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LLNL-TR-748518

Computer Simulation of Nuclear Well Logging Devices Final Report CRADA No. TC-824-94F

J. Ferguson, P. Brown, L. Jacobsen

March 26, 2018

Disclaimer

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Computer Simulation of Nuclear Well Logging Devices

Final Report
CRADA No. TC-824-94F

Date: Revision:

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and Halliburton Energy Services.

University of California
Lawrence Livermore National Laboratory
7000 East Avenue, L-795
Livermore, CA 94550

Halliburton Energy Services
PO Box 42800
Houston TX 77242

B. Project Scope

Accurate computer simulation is vital for interpretation of data obtained using nuclear logging tools in exploratory boreholes or existing wells. Successful interpretation can lead to large increases in recovery efficiency. Currently, the computer simulation is done using Monte Carlo codes, which contain an inherent statistical uncertainty and are very computationally intensive. We have developed a deterministic code that does not have statistical uncertainties and should be particularly useful for parameter studies. We have written the deterministic code to perform high-resolution computer simulations of nuclear well-logging tools to aid in determining the lithology, porosity, and fluid characteristics of the formation surrounding a borehole. We use parallel methods and modern finite element algorithms to solve the three-dimensional multigroup, neutron/radiation transport equation.

C. Technical

Because of significant funding reductions, we were not able to attain all the goals of the program. However, we were able to write and test the prototype code, running problems on the Cray T3D computer. Also, we reached the point of running benchmark problems provided by the industrial partners to test and further develop the code capabilities. We are pursuing other means of support to bring the code to production status.

D. Partner Contribution

Since the LLNL group had no background or experience in oil well logging, it was necessary for Halliburton, the industrial partner, to provide guidance and expertise in this area. The original program was conceived and planned through a series of meetings in Houston, Texas, and two visits to the San Francisco Bay Area by Halliburton personnel. The LLNL group obtained the necessary background to choose a computing strategy and select a suitable database. The Halliburton group provided some descriptions of the experimental apparatus and some idealized test problems. Had the program not been cut short, Halliburton would have run the prototype code and provided input needed to convert the prototype into a useful production tool.

E. Documents/Reference List

Concurrent Source Iteration in the Solution of Three-Dimensional, Multigroup, Discrete Ordinates Neutron Transport Equations; Milo R. Dorr, Charles H. Still, UCRL-JC-116694, May, 1995

Spherical Harmonic Solutions of Neutron Transport Systems via Discrete Ordinates, Peter N. Brown, Milo R. Dorr, UCRL-JC-119761, January 1995

F. Acknowledgment

Participant's signature of the final report indicates the following:

1) The Participant has reviewed the final report and concurs with the statements made therein.
2) The Participant agrees that any modifications or changes from the initial proposal were discussed and agreed to during the term of the project.
3) The Participant certifies that all reports either completed or in process are listed and all subject inventions and the associated intellectual property protection measures attributable to the project have been disclosed or are included on a list attached to this report.
4) The Participant certifies that if real property was exchanged during the agreement, all has either been returned to the initial custodian or transferred permanently.
5) The Participant certifies that proprietary information has been returned or destroyed by LLNL.

Larry Jacobsen 4/23/98

Larry Jacobsen Date
Halliburton Energy Services

Jim Ferguson Date
Lawrence Livermore National Laboratory

Attachment I – Final Abstract
Attachment II – Project Accomplishments Summary
Attachment III – Final Quarterly Report

Spherical Harmonic Solutions of Neutron Transport Systems via Discrete Ordinates, Peter N. Brown, Milo R. Dorr, UCRL-JC-119761, January 1995

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5) The Participant certifies that proprietary information has been returned or destroyed by LLNL.

Larry Jacobsen 4/23/98
Larry Jacobsen Date
Halliburton Energy Services

Jim Ferguson 5/7/98
Jim Ferguson Date
Lawrence Livermore National Laboratory

Attachment I – Final Abstract
Attachment II – Project Accomplishments Summary
Attachment III – Final Quarterly Report

Computer Simulation of Nuclear Well Logging Devices

Abstract (Attachment I)
CRADA No. TC-824-94F

Date: Revision:

ABSTRACT

Accurate computer simulation is vital for interpretation of data obtained using nuclear logging tools in exploratory boreholes or existing wells. Millions of dollars are saved when general purpose simulation codes are utilized. Successful interpretation can lead to large increases in recovery efficiency and can aid the industrial competitiveness of the U.S. oil and gas industry. Currently, the computer simulation is done using Monte Carlo codes, which randomly track particles through the tool and the formation. We have developed a deterministic code that does not have statistical uncertainties and should be particularly useful for parameter studies. We use parallel methods to solve the three-dimensional multigroup, neutron/radiation transport equation. We have written and tested the prototype code, running problems on the Cray T3D computer. Also, we have run benchmark problems provided by the industrial partners to test and further develop the code capabilities.

Computer Simulation of Nuclear Well Logging Devices

Project Accomplishments Summary (Attachment II)
CRADA No. TC-824-94F

Date: Revision:

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and Halliburton Energy Services.

University of California
Lawrence Livermore National Laboratory
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Livermore, CA 94550

Halliburton Energy Services
PO Box 42800
Houston TX 77242

B. Background

Accurate computer simulation is vital for interpretation of data obtained using nuclear logging tools in exploratory boreholes or existing wells. Successful interpretation can lead to large increases in recovery efficiency and can aid the industrial competitiveness of the U.S. oil and gas industry. Currently, the computer simulation is done using Monte Carlo codes, which randomly track particles through the tool and the formation. These codes contain an inherent statistical uncertainty, and are very computationally intensive. We have developed a deterministic code that does not have statistical uncertainties and should be particularly useful for parameter studies.

C. Description

We have written a deterministic code to perform high-resolution computer simulations of nuclear well-logging tools to aid in determining the lithology, porosity, and fluid characteristics of the formation surrounding a borehole. We use parallel methods to solve the three-dimensional multigroup, neutron/radiation transport equation. Because of significant funding reductions, we were not able to attain all the goals of the program. However, we were able to write and test the prototype code, running problems on the Cray T3D computer. Also, we reached the point of running benchmark problems provided by the industrial partners to test and further develop the code capabilities. We are pursuing other means of support to bring the code to production status.

D. Expected Economic Impact

Industry leverage of LLNL capabilities and expertise improves their ability to simulate the response characteristics of nuclear well-logging instruments. Millions of dollars can be saved when general purpose simulation codes are utilized. In addition, duplication of effort and resources is minimized. Additional oil and gas production worth millions of dollars results because precise knowledge of the characteristics of nuclear well-logging sounds in various operating environments allows much better interpretation of their measurements.

E. Benefits to DOE

The technical requirements for this project strongly overlap some of those in the Stockpile Stewardship and Management Program. In particular, the Department of Energy ASCII program has a strong requirement for efficient solution of the large, three-dimensional problems involving the transport of neutrons and radiation in matter. Thus, many of the techniques and coding developed under the current task can be directly applied to in-house DOE projects.

F. Industry Area

Since this project was cut short, we have not been able to supply the oil well logging industrial partner with codes directly applicable to field problems. However we are pursuing other means to accomplish this, and hope to eventually to provide useful production codes to the industry.

G. LLNL Point of Contact for Project Information

Dr. Jim Ferguson L-170
Lawrence Livermore National Laboratory
PO Box 808
Livermore CA 94551
(510) 424-4768 (voice) (510) 424-2709 (FAX)

Dr. Peter Brown L-561
Lawrence Livermore National Laboratory
PO Box 808
Livermore CA 94551
(510) 423-2098 (voice)

H. Company Size and Point(s) of Contact

Dr. Larry Jacobsen
Halliburton Energy Services
PO Box 42800
Houston TX 77242
(713) 496-8253 (voice) (713) 596-4234

I. Project Examples

Comparisons of calculations of benchmark problems, provided by industry, are available.

J. Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.

Larry D. Jacobsen — 4/23/98

Dr. Larry Jacobsen
Halliburton Energy Services

Date

RELEASE OF INFORMATION

I certify that all information contained in this report is accurate and releasable to the best of my knowledge.

NE Dunford
for Karena McKinley, Director
Industrial Partnerships
and Commercialization

6/29/98
Date

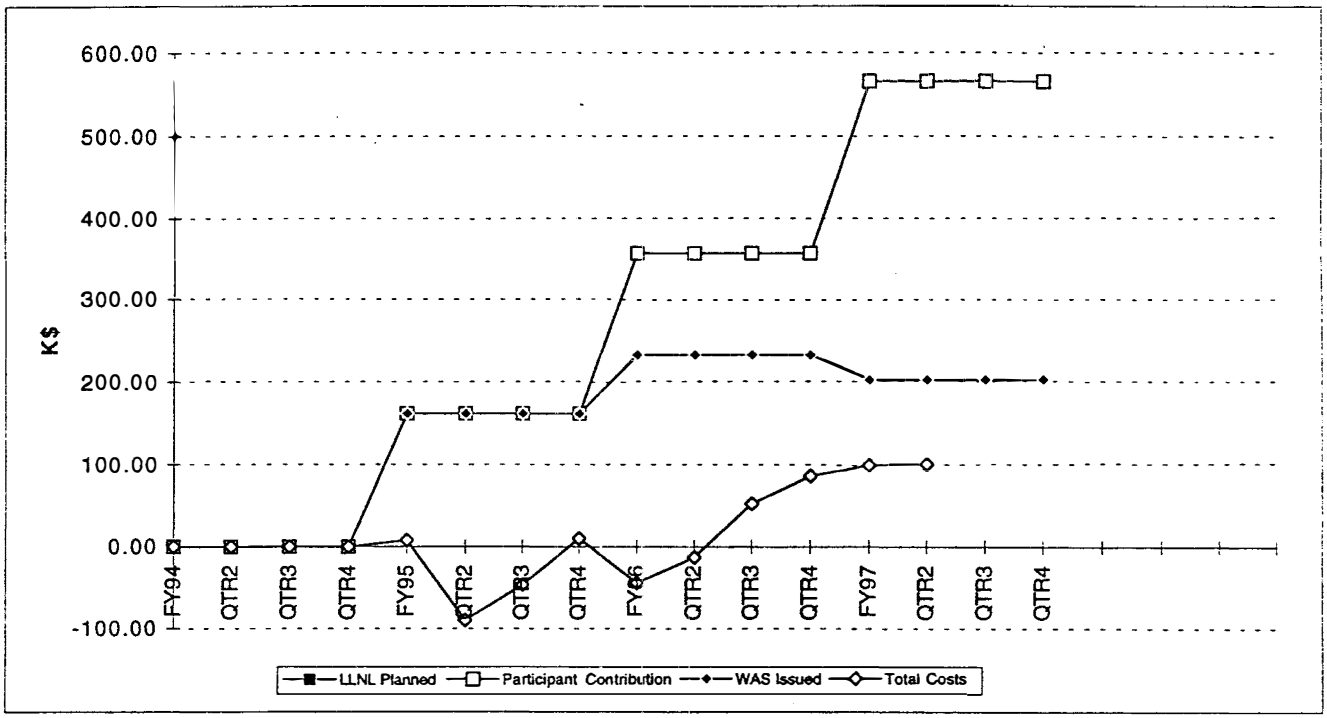
Lawrence Livermore National Laboratory

Title: HPPP Nuclear Well Logging
Participant: Halliburton Corporation
DOE TTI No.: 94-MULT-003-XX-1
CRADA No.: TC-0824-94-(F)
Account Numbers: 4745-76, 86
Accounts Closed: 12/21/96

Reporting Period: 07/01/95 - 12/31/96
Date CRADA Executed: 11/22/94
DOE Approval Date: 12/5/94
Scheduled Ending Date: 11/21/97
Project Completion Date: 11/30/96
B & R Code (S): DP0301, YN01000

Approved Funding Profile ($K)

	FY94	FY95	FY96	FY97	FYOUT	Total
LLNL Planned	0	162	195	209	0	566
Participant In-Kind	0	162	195	209	0	566
Paticipant Funds-I	0	0	0	0	0	0
WAS DP0301	0	55	70	-30	0	95
LDRD Funds	0	107	0	0	0	107
Total Costs	0	10	77	8	0	94



DP0301	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	FYTD
FY94	0	0	0	0	0	0	0	0	0	0	0	0	0
FY95	0	0	8	17	10	-124	11	14	17	11	32	14	10
FY96	-68	8	6	11	7	13	52	-6	19	16	-12	30	77
FY97	9	0	5	0	-6	0	0	0	0	0	0	0	8
FYOUT	0	0	0	0	0	0	0	0	0	0	0	0	0

94

YN01000	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	FYTD
FY94	0	0	0	0	0	0	0	0	0	0	0	0	0
FY95	0	0	0	0	0	0	0	0	0	0	0	0	0
FY96	0	0	0	0	0	0	0	0	0	0	0	0	0
FY97	0	0	0	0	0	0	0	0	0	0	0	0	0
FYOUT	0	0	0	0	0	0	0	0	0	0	0	0	0

0

STAFF w/phone:

Lab PI: Milo Dorr (510) 423-2423
Participant: Larry Jacobsen (713) 496-8253
Resource Manager: Steve Stinson (510) 423-2888
DOE OAK: Jerry Scheinberg (510) 637-1653
DOE HQ: A. Larzelere (202) 586-1101

Reporting Period : 07/01/95 - 12/31/96
DOE TTI No.: 94-MULT-003-XX-1
CRADA No.: TC-0824-94-(F)

Milestones and Deliverables:

List the complete set of milestones for all phases of the CRADA. Continue on a separate page if necessary.
Report any changes from the original CRADA or previous quarterly report on the CRADA Change Form.

		Completion Date: Scheduled	Actual
1	Prototype Code Running on the T3D	10/95	10/95
2	Full Scale Code Running on the T3D	06/96	06/96
3	Shakedown on Halliburton Problems	12/96	10/96
4	Time Dependent Capability Added to Code	06/97	
5	Visualization Output Incorporated	09/97	
6	Documentation and Full Release	11/97	
7			
8			

Verification of participants' in-kind contribution was made in accordance with LLNL policy. Explain basis of verification:

Please initial: YES X NO ____

List any subject inventions by either party (include IL# for LLNL inventions), additional background intellectual property, patents applied for, software copyrights, publications, awards, licenses granted or reportable economic impacts.

Verification that all equipment and proprietary information has been returned to the initial owner or permanently transferred.

Please initial: YES X NO ____

Accomplishments

Describe Technical/Non-Technical lessons learned and other observations.
Summarize causes/justification of deviations from original scope of work.

See Final Report.

Reviewed by CRADA project Program Manager: _____ Date: _____

Reviewed by Karena McKinley, Director, LLNL/IP&C: _____ Date: _____

Direct questions regarding this Report to IP&C Resource Manager, Carol Asher, at (510) 422-7618