project Coordination and Documentation – We put considerable effort into developing the presentation for the ACRS meetings held on January 29 and 30, 1981. We have also started work on the final report.

B. Next Quarter

In the next quarter we will complete the final report documenting Phase I. We will also improve the plotting capabilities of DOALL and HAZARD and start working on HAZARD-MC.

C. Concerns

1. **Technical**
   None.
2. **Schedule**
   None.
3. **Cost**
   The cost of updating the hazard curve to account for charges introduced by the feedback loop and second round questionnaire was higher than anticipated. The main reason for this was that several experts extensively revised their models, requiring significantly more effort than budgeted. Also, the preparation for the January ACRS meeting took significantly more effort than anticipated. This puts us in a very tight budget situation.

PROJECT III
SOIL-STRUCTURE INTERACTION
FIN A0130

Personnel

NRC Program Manager: C. W. Burger
NRC Project Manager: J. F. Costello
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: J. J. Johnson

Objectives

1. Using state-of-the-art analysis methods, develop transfer functions that relate the free-field ground acceleration time histories to basemat and in-structure response.
2. Identify important parameters in the soil-structure interaction phenomenon through sensitivity studies.
3. Compare analysis techniques for a number of critical parameters.

Task Description

Task III.1 – Analytical Development

The analytical development task implements the computer software necessary to execute the soil-structure interaction project. Implementation of the CLASSI and FLUSH computer programs and other supporting software at LLNL or LBL is to be accomplished. Preprocessing and postprocessing of data must be done to execute the main analytical tools and compare the results.

Task III.2 – Response Computation Soils Input Data

The response computation input task encompasses (1) preparation of the required soils input information to SMACS for the SSI portion of the seismic analysis, (2) development of soil characteristics and their variability for increasing levels of excitation, and (3) generation of the impedance functions and scattering matrices for representative excitation levels.

Task III.3 – Sensitivity Studies

Three sensitivity studies are to be performed. Their purposes are (1) to provide guidance to SMACS and SEISIM as to potentially important factors to be included in the analysis and (2) to establish the biases in response due to different modeling assumptions.

Task III.3.1 – SSI Phenomenon

Investigation of the effects of embedment, structure-to-structure interaction, wave passage, and varying soil material properties on dynamic response is accomplished using the substructure approach for the Zion nuclear power plant.

Task III.3.2 – Comparative Linear Analysis of Zion Multistructure Configuration

For comparison purposes, soil-structure interaction analysis of the Zion nuclear power plant will be performed by the substructure approach and the linear direct method of analysis.

Task III.3.3 – Comparative Analysis of Linear and Nonlinear Techniques

Soil-structure interaction analysis of a simple structure with characteristics approximating the Zion reactor building will be performed by the substructure approach, linear direct method of analysis, and nonlinear direct method of analysis.

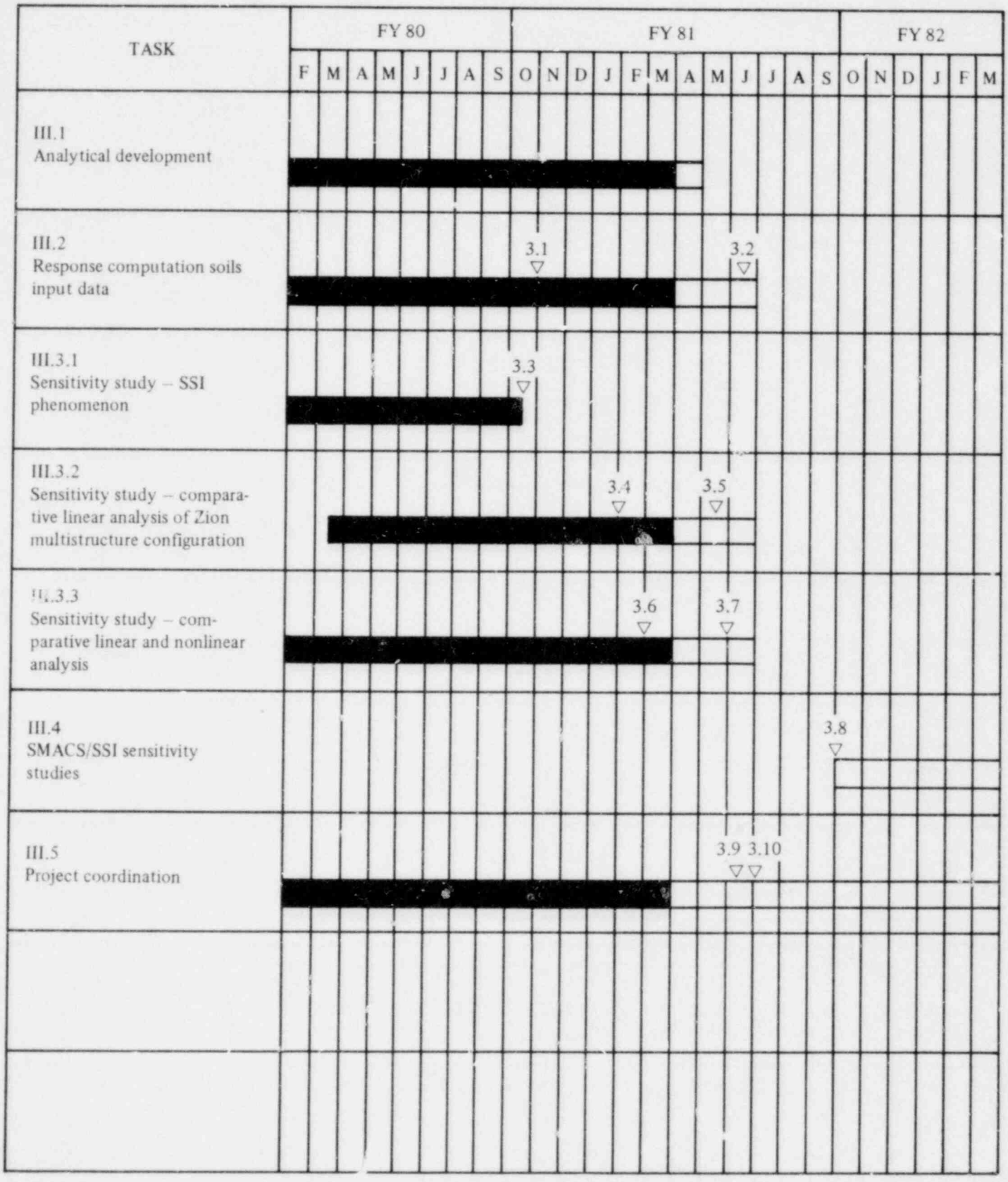
Task III.4 – SMACS/SSI Sensitivity Studies

The objective of the sensitivity studies is to investigate the adequacy of the assumptions of the Phase I model and their effect on the figures of merit–structural response and probability of radioactive release. Four key items require additional consideration: (1) soil property variations; (2) flexible basemat for the Zion Auxiliary-Fuel-Turbine building; (3) structure-to-structure interaction; and (4) the effect of local nonlinear behavior, i.e., soil-structure separation. In addition, the use of soil shear modulus and damping as an effective mechanism to incorporate uncertainty in SSI will be reevaluated. Special consideration will be given to their ability to represent random and modeling uncertainty distinctly as we wish to do in Phase II. Phase I results will be evaluated for genericness in light of the unique features of Zion with respect to SSI.

Task III.5 – Project Coordination

The purposes of this task are to provide guidance on technical, administrative, and budget matters for the project and to interface with the other SSMRP projects.

Project III Schedule



Project III Milestone Dates

	Milestone	Original Target Date	Revised Target Date	Completed Date
3.1	Complete soils input variability for SMACS	11-1-80		11-1-80
3.2	Documentation on response computations – draft report transmitted to NRC	2-28-81	6-15-81	
3.3	Documentation of SSI Sensitivity Studies – draft report transmitted to NRC	10-16-80		10-16-80
3.4	Linear FEM analysis complete	2-1-81		1-15-81
3.5	Documentation of linear FEM vs. substructure approach complete (Task III.3.2) – draft report transmitted to NRC	3-1-81	5-15-81	
3.6	Nonlinear analysis complete	3-1-81		3-1-81
3.7	Documentation of nonlinear sensitivity study complete (Task III.3.3) – draft report transmitted to NRC	4-1-81	6-1-81	
3.8	Initiate flexible foundation, soil property variations, and shear modulus damping study	10-1-81		
3.9	Documentation of Phase I results – draft report transmitted to NRC	6-15-81		
3.10	Documentation of Phase I results – camera-ready copy transmitted to NRC	7-1-81		

Project III Topical Reports

	Report*	Original Target Date	Revised Target Date	Completed Date
SSI-1.	Soil-Structure Interaction (SSI) Review Reports assessing the state-of-the-art of SSI analysis methodology, accuracy, uncertainties, and itemizing benchmark problems.	6-80		8-80

Project III Topical Reports
(continued)

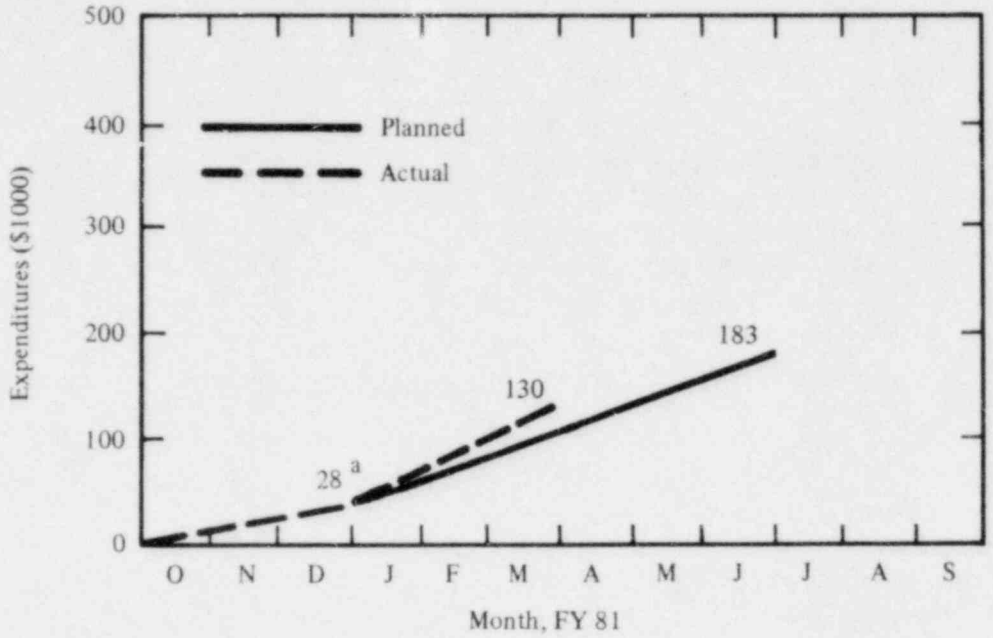
	Report*	Original Target Date	Revised Target Date	Completed Date
SSI-2.	Sensitivity Study of Soil-Structure Interaction phenomenon for structure-structure interaction, soil properties and soil configuration, wave passage, and azimuth effects for Zion nuclear power station using continuum analysis approach.	6-80		10-80
SSI-3.	Sensitivity study comparing linear finite element analysis with continuum analysis approach for Zion nuclear power station.	9-80	5-81	
SSI-4.	Summary of nonlinear analysis Task with evaluation of future work to be done for the development, verification, and comparison of nonlinear SSI methods with linear techniques.	11-80	5-81	

*Published reports are listed under Reports Generated by the SSMRP, following the Project VIII progress report.

Subcontractors

1. Prof. J. E. Luco, University of California, San Diego
2. Prof. J. Lysmer, University of California, Berkeley
3. Prof. J. Roesset, University of Texas
4. Prof. H. B. Seed, University of California, Berkeley
5. Prof. A. Veletsos, Rice University
6. Prof. H. L. Wong, University of Southern California
7. Prof. T. Hughes, California Institute of Technology
8. Prof. J. Prevost, Princeton University

Expenditures for FY 81, Project III, Soil-Structure Interaction (FIN A0130)



Phase I Budget Summary, Project III, Soil Structure Interaction (FIN A0130)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	22
Prior year (FY 79)	131
Last year (FY 80)	380
Current year (FY 81)	28
Total	561

a. End of Phase I.

Phase II Budget Summary, Project III, Soil-Structure Interaction (FIN A0130)

Year	Budgeted Amount ($1000)
Current year (FY 81)	155
Total	155

Project III, FY 81 Cost Breakdown

	Task	Amounts ($1000) FY 81 Budget[a]	YTD Spent[b]
III.1	Analytical development	5	5
III.2	Response computations soils input	30	5
III.3	Sensitivity studies		
	3.1 SSI phenomenon (CLASSI)	0	0
	3.2 Comparative linear analysis of Zion multistructure configuration	65	55
	3.3 Comparative analysis of linear and nonlinear techniques		
	3.3.1 Linear	30	20
	3.3.2 Nonlinear	33	30
III.4	SMACS/SSI Sensitivity Studies	0	0
III.5	Project coordination	20	15
	Totals	183	130

a. Proposed
b. As of March 31, 1981

PROJECT III. SOIL-STRUCTURE INTERACTION

A. Accomplishments

Task III.1, Analytical Development – The major effort for this task was implementing the compaction portion of the multisurface plasticity model in the computer program DYNA3D for the sensitivity study (Task III.4.3). Documentation of the algorithmic aspects of the model was completed by Prof. T. Hughes. The report on SCHEME was released.

Task III.2, Response Computation Soil Input Data – The work for this task concentrated on documentation of the Phase I activities with respect to SSI.

Task III.3, Sensitivity Studies – The comparison of structural response as computed by a direct method (FLUSH) and a substructure approach (CLASSI) neared completion during the quarter. All of the FLUSH analyses have been completed. The FLUSH analyses were performed at LBL and the data transferred to LLNL computer system for postprocessing and comparative plotting. In summary, the analyses performed are as follows: four cross-sections analyzed (one isolated reactor building and three multistructure cases); two sets of control motions of three components (one recorded earthquake and one synthetic); and response assuming free-field soil properties and iterated soil properties. Input for the second-stage analysis, basemat translations and rotations, is complete. The isolated reactor building has been analyzed by CLASSI and FLUSH and responses compared. The multistructure CLASSI analysis is ready to proceed upon receipt of the multistructure impedances and scattering matrices from Prof. H. L. Wong.

Documentation of this sensitivity study is complete up to the comparison of the multistructure response. An abbreviated report was submitted to SMiRT-6 containing response comparisons for the isolated reactor building.

Significant effort was expended during the quarter on three aspects of the nonlinear SSI analysis task: (1) soil amplification study in one dimension; (2) three-dimensional nonlinear SSI; and (3) documentation. In summary of the soil amplification study, steady state and synthetic earthquake motions were analyzed by equivalent linear and nonlinear models and the results compared. In all cases, the control motion was defined at an assumed bedrock 110 feet below the soil free surface. This soil configuration is typical of a number of midwestern nuclear power plant sites and, in particular, the Zion nuclear power plant. Four sinusoidal excitations, (0.1 g, 4 Hz), (0.2 g, 4 Hz), (0.1 g, 10 Hz), and (0.2 g, 10 Hz), were considered. These produced up to 0.6 g on the surface. Results from an equivalent linear analysis using SHAKE and a nonlinear analysis with DYNA2D were compared: free surface acceleration time histories and response spectra; and peak accelerations, shear stresses, and shear strains as a function of depth. Analysis of the soil column was extended to 15 synthetic time histories of 10 seconds duration and peak accelerations ranging from 0.1 g to 0.3 g at bedrock. Surface peak accelerations ranged up to 0.6 g. Again, comparisons between equivalent linear and nonlinear responses were made: mean of 5 time histories, free surface response spectra for 0.1 g, 0.2 g, and 0.3 g excitations; and peak accelerations, shear stresses, and shear strains for each of the 15 earthquakes as a function of depth. Two observations concerning the comparisons: the resonant frequencies of the soil column (as determined by each analysis) compared quite closely; the nonlinear response on the surface of the soil possessed more high frequency content than the equivalent linear case.

The nonlinear SSI of a structural system representative of a nuclear reactor building was completed. A uniform soil layer 110 feet in depth over a stiff bedrock was the soil configuration. The structure was embedded 1/3 of its height. Two independent structures were supported off the basemat to roughly simulate the containment shell and internal structure typical of PWR systems. Both structures were modeled with three-dimensional solid elements. The containment shell had a fundamental frequency of 4 Hz, the internal structure 14 Hz. The soil and structure paralleled the Zion configuration. The nonlinear model assumed a soil island 1,000 feet in diameter and 110 feet in depth. DYNA3D results

for a synthetic earthquake of 0.3 g at the bedrock were considered. Response in the soil and structures was computed. A comparison of structural response with linear analysis techniques is nearing completion.

Documentation of this study was initiated and is nearing completion. An abbreviated report was submitted to SMiRT-6 with emphasis on the soil amplification study.

Task III.4, SMACS/SSI Sensitivity Studies – There was no activity in this task during the quarter.

Task III.5, Project Coordination – Documentation of the Phase I activities with respect to SSI progressed during the quarter. Input was provided for the summary report, "Seismic Safety Margins Research Program–Overview," NUREG/CR-2015, Vol. 1 (also UCRL-53021, Vol. 1), which was completed. The in-depth documentation of SSI for Phase I was initiated.

Presentations were made to Prof. A. Cornell and NRC representatives on January 28, 1981 at LLNL, and to the ACRS Subcommittee on Extreme External Phenomena in Los Angeles on January 29-30, 1981.

A work scope for FY 82 was proposed during the quarter.

B. **Next Quarter**

We expect to accomplish the following in the next quarter:

1. Complete the analysis and documentation for Task III.3.2.
2. Complete documentation of Task III.3.3.
3. Complete Phase I detailed documentation.

C. **Concerns**

1. **Technical**

   None.

2. **Schedule**

   Task III.3.2 is further delayed because Professor Wong has not completed generation of the multistructure impedances and scattering matrices.

3. **Cost**

   None.

PROJECT IV
MAJOR STRUCTURE RESPONSE
FIN A0130

Personnel

NRC Program Manager: C. W. Burger
NRC Project Director: C. W. Burger
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: J. J. Johnson

Objectives

1. Using state-of-the-art analysis techniques, compute structural response due to earthquake motions. Structural response serves two main purposes: input motion for the subsequent subsystem analysis, and measures of response in an appropriate form for estimating structural failure.
2. Perform sensitivity studies to provide guidance to systems analysis and insight into the effects of uncertainty on structural response.

Task Description

Task IV.1 – Sensitivity Studies

Sensitivity studies on structural response include two main areas. One area is to investigate the sensitivity of structural response to variations in eigensystem, damping, and other uncertainties. The other is to evaluate alternative structural modeling techniques for Zion nuclear power plant structures of interest.

Task IV.2 – Response Computation Input

Develop the input necessary to perform response computations with SMACS for input to SEISIM; this work includes structural models accounting for uncertainties. Develop reduced structural models for SSI analysis.

Task IV.3 – Structural Damping

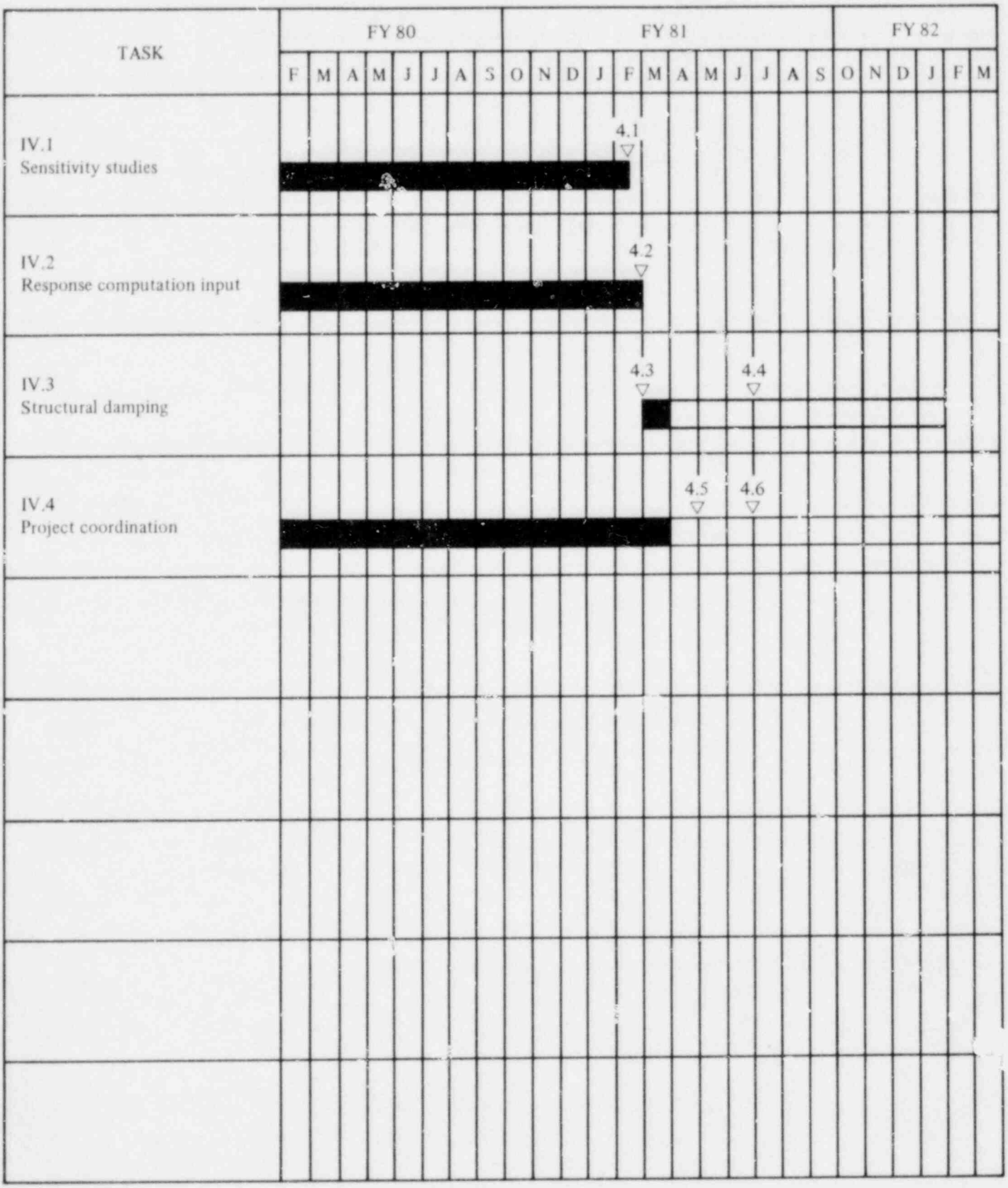
The objective here is to review and assess the structural damping data presently available. To this end, we will categorize existing data in natural groupings, identify deficiencies, and recommend additional testing.

The approach to the problem is: (1) data acquisition and assessment, which includes identification and acquisition of damping data; and (2) the review, evaluation, and categorization of the data. Particular emphasis will be placed on soil-structure interaction effects, structural types (material, type of construction, and plan-height), and the excitation (type and level).

Task IV.4 – Project Coordination

The purposes of this task are to provide guidance on technical, administrative, and budget matters for the project and to interface with the other SSMRP projects.

Project IV Schedule



Project IV Milestone Dates

	Milestone	Original Target Date	Revised Target Date	Completed Date
4.1	Documentation of structural modeling (STR-5) – draft report transmitted to NRC	2-15-81		3-31-81
4.2	Documentation complete	2-28-81		2-23-81
4.3	Initiate structural damping assessment – data acquisition and literature review	3-1-81		3-1-81
4.4	Initiate analytical study	7-1-81		
4.5	Documentation of Phase II results – draft report transmitted to NRC	5-1-81		
4.6	Documentation of Phase II results – camera-ready copy transmitted to NRC	7-1-81		

Project IV Topical Reports

	Report*	Original Target Date	Revised Target Date	Completed Date
STP-1.	General structural building response analysis review with special emphasis on damping and nonlinearity	2-80		2-28-80
STR-2.	Response of nuclear power plant structures to three input components.	6-80		4-24-80
STR-3.	Effect of structural damping on nuclear power plant structures. This is another study by expanding LLL/ DOR Seismic Conservatism Program (Parts III & IV) to typical nuclear power plant structures (Zion station).	6-80		6-30-80
STR-4.	Identify modeling variables, systematic or random, in the major structure response analysis. Rank in terms of their effect on the uncertainty of structural response.	3-80		3-7-80

Project IV Topical Reports
(continued)

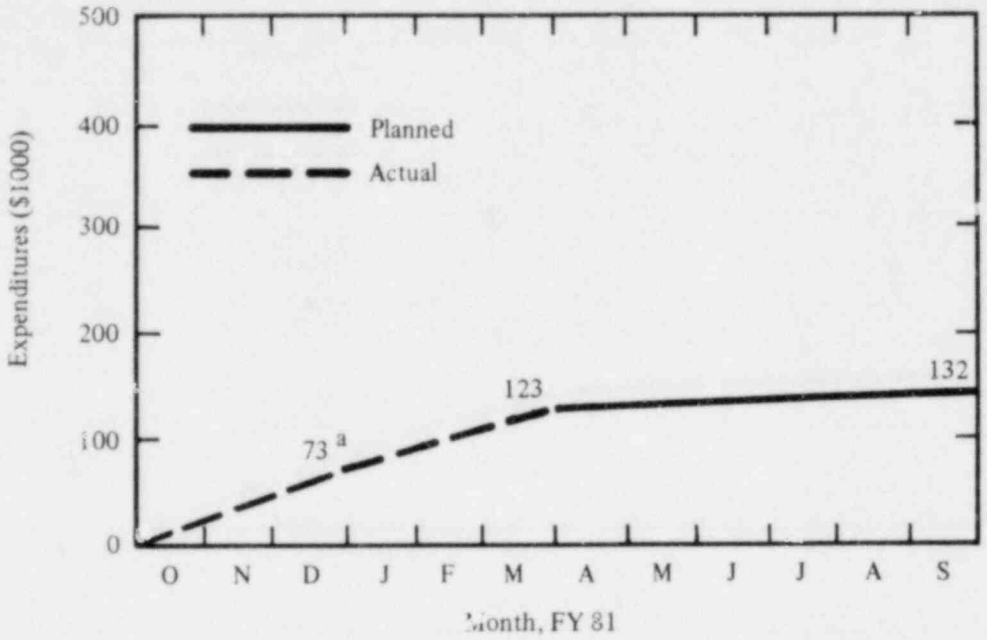
	Milestone	Original Target Date	Revised Target Date	Completed Date
STR-5.	Accuracy of finite element method and lumped mass method in seismic analysis.	9-80	2-81	3-81

*Published reports are listed under Reports Generated by the SSMRP, following the Project VIII progress report.

Subcontractors

1. SMA

Expenditures for FY 81, Project IV, Major Structure Response (FIN A0130)



Phase 1 Budget Summary, Project IV, Major Structure Response (FIN A0130)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	10
Prior year (FY 79)	233
Last year (FY 80)	328
Current year (FY 81)	73
Total	644

a. End of Phase 1.

Phase II Budget Summary, Project IV, Major Structure Response (FIN A0130)

Year	Budgeted Amount ($1000)
Current year (FY 81)	59
Total	59

Project IV, FY 81 Cost Breakdown

	Task	Amounts ($1000)	
		FY 81 Budget[a]	YTD Spent[b]
IV.1	Sensitivity studies	62	70
IV.2	Response computation input	30	31
IV.3	Structural damping	20	2
IV.4	Project coordination	20	20
	Totals	132	123

a. Proposed
b. As of March 31, 1981

PROJECT IV, MAJOR STRUCTURE RESPONSE

A. Accomplishments

Task IV.1, Sensitivity Studies – Editing of the final report on the study to quantify the variation in structural dynamic response introduced by model assumptions was completed. In the study, four different mathematical models were created to describe a portion of the AFT complex. The modeling idealizations were (1) a detailed finite-element model, (2) a detailed finite-element model with masses lumped at selected nodes, (3) a detailed finite-element model with the constraint of rigid floors, and (4) an equivalent beam model. Dynamic characteristics and response quantities were determined for the models and compared. Results indicate that large variations in both dynamic characteristics and response can be introduced by modeling assumptions when a need exists to reduce the number of dynamic degrees of freedom. A condensed version of the report was submitted to the SMiRT-6 conference.

Documentation of the SMACS sensitivity study is nearing release.

Task IV.2, Response Computation Input – A report describing the finite-element model of the Zion auxiliary/fuel-handling/turbine building complex was completed. A similar report was completed for the Zion reactor building model. These models were developed as part of the program's on-line calculations. The reports described the physical structures, the development of the mathematical models and their inherent assumptions, the modal analyses conducted with the models, and the inclusion of the modal data in the seismic analysis methodology.

Further analyses were conducted as part of the continuing fragilities review of the AFT complex. Ten time history analyses were performed using different earthquake records. The responses of selected shear walls and floor diaphragms in the auxiliary building were recorded for each analysis. The response quantities consisted of peak element force and moment values. The results were then transmitted to the Fragilities Project (Project VI).

Input was provided to the summary report, "Seismic Safety Margins Research Program Phase I Final Report–Overview," NUREG/CR-2015, Vol. 1 (also UCRL-53021, Vol. 1), which was completed. Input to Volume 1 consisted of a brief description of the structural models and summaries of the side studies. The in-depth documentation of this project was also completed with the models and side studies reported in significantly more detail. Interaction with the editor is ongoing.

Task IV.3, Structural Damping – The structural damping study was initiated during the quarter.

Task IV.4, Project Coordination – Presentations were made to Prof. A. Cornell and NRC representatives on January 28, 1981 at LLNL and to the ACRS Subcommittee on Extreme External Phenomena in Los Angeles on January 29-30, 1981.

A work scope for FY 82 was proposed during the quarter.

B. Next Quarter

Our objectives for the next quarter are as follows:

1. Release documentation of the modeling sensitivity study.
2. Release Phase I documentation.
3. Continue the damping study.

C. Concerns

1. **Technical**
   None.
2. **Schedule**
   None.
3. **Cost**
   None.

PROJECT V
SUBSYSTEM RESPONSE
FIN A0126

Personnel

NRC Program Manager: C. W. Burger
NRC Project Manager: J. J. Burns
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: T. Y. Chuang

Objectives

1. Compute response parameters of subsystems, given the input environment (e.g., subsystem support motion) for components and systems whose failure leads to an accident condition. These components and systems will be identified on the fault trees. Response parameters will be consistent with fragility descriptions.
2. Perform sensitivity studies on subsystem response to provide guidance to systems analysis and insight into the effects of uncertainty on the response.

Task Description

Task V.1 – Piping Models and Fault Tree Coordination Development

Our objective here is to develop the information necessary to determine the dynamic response of safety systems. The information will include dynamic models for reanalysis and estimates of response from design results. We will coordinate the fault trees of these systems with calculated responses. We will also identify the support location of safety systems and coordinate with Project IV, Major Structure Response.

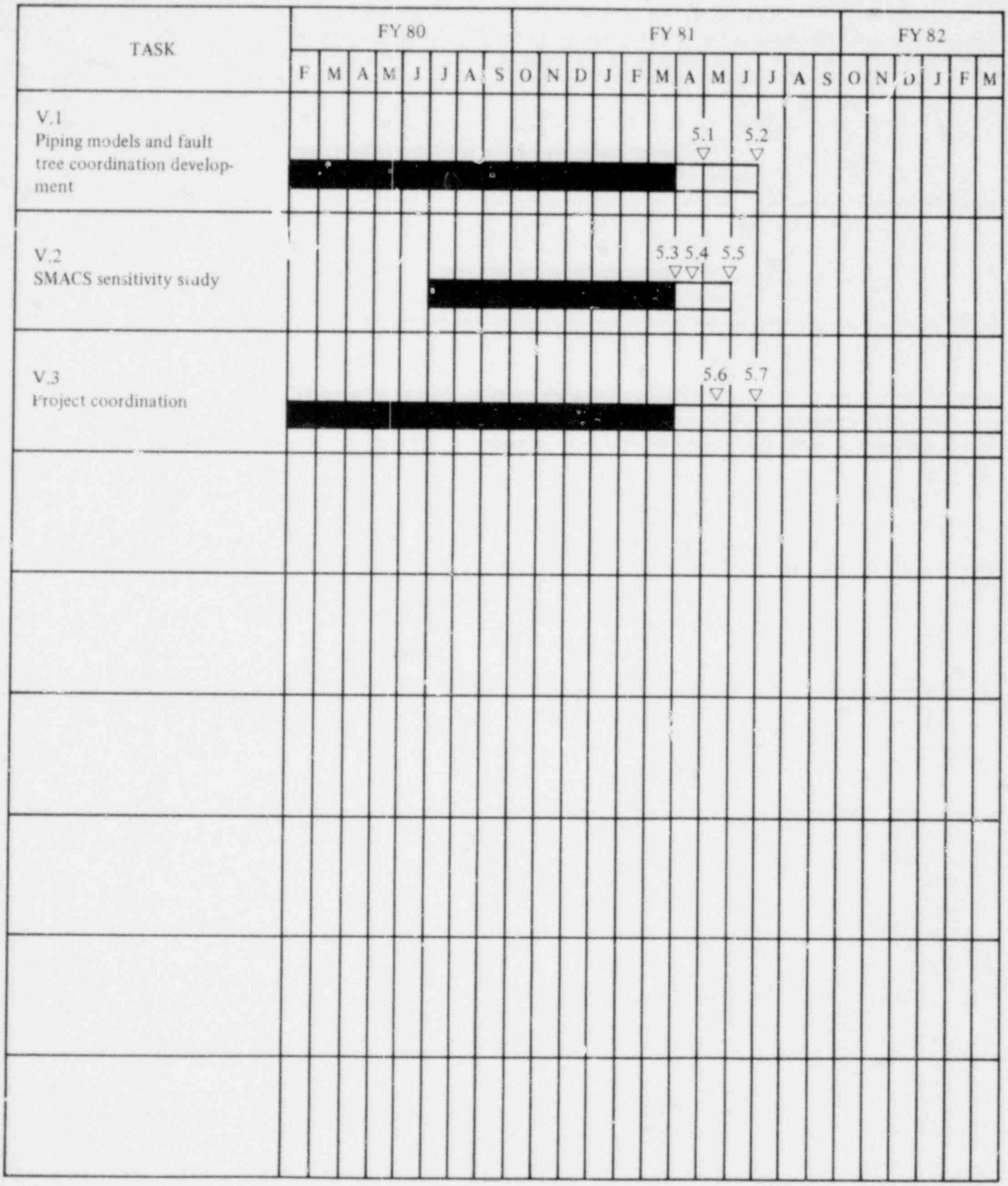
Task V.2 – SMACS Sensitivity Study

Our objective in the SMACS sensitivity study is to determine which of the seismic methodology chain (SMC) areas contributes most to the uncertainty in the subsystem response. The responses considered are, for example, peak moments at various points in the piping system. All areas of the SMC will be considered, i.e., (1) seismic input, (2) soil-structure interaction, (3) major structure response, and (4) subsystem response.

Task V.3 – Project Coordination

The purposes of this task are to provide guidance on technical, administrative, and budget matters for the project and to interface with the other SSMRP projects.

Project V Schedule



Project V Milestone Dates

	Milestone	Original Target Date	Revised Target Date	Completed Date
5.1	Piping models developed	5-1-81		
5.2	Fault trees coordinated	7-1-81		
5.3	Complete SMACS analyses incorporating parameter variations	10-31-80	3-31-81	3-31-81
5.4	Complete statistical analysis	11-10-80	4-17-81	
5.5	Documentation for SMACS sensitivity study – draft report transmitted to NRC	11-30-80	5-31-81	
5.6	Documentation of Phase I results – draft report transmitted to NRC	5-15-81		
5.7	Documentation of Phase I results – camera-ready copy transmitted to NRC	7-1-81		

Project V, Topical Reports

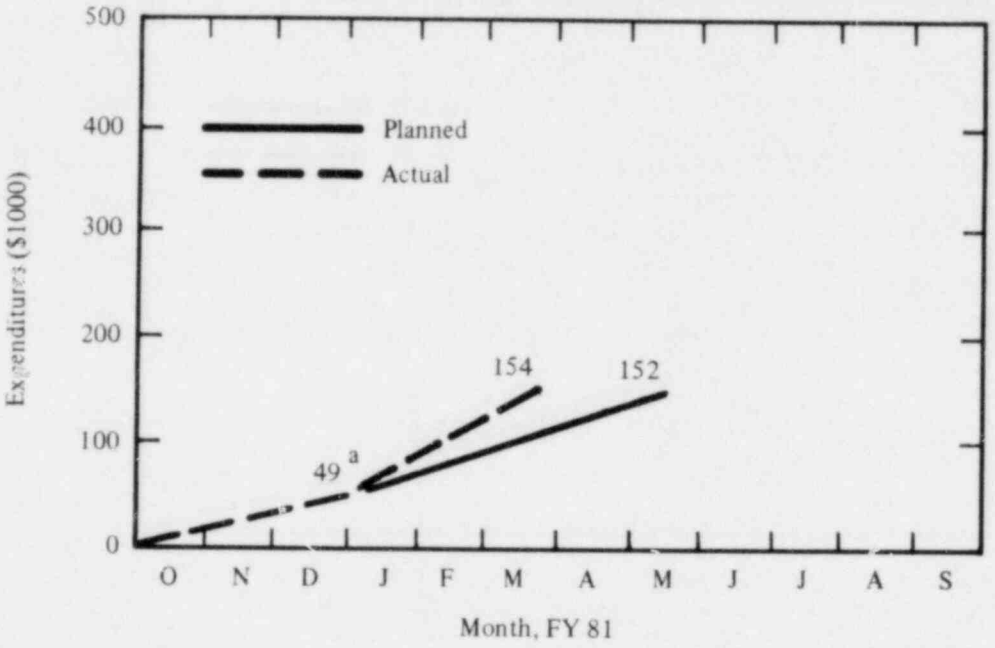
	Report[a]	Original Target Date	Revised Target Date	Completed Date
SUB-1.	Subsystem Response Review Reports assessing the state-of-the-art of subsystem response determination, accuracy, and uncertainties.	2-80		3-80
SUB-2.	Sensitivity study investigating the effects of uncertainties on subsystem response.	10-80	Note b	
SUB-3.	Sensitivity study on nonlinear analysis of a key safety system.	10-80	Note c	
SUB-4.	Sensitivity study to rank contributors to uncertainty in subsystem response.	11-80	5-81	

a. Published reports are listed under Reports Generated by the SSMRP, following the Project VIII progress report.
b. SUB-2 is now included in SUB-4.
c. SUB-3 is deferred to FY 82.

Subcontractors

1. Engineering Decision Analysis Company (EDAC)
2. NSC/Quadrex
3. EG&G
4. Sargent & Lundy (S&L)
5. Structural Mechanics Associates (SMA)

Expenditures for FY 81, Project V, Subsystem Response (FIN A0126)



Phase I Budget Summary, Project V, Subsystem Response (FIN A0126)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	6
Prior year (FY 79)	190
Last year (FY 80)	377
Current year (FY 81)	49
Total	622

a. End of Phase I.

Phase II Budget Summary, Project V, Subsystem Response (FIN A0126)

Year	Budgeted Amount ($1000)
Current year (FY 81)	103
Total	103

Project V, FY 81 Cost Breakdown

	Task	Amounts ($1000)	
		FY 81 Budget[a]	YTD Spent[b]
V.1	Piping models and fault tree coordination development	30	20
V.2	SMACS sensitivity study	60	84
V.3	Project coordination	62	50
	Totals	152	154

a. Proposed.
b. As of March 31, 1981.

PROJECT V, SUBSYSTEM RESPONSE

A. Accomplishments

Task V.1, Piping Models and Fault Tree Coordination Development – The SMACS analysis of all thirteen dynamic models for Phase I has been completed. The results showed a very large variation in the seismic responses of piping systems (e.g., standard deviation of the logarithm of responses is greater than 1.0 for the resultant moments in some of the pipes). Two piping models have been created. The first model is for the AFW piping between steam generator 1-B and the corresponding containment penetrations. The second model is for the AFW piping between steam generator 1-C and the corresponding containment penetrations.

Task V.2, SMACS Sensitivity Study – Analysis of the set of SMACS runs completed in the previous quarter, using 22 real earthquake time histories, showed that a set of 22 responses at each node did not give us enough statistical accuracy for the questions we are asking, given the large model (four SMC areas) and sometimes complex response behavior. Therefore, a new series of SMACS runs was started using a set of 90 synthetic earthquake time histories. This series used subsystem models from the SMACS on-line calculations: the same two models (AFW and RCL) as in the prior sensitivity study but with an expanded list of response points, and an RHR/SI model in the auxiliary building. During the quarter, the series of SMACS runs and much of the statistical analysis were completed. For the assumed input uncertainties, the subsystem area of the SMC turns out to be the most important contributor to the subsystem response (acceleration or moment) uncertainties. Consideration of the response's sensitivity to its inputs indicates that the subsystem frequency variation in particular is important. Whether the other SMC areas should be lower in importance, as our results indicate, depends on whether most of the important SMC uncertainties are captured in our model and its input variations. A review of the extent to which this has been achieved is in progress, based on the results we have calculated in this quarter.

Task V.3, Project Coordination – Interfacing with other SSMRP projects is being carried on. A presentation was made during the quarter to the Advisory Committee on Reactor Safeguards on January 29-30, 1981 at Los Angeles. The draft for Project V for the SSMRP Phase I final report, "Volume 1 – Overview," has been completed. The rough draft of "Volume 6 – Subsystem Response" has been completed and all necessary figures and tables have been generated.

B. Next Quarter

In the next quarter we plan to:

1. Complete the SMACS sensitivity study.
2. Complete the Phase I report.
3. Complete the piping models of the auxiliary feedwater system.

C. Concerns

1. **Technical**
   None.
2. **Schedule**
   None.
3. **Cost**
   None.

PROJECT VI
FRAGILITIES
FIN A0126

Personnel

NRC Program Manager: C. W. Burger
NRC Project Manager: J. J. Burns
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: M. P. Bohn

Objectives

1. Complete and document the fragility relations for Phase I.
2. Perform a detailed evaluation of the preliminary fragility relations developed and used in Phase I, looking in particular at (a) the adequacy for the generic categorization scheme and (b) the associated uncertainty factors.
3. Benchmark the Phase I fragility curves against data known to exist, and seek and incorporate new data.
4. Separate fragilities uncertainty into random and modeling components.

Task Description

General Information

The major effort beginning in FY 81 and extending into FY 82 will be to benchmark the fragility curves developed from the expert opinion survey performed in FY 80. A major part of this effort will be to obtain data from sources identified during the expert opinion survey and to seek new sources of data existing outside the nuclear community. To help us understand the data and its relation to the preliminary fragility curves developed in Phase I of the SSMRP, a number of consultants (two per generic fragilities category) will be retained. The experts will be selected from among those who are both interested in and capable of participating further in the expert opinion survey.

Task VI.1 – Complete Phase I Fragilities

All data generated by the expert opinion survey and analyses of generic components by our consultants will be combined and put into cumulative probability function format for use in the Phase I SEISIM computations. Both normal and lognormal forms will be generated. All fragilities development will be documented.

Task VI.2 – Data Gathering and Reduction

A major effort to obtain and correlate existing fragility data will be made. Data will be sought from two main sources. The first source consists of the component manufacturers and independent testing laboratories which, during the expert opinion survey, indicated they had access to failure data. The second source will consist of known testing programs associated with U. S. military site-hardening and crashworthiness programs. The data obtained will be compiled and compared with the preliminary fragility curves developed from expert opinion during Phase I. The data will be used to benchmark the preliminary fragility curves developed in Phase I and to resolve a number of questions which have been identified in Phase I, as described in Task VI.3 below.

Task VI.3 – Benchmark and Revise Fragility Descriptions

A number of questions concerning the results of the expert opinion survey have been identified, whose resolution is considered essential before using the fragility curves in a final calculation of the magnitude of seismic hazard. Especially important are the following questions. Are the identified generic categories too broad, and would the present uncertainty in fragility be reduced by a finer resolution in generic category definition? Is the wide spread in fragility levels associated with different definitions of failure from different expert opinion respondents? Are the independent fragility parameters truly those most applicable to failure, or were they chosen because they were most convenient for specification of qualification testing?

To answer these and other questions of a fundamental nature and to benchmark the fragility curves developed for Phase I, two experts having experience with the performance of the components in question will be identified for each generic category. These experts will review the data obtained in Task 1 and new data as it becomes available. They will also review their own data sources and assist in evaluating the data to determine its applicability to seismic loading conditions and to resolving the questions raised above.

Task VI.4 – Random vs. Modeling Uncertainty

In order to place uncertainty bounds on the final risk probabilities, it is necessary to separate the variance for each fragility curve into components due to (1) random uncertainty (which cannot be further reduced by additional testing or analysis), and (2) due to modeling, or systematic, uncertainty (which can be further reduced by testing or analysis). This has already been done for each independent mode in the expert opinion survey results. However, a valid statistical method must be devised to combine these independent modes into a single effective fragility curve with meaningful bounds.

Task VI.5 – Fragilities Panel

The present panel will continue to review and guide the entire fragilities effort. The panel consists of:

Spencer H. Bush	Battelle Pacific Northwest Laboratories
Robert P. Kennedy	Structural Mechanics Associates
George D. Shipway	Wyle Laboratories
John D. Stevenson	Structural Mechanics Associates
Jerrell M. Thomas	Failure Analysis Associates
Peter P. Zemanick	Westinghouse Electric Corporation

The panel made an outstanding contribution to the direction and scope of the fragilities definition work performed in Phase I and their continued involvement is considered essential.

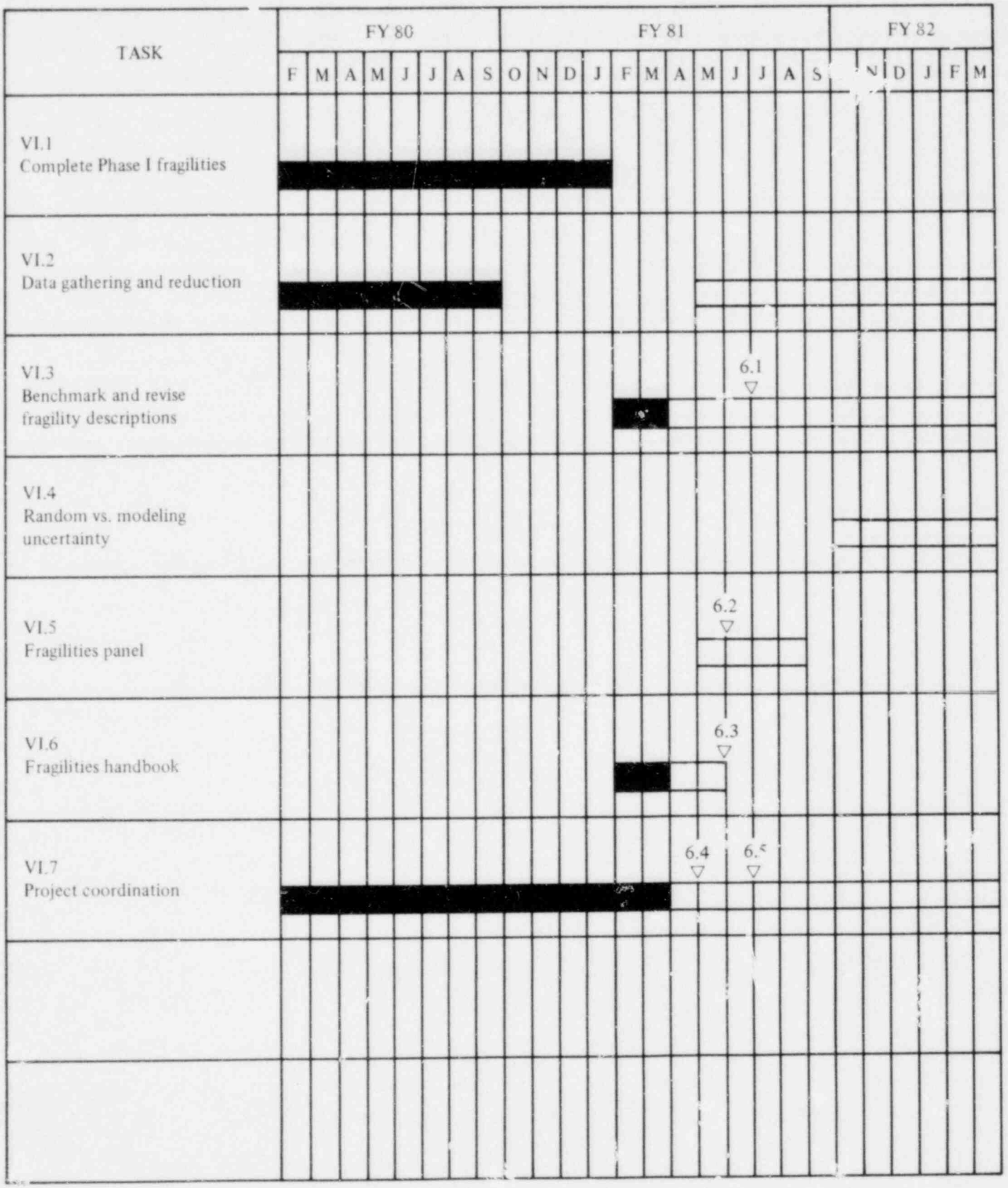
Task VI.6 – Fragilities Handbook

After incorporating all new data from Task VI.1, and after the reevaluation and revision of the fragilities in Task VI.2, the final resulting fragility curves will be documented in an update of the Phase I Fragility Handbook.

Task VI.7 – Project Coordination

The purpose of this task is to provide coordination between projects within the SSMRP and coordination with outside projects whose work is related to the tasks and goals of the SSMRP.

Project VI Schedule



Project VI Milestone Dates

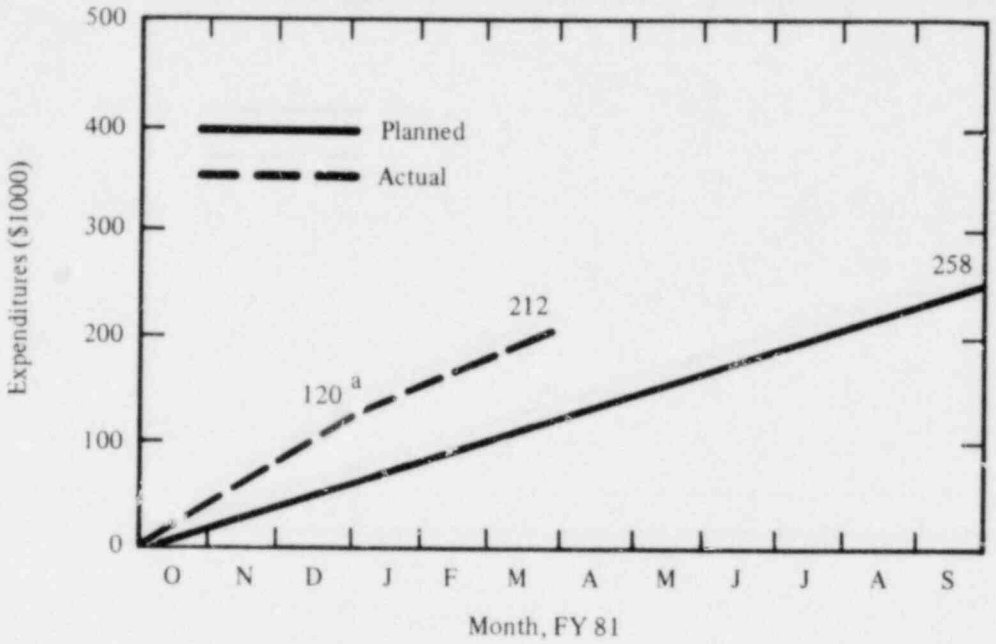
	Milestone	Original Target Date	Revised Target Date	Completed Date
6.1	Experts identified for Phase II fragilities reevaluation and invited to participate	7-1-81		
6.2	Phase I fragilities sent to Fragilities Panel	6-1-81		
6.3	Phase I Fragilities Handbook – draft copy transmitted to NRC	6-1-81		
6.4	Documentation of Phase I results – draft report transmitted to NRC	5-1-81		
6.5	Documentation of Phase I results – camera-ready copy transmitted to NRC	7-1-81		

Project VI Topical Reports

	Report[a]	Original Target Date	Revised Target Date	Completed Date
FRA-1	Final Report, Phase I (Draft to NRC)	4-81	5-81	
FRA-2	Fragilities Handbook[b] (Draft to NRC)	9-80	6-81	

a. Published reports are listed under Reports Generated by the SSMRP, following the Project VIII progress report.
b. Combination of reports previously listed as FRA-2 and FRA-3.

Expenditures for FY 81, Project VI, Fragilities (FIN A0126)



Phase I Budget Summary, Project VI, Fragilities (FIN A0126)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	28
Prior year (FY 79)	183
Last year (FY 80)	388
Current year (FY 81)	120
Total	719

a. End of Phase I.

Phase II Budget Summary, Project VI, Fragilities (FIN A0126)

Year	Budgeted Amount ($1000)
Current year (FY 81)	138
Total	138

Project VI, FY 81 Cost Breakdown

	Task	Amounts ($1000) FY 81 Budget[a]	YTD Spent[b]
VI.1	Complete Phase I fragilities	183	183
VI.2	Data gathering and reduction	7	0
VI.3	Benchmark and revise fragility descriptions	22	10
VI.4	Random vs. modeling uncertainty	0	0
VI.5	Fragility panel	9	0
VI.6	Fragilities handbook	10	5
VI.7	Project coordination	27	14
	Totals	258	212

a. Proposed
b. As of March 31, 1981.

PROJECT VI. FRAGILITIES

A. Accomplishments

The major activity for the first month of this quarter was the analysis of the component and building failure probabilities obtained from the Phase I SEISIM code calculations. These failure probabilities were compared with hand calculations for selected buildings and components to ensure that the code results were accurate and that the correspondence between responses and fragility categories was correct. Based on these comparisons several minor errors were corrected.

The second major activity was preparation for the ACRS presentations made on January 28-29, 1981. The preparation included comparisons of our probability-of-failure predictions for components with other studies (especially with the ongoing LLNL Load Combination Program results).

One question raised at the ACRS meeting was whether the number of pipe cross-sections considered in the failure calculation for a length of piping could affect the computed failure probability. (It was noted at the meeting that this could not happen in the Phase I results presented because the probability of failure of a pipe run was taken as the probability of failure at its "weakest" link.) A preliminary investigation into this question was begun in this quarter, and initial results showed that, for the variances in response and fragility computed in Phase I, the probability of pipe failure of an active pipe run approached the weakest link probability for high correlation between fragilities. This work is being continued.

The balance of the activity in this quarter consisted of writing the Fragility section of the Phase I final report, preparation of a paper to be presented at the 6th SMiRT conference next summer, and final review of two contractor reports.

B. Next Quarter

The Fragilities Handbook document will be completed and released, and initial work on the SONGS fragility development will begin.

C. Concerns

1. **Technical**
   None.
2. **Schedule**
   None.
3. **Cost**
   Funds are getting low for the remainder of FY 81.

PROJECT VII
SYSTEMS ANALYSIS
FIN A0126

Personnel

NRC Program Manager: C. W. Burger
NRC Project Manager: J. J. Burns
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: G. E. Cummings/J. E. Wells

Objectives

1. Develop a computational procedure for estimating the relative importance of the factors contributing to reactor seismic safety. The procedure, which will give insights into seismic safety requirements, will be used to calculate failure and radioactive release probabilities and their uncertainties over a range of earthquake levels.
2. Develop event-tree/fault-tree models of nuclear power plants for incorporation into the computational procedure. These models will be used to calculate the required failure and release probabilities. For Phase 1 of this program, event-tree/fault-tree models of the Zion 1 Nuclear Power Plant are being constructed.

Task Descriptions

Task VII.1 – System Analysis Methods

This task is to provide support for the event-tree/fault-tree methodology being used to predict seismically induced failure and release probabilities used by SSMRP. A review of design error frequency at Zion 1 is under way; so is a study of methods for incorporating design error effects into the SSMRP methodology. In progress are studies of the special properties of distributions that can be used to provide better fits to sparse data. Also in progress are studies to determine suitable variance reduction techniques applicable to multivariate stress-strength analysis as used to calculate failure probabilities in this computational procedure.

Task VII.2 – Probabilistic Computation Techniques

The purpose of this task is to provide support relating to the statistical methods used in the computational procedure. Studies are under way to access methods for performing sensitivity studies to accomplish program objectives.

Task VII.3 – Event-Tree/Fault-Tree Development

The objective of this task is to construct an event-tree/fault-tree model of a nuclear power plant for incorporation into the computational procedure developed in Task VII.4. This model will be used by the computational procedure for estimating failure and radioactive release probabilities and for dominance ranking of events. The Zion 1 nuclear power plant was modeled in Phase I of this program.

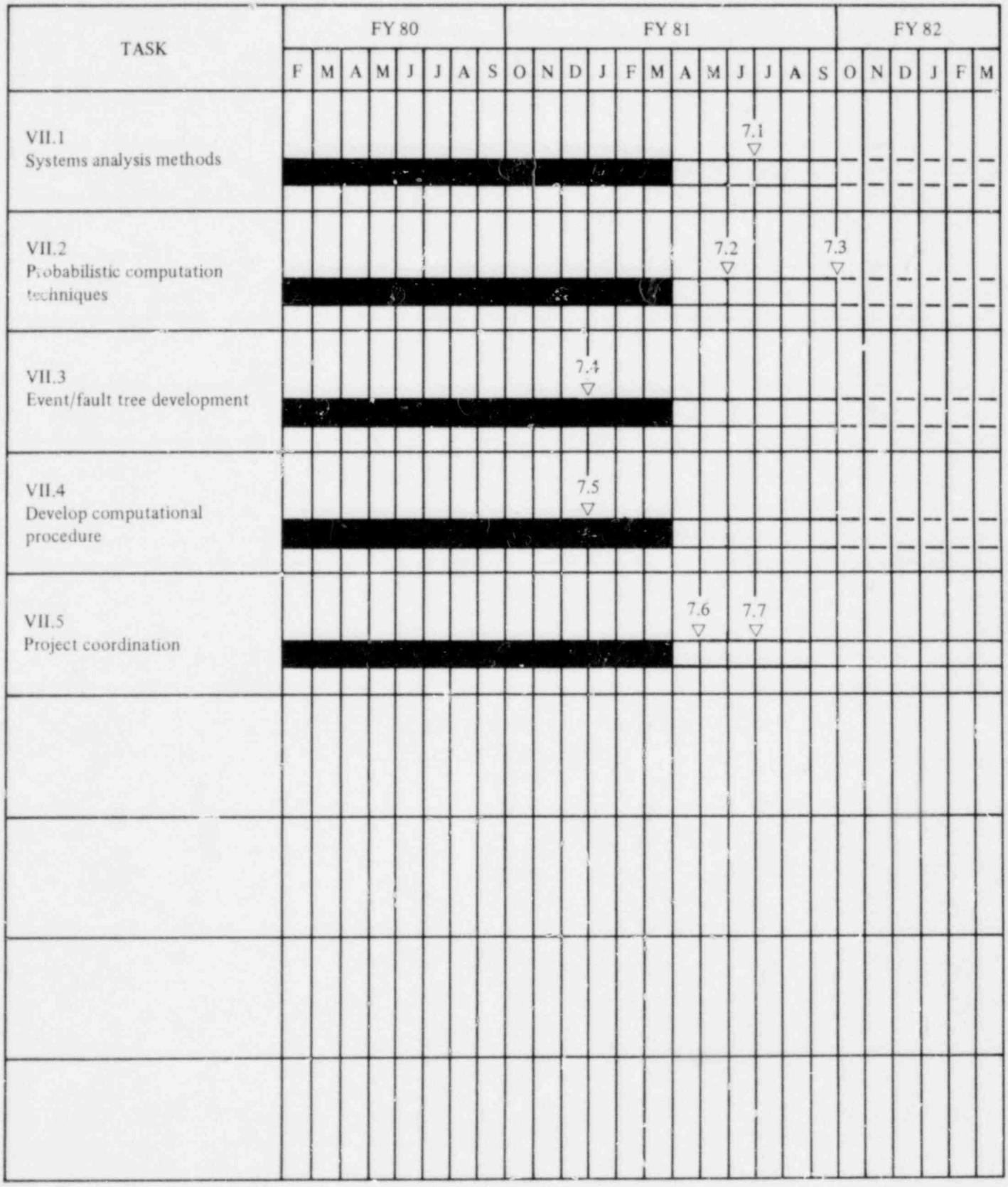
Task VII.4 – Develop Computational Procedure

The objective of this task is to develop a computational procedure (named SEISIM) that calculates failure and release probabilities and generates the dominance ranking of events so as to give insights into seismic safety requirements of nuclear plants. Inputs will be in terms of equipment and structural response, fragilities, and the cut set representation of event and fault tree models.

Task VII.5 – Project Coordination

The purposes of this task are to provide guidance on technical, administrative, and budget matters for the project and to interface with the other SSMRP projects.

Project VII Schedule



Project VII Milestone Dates

	Milestone	Original Target Date	Revised Target Date	Completed Date
7.1	Variance reduction – draft copy transmitted to NRC	7-1-81		
7.2	Probabilistic techniques report – draft copy transmitted to NRC	6-1-81		
7.3	Sensitivity analysis report – draft copy transmitted to NRC	10-1-81		
7.4	Initial event/fault tree complete	1-1-81		9-1-80
7.5	SEISIM demonstration	1-1-81		1-27-81
7.6	Documentation of Phase I results – draft report transmitted to NRC	5-1-81		
7.7	Documentation of Phase I results – camera-ready copy transmitted to NRC	7-1-81		

Project VII Topical Reports

	Report*	Original Target Date	Revised Target Date	Completed Date
SYS-1.	Description of computational methodologies for prediction of core melt probabilities in a nuclear power plant due to seismic events.	4-79		4-79
SYS-2.	Description of a design concept for calculating probability of radioactive release, core melt, safety system, structural and component failure probabilities from a set of nuclear plant seismic responses.	8-79		6-79
SYS-3.	Operating Seismic Safety Analysis Code - SEISIM (Option 1 only).	1-81		12-80
SYS-4.	Accident sequences as the result of earthquakes at Zion 1 nuclear power plant.	10-79		8-79

Project VII Topical Reports
(continued)

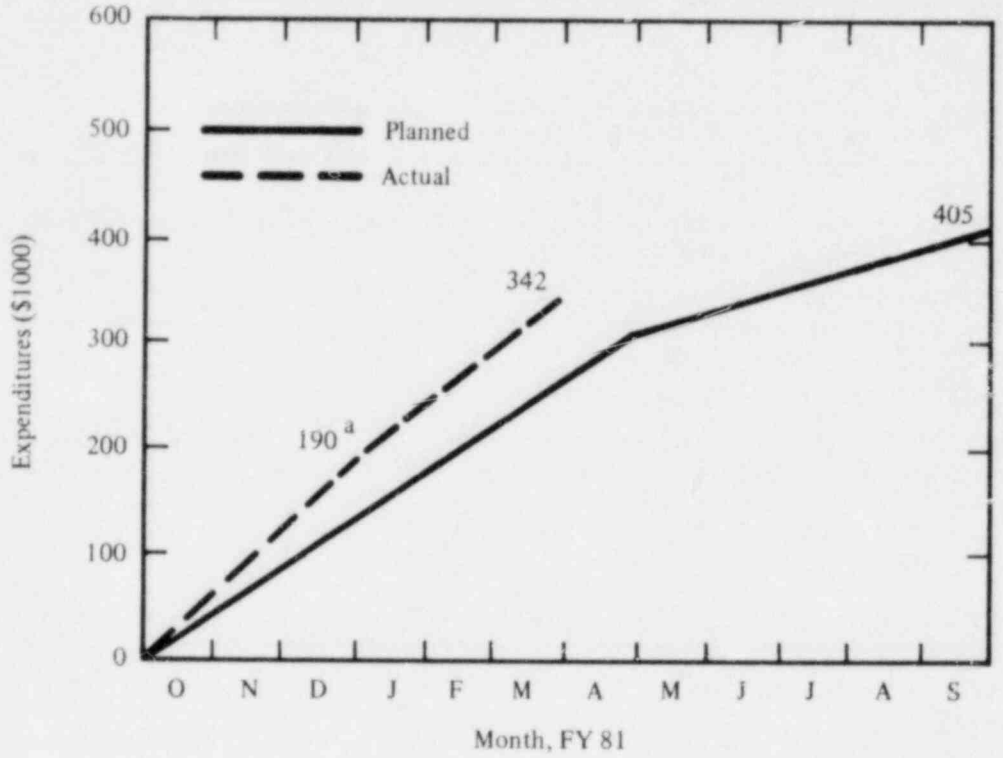
	Report*	Original Target Date	Revised Target Date	Completed Date
SYS-5.	Fault trees of some safety systems of Zion 1 nuclear plant (auxiliary feedwater system, service water system, emergency core cooling system, residual heat removal system, parts of the electric power and instrumentation and control system pertaining to the above).	1-81		9-80

*Published reports are listed under Reports Generated by the SSMRP, following the Project VIII progress report.

Subcontractors

1. College of Engineering
   Operations Research Center
   University of California, Berkeley
   (Prof. Ron Wolff) (Task VII.2)
2. J. H. Wiggins Co. (Task VII.4)
   Redondo Beach, CA
3. School of Engineering and Applied Science
   University of California, Los Angeles
   (Dr. George Apostolakis) (Tasks VII.1 and VII.3)
4. Science Applications, Inc.
   Bethesda, MD and
   Palo Alto, CA (Task VII.3)

Expenditures for FY 8 , Project VII, Systems Analysis (FIN A0126)



Phase I Budget Summary, Project VII, Systems Analysis (FIN A0126)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	26
Prior year (FY 79)	519
Last year (FY 80)	520
Current year (FY 81)	190
Total	1255

a. End of Phase I.

Phase II Budget Summary, Project VII, Systems Analysis (FIN A0126)

Year	Budgeted Amount ($1000)
Current year (FY 81)	215
Total	215

Project VII, FY 81 Cost Breakdown

	Task	Amounts ($1000)	
		FY 81 Budget[a]	YTD Spent[b]
VII.1	Systems analysis methods	45	33
VII.2	Probabilistic computation techniques	101	83
VII.3	Event/fault tree development	64	61
VII.4	Develop computational procedure	155	140
VII.5	Project coordination	40	25
	Totals	405	342

a. Proposed
b. As of March 31, 1981

PROJECT VII, SYSTEMS ANALYSIS

A. Accomplishments

During the reporting period, the J. H. Wiggins Company completed the user's manual for Option 1 of the SSMRP probabilistic analysis code, SEISIM. Option 1 of SEISIM will provide a completely analytical computational procedure using normal or lognormal distribution functions to characterize the input data. The data is passed to SEISIM to compute means, standard deviations, and correlations. Also included as input are accident sequence expressions in the form of minimal cut sets of safety system components. Output from Option 1 will be the failure and release probabilities as well as importance rankings of accident sequences and safety systems. Also completed by the J. H. Wiggins Company was a regression module that analyzes the output of SEISIM to determine the effects over a range of earthquakes.

Analysis of the Zion 1 fault trees was completed. Reduction of the trees was completed by eliminating high order cut sets and by combining failure modes. The level of detail in the fault trees before reduction appears appropriate should more in-depth studies be necessary. It also ensures that unwarranted simplifications will not be made. All the accident sequences used in Phase I of SSMRP were completed. These accident sequences were used in the SEISIM demonstration, which was also completed this quarter.

The System Analysis Project Phase I final report is currently under way. Volume 1 of this report was completed during the quarter.

B. Next Quarter

During the next quarter, we expect to complete the Systems Analysis Project Phase I report. In addition, we will begin our sensitivity analysis effort using the data generated in Phase I. Numerous enhancements to the SEISIM computer code are planned and many will be implemented during the next quarter.

C. Concerns

1. Technical

We are making needed adjustments as we get into the details of SEISIM and fault tree construction. Since the detailed fault trees contain a large number of cut sets, we have to reduce the trees in a rational manner before entering the data into SEISIM. We have always envisioned the need for such reduction. Consequently, we have anticipated doing this on a probabilistic basis and by combining some failure modes. Continued attention to this area is warranted.

We have had internal discussions on such matters as the types of sensitivity studies to be undertaken, methods to be used, parameters to be varied, number of runs required, and handling of modeling vs. random uncertainties. A derivative option (DERIV) is available in SEISIM to calculate point derivatives, and some off-line capability involving regression analysis is being developed at LLNL. More needs to be done to establish firmly the type and number of sensitivity studies, but only minimal effort (less than 1/2 man-year) is being applied to the task this year.

Only Option 1 of SEISIM will be developed this year. In this option, propagation of uncertainties is by covariance matrix manipulation and limited to normal and lognormal distributions of variables. These distributions will be described by first and second moments only (means and standard deviations). This limitation could present problems because of its inflexibility.

This year, fault trees will not be developed for all of the systems identified on the event trees. They were developed only for those judged as most important to seismic safety. Probabilities of failure for the remaining systems were estimated on the basis of available data. If some of them turn out to be important contributors to the probability of release, fault trees will have to be developed for them.

2. **Schedule**

Work to develop techniques for conducting sensitivity studies at LLNL continues. A report discussing the probabilistic techniques that have been studied was completed. This report discusses simulation stopping rules, system interference analysis, estimation of fragility functions, and variance reduction techniques.

3. **Cost**

The spending rate was higher than planned at the beginning of the year because of the increased activity involved in solving all the fault trees, generating the accident sequences, and running the SEISIM computer code.

PROJECT VIII, SMACS AND BE-EMS
FIN A0126 and A0130

Personnel

NRC Program Manager: C. W. Burger
NRC Project Manager: C. W. Burger
Contractor: Lawrence Livermore National Laboratory
LLNL Project Manager: J. J. Johnson

Objectives

1. Develop computer software entitled Seismic Methodology Analysis Chain with Statistics (SMACS) to link together the seismic input, soil structure interaction, structural response, and subsystem structural response calculations. The output of SMACS will be structural and subsystem response for comparison purposes and input to systems analysis.
2. Execute SMACS.
3. Compare best-estimate and evaluation methodologies, seismic (BE-EMS) in the links of the seismic methodology chain.

Task Description

Task VIII.1 – Seismic Methodology Analysis Chain with Statistics (SMACS) Development

Task VIII.1 is to develop an initial version of SMACS to perform interaction, major structural response, and subsystem structural response. The initial version will link together existing software with new developments as necessary.

Task VIII.2 – Execution of SMACS

Task VIII.2 is to execute SMACS for Zion, including the complete range of peak acceleration and spectral shape parameters and random uncertainties.

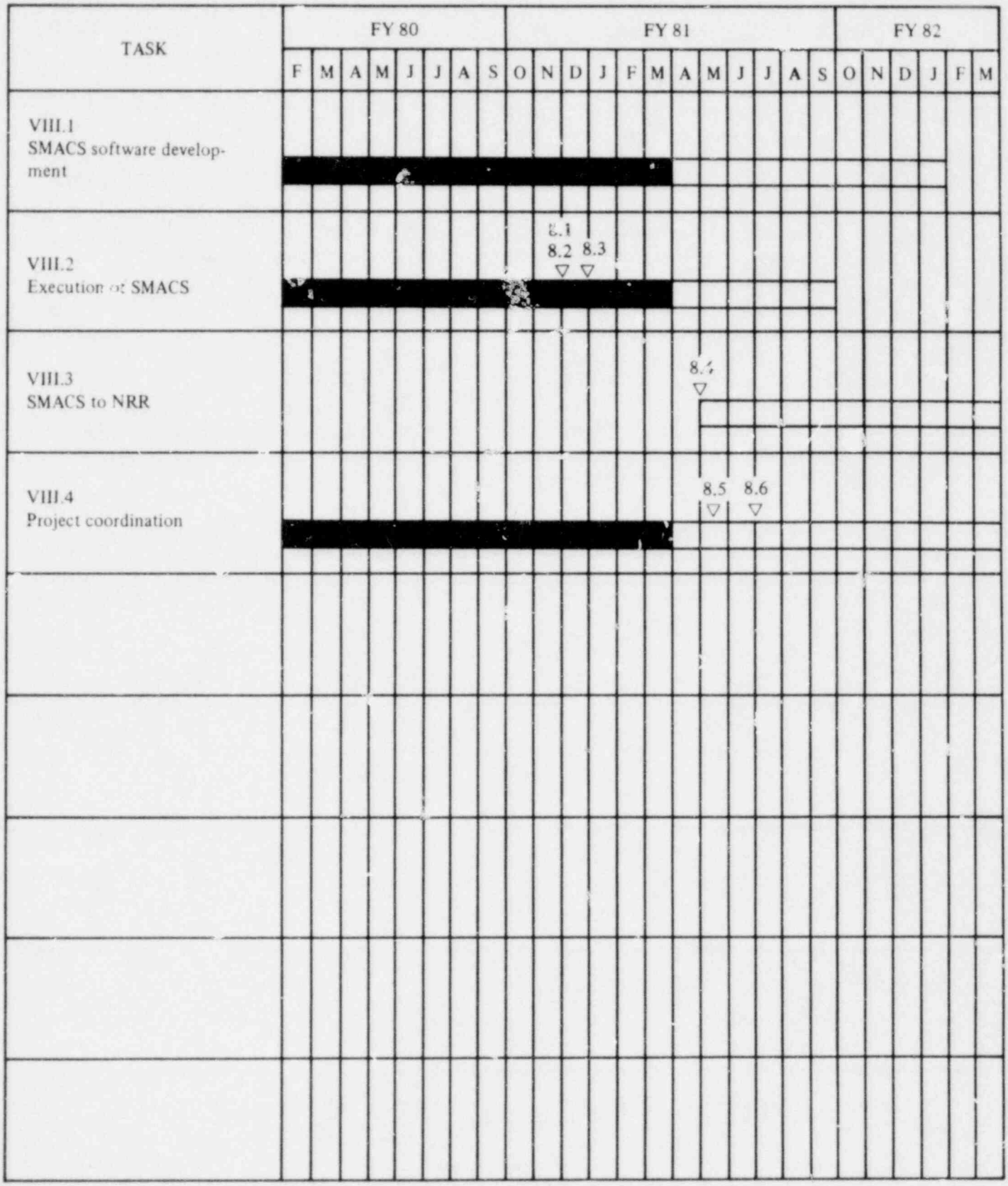
Task VIII.3 – SMACS to NRR

Task VIII.3 is to implement, document, and maintain a version of SMACS accessible to the NRC.

Task VIII.4 – Project Coordination

The purposes of Task VIII.4 are to provide guidance on technical, administrative, and budget matters for the project, and to interface with the other SSMRP projects.

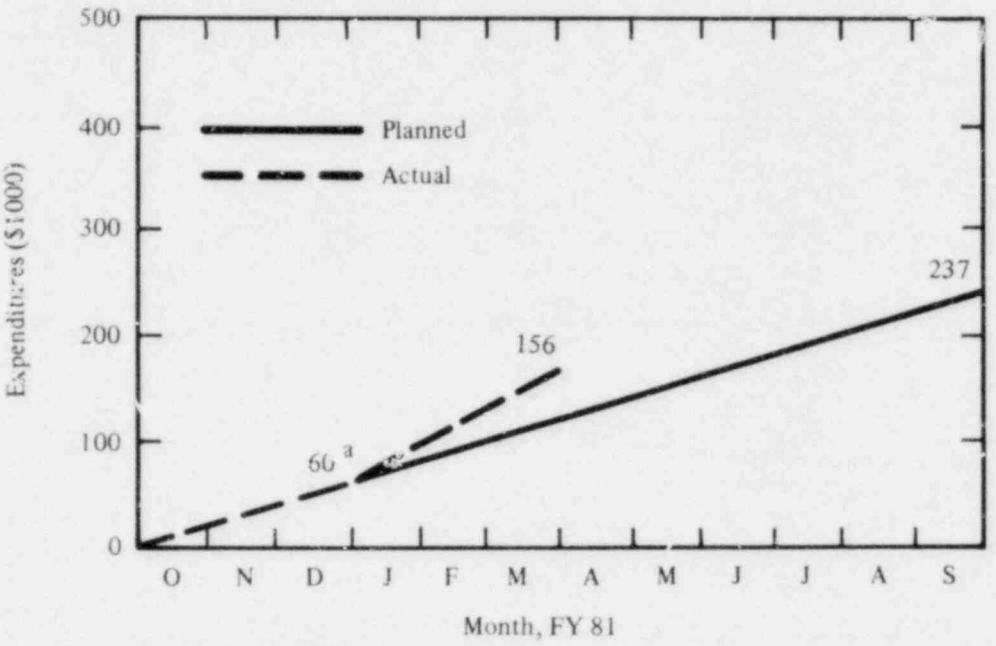
Project VIII Schedule



Project VIII Milestone Dates

	Milestone	Original Target Date	Revised Target Date	Completed Date
8.1	SMACS input data complete	12-1-80		12-1-80
8.2	Initiate SMACS execution	12-1-80		12-1-80
8.3	Response vectors transmitted to Project VII	1-1-81		1-1-81
8.4	Initiate SMACS conversion to LBL	5-1-81		
8.5	Documentation of Phase I results – draft report transmitted to NRC	5-15-81		
8.6	Documentation of Phase I results – camera-ready copy transmitted to NRC	7-1-81		

Expenditures for FY 81, Project VIII, SMACS and BE-EMS (FIN A0130 and A0142)



Phase I Budget Summary, Project VIII, SMACS and BE-EMS (FIN A0130)

Year	Budgeted Amount ($1000)
Prior year (FY 78)	0
Prior year (FY 79)	0
Last year (FY 80)	176
Current year (FY 81)	60
Total	236

a. End of Phase I.

Phase II Budget Summary, Project VIII, SMACS and BE-EMS (FIN A0130)

Year	Budgeted Amount ($1000)
Current year (FY 81)	177
Total	177

Project VIII, FY 81 Cost Breakdown

	Task	Amounts ($1000)	
		FY 81 Budget[a]	YTD Spent[b]
VIII.1	SMACS development	62	55
VIII.2	Execution of SMACS	85	80
VIII.3	SMACS to NRR	40	1
VIII.4	Project coordination	50	20
	Totals	237	156

a. Proposed.
b. As of March 31, 1981.

PROJECT VIII, SMACS AND BE-EMS

A. Accomplishments

Task VIII.1, SMACS Development – Conversion of SMACS from the CDC 7600 to the CRAY computer at LLNL is complete. A check problem duplicating the important aspects of a production run from the CDC 7600 has been run and verified. Initial timings showed faster CPU on the CRAY but significantly slower I/O. Both aspects are being optimized presently to speed up computations. Small utility routines are being developed to convert CRAY files to CDC 7600 format to permit use of the significant graphics capability.

An additional postprocessor called CHANGO was written to compare the output from various SMACS runs (e.g., responses and their distributions from different acceleration ranges). CHANGO compares medians, betas, and other characteristics of the responses. Graphic output is used almost exclusively.

Task VIII.2, SMACS Execution – A selected number of SMACS runs were completed to provide insight and understanding in connection with the Phase I responses. The case of reduced variability was run—variability on the input parameters was halved and its effect on response statistics obtained.

Documentation of the Phase I activities with respect to SMACS/BE-EMS progressed during the quarter. Input was provided for the summary report "Seismic Safety Margins Research Program Phase I Final Report—Overview," NUREG/CR-2015, Vol. 1 (also UCRL-53021, Vol. 1), which was completed. The in-depth documentation of SMACS/BE-EMS for Phase I was initiated.

Presentations were made to Prof. A. Cornell and NRC representatives on January 28, 1981, at LLNL and to the ACRS Subcommittee on Extreme External Phenomena in Los Angeles on January 29-30, 1981. The work scope for FY 82 was completed during the quarter.

B. Next Quarter

We expect to accomplish the following in the next quarter:

1. Complete Phase I documentation.
2. Initiate implementation of SMACS and its support codes at LBL, if NRC decides to use the LBL computer system.

C. Concerns

1. **Technical**
   None.
2. **Schedule**
   Complete documentation of Phase I activities has been slightly delayed.
3. **Cost**
   None.

REPORTS GENERATED BY THE SSMRP

The following reports are either forecast, partially completed, or completed for the SSMRP. Completed reports are available on request from: Oak Ridge Technical Information Center, P. O. Box 62, Oak Ridge, Tennessee 37830. This listing is by projects.

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
SEISMIC INPUT				
SI-1 Feasibility of using ARMA models to simulate earthquake time histories	9-79		Completed 7-79	
M. K. CHANG, J. W. KWIATKOWSKI, R. F. NAU, R. M. OLIVER, and K. S. PISTER, "ARMA Models for Earthquake Ground Motions," University of California, Report No. UCB/EERC-79/19, July 1979.				NUREG completed
SI-2 Simulation of time histories parameterized by magnitude, epicentral distance, and site conditions using ARMA models.	12-80		Completed 6-80	
R. F. NAU, R. M. OLIVER, and K. S. PISTER, "Simulating and Analysing Artificial Non-Stationary Earthquake Ground Motions," University of California, ORC 80-16, June 1980.				NUREG completed
SI-3 Differences between body wave magnitude in the eastern and western U.S. and the interrelation between local body and surface wave magnitudes.	4-80		Completed 4-80	
D. H. CHUNG and D. L. BERNREUTER, "Regional Relationships Among Earthquake Magnitude Scales," Lawrence Livermore National Laboratory, April 1980, NUREG/CR-1457.				NUREG completed

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
SI-4				
Assessment and expansion of the strong ground motion data base.	4-80		Completed 4-80	
C. B. CROUSE, J. A. HILEMAN, B. E. TURNER, and G. R. MARTIN, "Compilation, Assessment and Expansion of the Strong Earthquake Ground Motion Data Base," Lawrence Livermore National Laboratory, UCRL-15227, NUREG/CR-1660. Prepared by Fugro, Inc., April 1980.				NUREG completed
SI-5				
Relative effect of Q on the strong ground motion from earthquakes between the eastern and western U.S.	7-80		Completed 7-80	
D. H. CHUNG and D. L. BERNREUTER, "The Effect of Regional Variation of Seismic Wave Attenuation on the Strong Ground Motion from Earthquakes," Lawrence Livermore National Laboratory, July 1980.				Submitted for NUREG
SI-6				
Improved Bayesian methodology for development of site dependent spectra.	12-80			

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
SOIL-STRUCTURE INTERACTION				
SSI-1 Soil-Structure Interaction (SSI) Review Reports assessing the state-of-the-art of SSI analysis methodology, accuracy, uncertainties, and itemizing benchmark problems.	6-80		Completed 8-80	
J. J. JOHNSON, "Soil Structure Interaction: The Status of Current Analysis Methods and Research," Lawrence Livermore National Laboratory, UCRL-53011, October 1980, NUREG/CR-1780.				NUREG completed
J. E. LUCO, "Linear Soil-Structure Interaction," Lawrence Livermore National Laboratory, Draft Report, July 1980.			Consolidated with J. J. Johnson's report.	
J. M. ROESSET, "A Review of Soil-Structure Interaction," Lawrence Livermore National Laboratory, UCRL-15262, June 1980.			Consolidated with J. J. Johnson's report.	
H. B. SEED and J. LYSMER, "The Seismic Soil-Structure Interaction Problem for Nuclear Facilities," Lawrence Livermore National Laboratory, UCRL-15254, April 1980.			Consolidated with J. J. Johnson's report.	
J. T. CHRISTIAN, "Soil-Structure Interaction," Lawrence Livermore National Laboratory, UCRL-15230, February 1980.			Consolidated with J. J. Johnson's report.	

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
SOIL-STRUCTURE INTERACTION (continued)				
J. ISENBERG, "A Review of Structure-Medium Interaction Analysis Methods with Application to SSMRP," Lawrence Livermore National Laboratory, UCRL-15255, May 1980.			Consolidated with J. J. Johnson's report.	
SSI-2 Sensitivity Study of Soil-Structure Interaction phenomenon for structure-structure interaction, soil properties and soil configuration, wave passage, and azimuth effects for Zion nuclear power station using continuum analysis approach.	6-80		Partially completed 6-80	
H. L. WONG, "Identification of Sensitive Parameters for Statistical Simulation of Soil-Structure Interaction," June 1980.				
SSI-3 Sensitivity study comparing linear finite element analysis with continuum analysis approach for Zion nuclear power station.	9-80			
SSI-4 Summary of nonlinear analysis task with evaluation of future work to be done for the development, verification, and comparison of nonlinear SSI methods with linear techniques.				

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
MAJOR STRUCTURE RESPONSE				
STR-1 General structural building response analysis review with special emphasis on damping and nonlinearity.	2-80		Completed 2-80	
"Structural Building Response Review," Lawrence Livermore National Laboratory, UCRL-15183. Prepared by Sargent and Lundy, January 1980, NUREG/CR-1423, SL-3759, Vol. II.				NUREG completed
J. J. HEALEY, S. T. WU, and M. MURGA, "Structural Building Response Review," Lawrence Livermore National Laboratory, UCRL-15185. Prepared by Ebasco Services, February 1980, NUREG/CR-1423, vol. I.				NUREG completed
STR-2 Response of nuclear power plant structures to three input components.	6-80		Completed 4-80	
S. E. BUMPUS, J. J. JOHNSON, and P. D. SMITH, "Best Estimate Method vs. Evaluation Method: A Comparison of Two Techniques in Evaluating Seismic Analysis and Design," Lawrence Livermore National Laboratory, UCRL-52746, NUREG/CR-1489, May 1980.				NUREG completed
STR-3 Effect of structural damping on nuclear power plant structures. This is another study by expanding LLL/DOR Seismic Conservatism Program (Parts III & IV) to typical nuclear power plant structures (Zion station).	6-80		Completed 6-80	

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
MAJOR STRUCTURE RESPONSE (continued)				
D. A. WESLEY, P. S. HASHIMOTO, and R. B. NARVER, Seismic Safety Margins Research Program (Phase I) Task (sic) IV, Structures Response, "Variability of Dynamic Characteristics of Nuclear Power Plant Structures," Lawrence Livermore National Laboratory, UCRL-15267, NUREG/CR-1661. Prepared by Structural Mechanics Associates, SMA 12205.02, June 1980.				NUREG completed
STR-4 Identify modeling variables, systematic or random, in the major structure response analysis. Rank in terms of their effect on the uncertainty of structural response.	3-80		Completed 3-80	
T. K. HASSELMAN and S. S. SIMONIAN, "Structural Uncertainty in Seismic Risk Analysis," Lawrence Livermore National Laboratory, UCRL-15218. Prepared by J. H. Wiggins Company, March 1980, NUREG/CR-1560.				NUREG completed
STR-5 Accuracy of finite element method and lumped mass method in seismic analysis.	9-80			

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
SUBSYSTEM RESPONSE				
SUB-1 Subsystem Response Review Reports assessing the state-of-the-art of subsystem response determination, accuracy, and uncertainties.	2-80		Completed 3-80	
J. FOGELQUIST, M. K. KAUL, R. KOPPE, S. W. TAGART, JR., H. THAILER, and R. UFFER, "Subsystem Response Review," Lawrence Livermore National Laboratory, UCRL-15215, NUREG/CR-1700. Prepared by Nuclear Services Corporation/Quadrex Corporation, March 1980.				NUREG completed
R. P. KENNEDY, R. D. CAMPBELL, D. A. WESLEY, H. KAMIL, A. GANTAYAT, and R. VASUDEVAN, "Subsystem Response Review," Lawrence Livermore National Laboratory. UCRL-15216, NUREG/CR-1706. Prepared by Engineering Decision Analysis Company, March 1980.				NUREG completed
SUB-2 Sensitivity study investigating the effects of uncertainties on subsystem response.	10-80	Merged with SUB-4		
SUB-3 Sensitivity study on nonlinear analysis of a key safety system.	10-80	FY 82		
SUB-4 Sensitivity study to rank contributions to uncertainty in subsystem response. (Added 7-10-80.)	None	11-80		

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
COMPONENT AND STRUCTURAL FRAGILITY				
FRA-1 NPRDS listing of Zion component in-service operational history.	6-79		Completed 6-79	Not appropriate for NUREG
FRA-2 Report on gathered fragilities related information.	9-80			
FRA-3 Report on expert opinion received on component fragility.	9-80			
FRA-4 Reports on failure modes for components and structures for a representative PWR plant.			Completed	
Components	2-80		8-79	
Buildings	2-80		10-79	
R. D. CAMPBELL and D. A. WESLEY, "Preliminary Failure Mode Predictions for the SSMRP Reference Plant (Zion 1 and 2)," Lawrence Livermore National Laboratory. UCRL-15042. Prepared by Engineering Decision Analysis Co., Inc., June 1979, NUREG/CR-1703.				NUREG completed
R. D. CAMPBELL and D. A. WESLEY, "Potential Seismic Structural Failure Modes Associated with the Zion Nuclear Plant," Lawrence Livermore National Laboratory, UCRL-15140. Prepared by Engineering Decision Analysis Co., Inc., October 1979, NUREG/CR-1704.				NUREG completed

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
COMPONENT AND STRUCTURAL FRAGILITY (continued)				
FRA-5 Fragility curves for components and structures for a representative PWR plant.	1-81			
FRA-6 Documentation of an overall fragility description development methodology.	4-81			
SYSTEMS ANALYSIS				
SYS-1 Description of computational methodologies for prediction of core melt probabilities in a nuclear power plant due to seismic events.	4-79		Completed 2-79	
I. B. WALL, M. K. KAUL, R. I. POST, S. W. TAGART, JR., and T. J. VINSON, "Specification of Computational Approach," Lawrence Livermore National Laboratory, UCRL-13985. Prepared by Nuclear Services Corp., February 1979, NUREG/CR-1702.				NUREG completed

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
SYSTEMS ANALYSIS (continued)				
J. D. COLLINS, J. M. HUDSON, and J. D. CHROSTOWSKI, "Specifications of Computational Approach," Lawrence Livermore National Laboratory, UCRL-13986. Prepared by J. H. Wiggins Company, February 1979, NUREG/CR-1701.				NUREG completed
SYS-2 Description of a design concept for calculating probability of radioactive release, core melt, safety system, structural and component failure probabilities from a set of nuclear plant seismic responses.	8-79		Completed 6-79	
"SEISIM Code Design Concept," Technical Report 78-1645-2, J. H. Wiggins Company, June 1979.				Awaiting release for NUREG
SYS-3 Operating Seismic Safety Analysis Code – SEISIM (Option 1 only).	1-81		Partially completed 4-80	
J. H. HUDSON, J. D. GASCA, and J. D. COLLINS, "SEISIM Option 1 Design Specification (Revision 1)," J. H. Wiggins Company Draft Report 80-1366-1, April 1980.				Awaiting release for

REPORTS GENERATED BY THE SSMRP
(continued)

Report	Original Due Date	Revised Due Date	Status of Completion	Status of NUREG
SYSTEMS ANALYSIS (continued)				
SYS-4 Accident sequences as the result of earthquakes at Zion 1 nuclear power plant.	10-79		Completed 8-79	
A. A. GARCIA and J. E. KELLY, "Event Tree Development and Construction," Science Applications, Inc., SAI-003-79-BE, August 1979.				Awaiting release for NUREG
SYS-5 Fault trees of some safety systems of Zion 1 nuclear plant (auxiliary feedwater system, service water system, emergency core cooling system, residual heat removal system, parts of the electric power and instrumentation and control system pertaining to the above).	1-81		Partially completed 5-80	
Draft Version of the Zion Unit 1 Auxiliary Feedwater System Fault Tree on the Seismic Safety Margins Research Program (SSMRP), May 14, 1980 (one tree).				Not appropriate for NUREG
Draft Version of the Zion Unit 1 Electrical Power System Fault Tree on the Seismic Safety Margins Research Program (SSMRP), May 30, 1980 (one tree).				Not appropriate for NUREG
Draft Version of the Zion Unit 1 Service Water System Fault Tree on the Seismic Safety Margins Research Program (SSMRP), June 27, 1980 (three trees).				Not appropriate for NUREG
Draft Version of the Zion Unit 1 Emergency Core Cooling System Fault Tree on the Seismic Safety Margins Research Program (SSMRP), July 1980 (four trees).				Not appropriate for NUREG

OTHER REPORTS

	Status of NUREG
C. K. CHOU, K. VEPA, L. GEORGE, and P. D. SMITH, "Seismic Safety Margins Research Program Project VIII Load Combination Project-Work Plan," Lawrence Livermore National Laboratory, UCID-18126, July 10, 1979.	
C. K. CHOU, R. W. MENSING, P. D. SMITH, K. VEPA, J. D. COLLINS, C. A. CORNELL, R. P. KENNEDY, and M. K. RAVINDRA, "Seismic Safety Margins Research Program Load Combination Project–Task 3, Load Combination Methodology Development Interim Report I," Lawrence Livermore National Laboratory, UCID-18149, January 31, 1980.	
C. K. CHOU, S. C. LU, and M. W. SCHWARTZ, "Load Combination Program, Phase II Work Plan," Lawrence Livermore National Laboratory Draft Report, April 15, 1980.	
R. G. DONG and P. D. SMITH, "Seismic Safety Margins Research Program (Phase I) Long Range Plan, Report I," Lawrence Livermore National Laboratory, April 2, 1980.	Submitted for NUREG 7-30-80
P. D. SMITH, F. J. TOKARZ, D. L. BERNREUTER, G. E. CUMMINGS, C. K. CHOU, V. N. VAGLIENTE, J. J. JOHNSON and R. G. DONG, "Seismic Safety Margins Research Program, Program Plan, Revision II," UCID-17824, Rev. II, August 11, 1978.	
R. L. SHARPE, J. W. REED, and C. B. WAUGH, "Seismic Safety Margins Research Program (Phase I), Project I – Plant/Site Selection Assessment Report," Lawrence Livermore National Laboratory UCRL-15110, NUREG/CR-1705. Prepared by Engineering Decision Analysis Company, Inc. July 20, 1979.	NUREG completed
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Meeting Attendance Summary

Date	Meeting	Location	LLNL Personnel Attending*	Comments
1/13/81	SSMRP	LLNL	DLB, GEC, GLG, JEW, JJJ, LLG, MPB, PDS, RGD, RWM, TYC, WJO	ACRS dry run
1/27/81	SONGS 1 AFWS Project	LLNL	PDS, RGD, DLB, LLC, TYC	
1/27/81	Meeting with C. A. Cornell	LLNL	DLB, GLG, JEW, JJJ, MPB, PDS, RGD, RWM, TYC	SSMRP consultation
1/28/81	SRRG Meeting	LLNL	DLB, GEC, GLG, JEW, JJJ, LLG, MPB, PDS, RGD, RWM, TYC, WJO	Preparation for ACRS Meeting
1/29/81	SONGS 1 AFWS Project Work Plan	Los Angeles, CA	LLC, GEC, PDS, TYC	
1/29, 30/81	ACRS Meeting	Los Angeles, CA	DLB, GEC, GLG, JEW, JJJ, LLG, MPB, PDS, RGD, RWM, TYC, WJO	Review of SSMRP Phase I
2/2, 3/81	AFWS Project	LLNL	DLB, GLG, JEW, JJJ, MPB, PDS, RGD, RWM, TYC	AFWS project planning
2/3/81	SONGS 1 AFWS Project Work Plan	LLNL	PDS, RGD, DLB, GEC, MPB, TYC	
2/6/81	SSMRP Phase I Final Report	LLNL	LLC, GEC, PDS, RGD	Status of final report writing
3/31/81	NRC/RES Meeting	Washington, DC	LLC, GEC, PDS, RGD	Preparation for mid-year review

*LLNL personnel abbreviations:

AFS	=	A. F. SHAKAL	MRE	=	M. R. EATON
BJB	=	B. J. BENDA	MWS	=	M. SCHWARTZ
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DHC	=	D. H. CHUNG	PDS	=	P. D. SMITH
DLB	=	D. L. BERNREUTER	RCC	=	R. C. CHUN
FJT	=	F. J. TOKARZ	RDB	=	R. D. BAILEY
GEC	=	G. E. CUMMINGS	RGD	=	R. G. DONG
GLG	=	G. L. GOUDREAU	RWM	=	R. W. MENSING
HCM	=	H. C. MC DONALD	RDS	=	R. D. STREIT
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JJJ	=	J. J. JOHNSON	TYL	=	T. Y. LO
JKS	=	J. K. STUART	TYC	=	T. Y. CHUANG
LLC	=	L. L. CLELAND	VNV	=	V. N. VAGLIENTE
LLG	=	L. L. GEORGE	WJO	=	W. J. O'CONNELL
MPB	=	M. P. BOHN			

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16. ABSTRACT (200 words or less)

This document is a progress report on the Seismic Safety Margins Research Program (SSMRP) covering the period January 1, 1981 through March 31, 1981. The report gives a general description of the program, together with financial summaries and individual project details. Each project is summarized to show accomplishments, schedules, milestones and completion dates, budget and expenditures, and any concerns that may affect the project.

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