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LABORATORY

Advanced Manufacturing Final Report CRADA No. TC-0880-94

J. Haskins, C. Gough, J. Johnson, M. Royce

November 14, 2017

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Advanced Manufacturing

Final Report
CRADA No. TC-0880-94

Date: February 14, 2001 Revision: 5

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and Chrysler Corporation (Chrysler), Ford Motor Company (Ford) and General Motors Research Laboratory (GM).

The Regents of the University of California
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Michael Royce
Phone: (248) 576-4996
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B. Project Scope

The LEP portion of USCAR defined five sectors of priority for a joint project between LEP, LLNL, Los Alamos National Laboratory (LANL), Sandia National Laboratory (SNL), Pacific Northwest Laboratory (PNL), Allied Signal Kansas City Division (ASKCD), Y12, and Idaho National Engineering Laboratory (INEL). These sectors were:

Sector I.	Part integrity
Sector II.	Powertrain components
Sector III.	Powertrain assembly
Sector IV.	Agile manufacturing
Sector V.	Predictive maintenance

In the first year of funding, LLNL participated in four of these activities (Sectors I, III, IV, & V). This report covers the work done at LLNL.

The goal of the project was to develop more efficient and cost effective tools and techniques in the five sectors addressed to improve LEP member competitiveness and to produce automobiles with less pollution and higher efficiency.

The National Laboratories had materials, manufacturing, and characterization technology which were of potential benefit to the automobile industry. The LEP members had expertise in these areas and an understanding of current needs and priorities in a high volume manufacturing environment. The partnership defined in this project increased LEP's competitiveness through more efficient and cost effective manufacturing.

The project deliverables were:

1) A report documenting the project results
2) An implementation plan for transferring results to LEP members

C. Technical Accomplishments

Sector I - Part Integrity, Track A - Part Integrity

The goal of the part integrity portion of this CRADA was to produce perfect parts. The objective was to apply advanced manufacturing tools to nonintrusively monitor and control processes on the production line. During the first year of this project, the focus on Sector I was on casting and coating-adhesion components. A matrix of components was chosen by the LEP that could be inspected within the process line. At the time the CRADA was established, these parts were typically inspected at the end of the process line, i.e., after the fact. As a result value added was consumed on defective parts. Multiple examples of parts of varying quality were supplied by LEP to the DOE facilities. Cast components were initially proposed since they were representative of one key manufacturing process common to all LEP members. In addition they required advanced manufacturing process monitoring and control. Mutual exchange of information between LEP and the DOE facilities enabled the latter personnel to better understand LEP requirements and former members to better understand new advanced inspection instruments that were available within the national labs and plants.

Task	Duration (Month)						
Tasks for Phase I only	1	6	12	18	24	30	36
1. Supply matrix of parts							
2. Evaluate & demo NDE techniques							
3. Mutual review/appl. to process line							
4. Production floor demo/trial							
5. Evaluate for on line auto production							
6. Complete production implementation							

Sector III - Powertrain Assembly, Track A - Near Net Shape

The goal of this project was to produce cast and formed components which had the correct dimensions and required no further machining or processing. This reduced scrap and increased efficiency. The first phase of the project addressed the cast iron process and produced these results:

1. Improved dimensional tolerances of the casting process beyond best current practice in all applicable industries including automotive suppliers.

2. Reduced the amount of machined material removed by a minimum of 30% by weight

3. Reduced machining time by a minimum of 25%

Task	Duration (Month)						
	1	6	12	18	24	30	36
Phase 1							
1. Choose specific part and casting process							
2. Current practice assessment							
3. Characterize manifold supplied by LEP							
4. Characterize manifold supplied by Y12							
5. Choose a casting variable to investigate							
6. Make test castings and evaluate							
7. Report results							
Phase 2							
8. Address remaining 2 alternatives							
9. Coordinated casting program with CERP							
Phase 3							
10. Experimental/modeling comparison							

Sector IV - Agile Manufacturing, Track A - Adaptive, Open Architecture Welding Applications

This project focused on a single aspect of production—adaptive, open-architecture welding applications. Its primary objective was to develop applicable hardware and software standards and create an open-architecture demonstration for the standards. The standards addressed details such as interface criteria for mechanical, electrical, and communications protocol, and the development of criteria for standards selection to include speed, cost, and other desirable capabilities. The scope of the standards included power supplies, sensors, controllers robots, CAD links, statistical control systems, and agile manufacturing links.

Concurrent with the development and demonstration of the standards, tasks were identified to facilitate establishing a working relationship with members of LEP and others presently working on appropriate standards, transferring applicable technological developments to other LEP programs (e.g., Intelligent welding for thin metal sections CRADA), and integrating technology transfer of Technologies Enabling Agile Manufacturing (TEAM) activities.

Sector V - Predictive Maintenance, Track A - Predictive Maintenance

The term "predictive maintenance" here meant monitoring specific signals from equipment in an effort to predict, from historical data, when failure of the equipment became imminent. Typical monitored signals were vibration spectra, motor-current spectra, data from oil and wear particle analysis, and data from infrared thermography, depending on the particular equipment being monitored. The advantages of preventative maintenance for the U.S. Automobile Industry included a decrease in scheduled equipment down-time, and an increase in the time between scheduled equipment repairs.

The objective of this task was to evaluate recent PDM reports. The purposes of such a PDM program were:

1. Provide timely notification of impending equipment failures
2. Identify the failing component
3. Identify the cause of the failure

The ultimate goal was to ensure that LEP partners have access to optimum PDM technologies.

LLNL was involved only in the last phase as shown below:

Tasks for LLNL	1	6	12	18	24	30	36
6. Implement state-of-the-art predictive maintenance			—				

Synopsis of Accomplishments

In the first phases of this project we evaluated NDE methodologies as an enabling technology for measuring and improving part integrity. In the remaining phases we concentrated on evaluating specific components.

The final phase of the project which primarily involved transmitting the data to the partners, generating a final report, and helping the partners to implement the technology in their own plants, was not completed because funding was cut off.

Specific Accomplishments

Part Scanning

FORD	7 laser welded parts
Ford	3 valve bodies
Ford	10 EFHD parts
GM	10 fuel handling parts
Ford	3 transmission pieces
GM	1 Saturn engine block
GM/IAP	10 powder metal parts
GM	5 powder metal experiments
Ford	1 shock absorber
Chrysler	Cylinder head section
Chrysler	Intake manifold section

Computers and Codes

Ford EFHD	Installed Sun workstation, Dell PC, frame grabber, and codes.
GM Delphi	Upgraded SPARC 10 workstation and installed codes.
IAP	Installed SPARC 5 workstation and codes.
General Use	Developed codes for viewing analyzing CT data on Pcs (PCVW). Installed and evaluated Archimedes (ARACOR product)
Chrysler PTPE	CT cloud to STL file
Chrysler PTPE	Develop STL editor in Chrysler CAE code
Chrysler PTPE	Develop means to read edited STL code into FIRE CFD code supporting engine flow analysis

D. Expected Economic Impact

The overall purpose of this Project was to materially aid in the maintenance of a viable, competitive automotive manufacturing capability in the U.S. This assurance was a prerequisite for equally significant goals of maintaining manufacturing-related jobs in this country. LLNL expected that the collaborations to be established in this Program would continue into other research projects that would also benefit the automotive industry. We anticipated that other interactions between the DOE laboratories and the US auto makers would also result from this work.

Tangible benefits were the development of significantly enhanced experience, capabilities, and demonstration of superplastic stainless steel through evaluation of laser modeling and prototype demonstrations. Intellectual Property developed was expected to include processing enhancements which could be patentable.

The DOE program was a primary beneficiary of the dual-use nature of the technology developed by this Program. The results established the framework for applying this material and processing technology to the DOE concerns including reduction of potentially harmful emissions from automobile sources, complex components, and structures performance in loading extremes, and significantly enhanced the industrial base available to DOE and its National Laboratories.

E. Partner Contribution

Sector I - Part Integrity Track A - Part Integrity

The responsibilities and tasks were shared across the DOE facilities. These included the 4DP labs, INEL and ASKCD. The coordinating lab function was assigned to LLNL for DOE defense program (DP) funding and INEL for non-DP funding. The coordinating-lab role was to ensure that the appropriate technologies were used and that the appropriate participating lab was chosen with the best capability for a particular part inspection requirement. For the first year, the program identified three key laboratory or plant participants in addition to LLNL. They were Allied Signal Kansas City Division, Los Alamos National Lab and Idaho National Engineering Lab. This report covers only the work done at LLNL.

TASK

Subtask

I. Part Integrity	
1. LEP supply matrix of parts	x
2. DOE demo. & eval. NDE techniques	x
3. Mutual review & appl. to process line	x
4. Production floor demo/trial	x
5. Evaluate for on line auto. production	x
6. LEP complete production implement.	x

Sector III, Powertrain Assembly, Track A - Near Net Shape

The responsibilities and tasks were shared across the DOE facilities. These included the 4DP labs and ASKCD. The coordinating lab was assigned to Y12 for DOE defense program (DP) funding. The coordinating-lab role was to ensure that the appropriate technologies were used and that the appropriate participating lab was chosen with the best capability for a particular part inspection requirement. For the first year, the program identified five key laboratory or plant participants. They were Y12, Allied Signal Kansas City Division, Los Alamos National Lab, Lawrence Livermore National Lab, and Sandia National Lab. This report covers only the work done at LLNL.

TASK

Subtask

I. Near Net Shape	
1. Current practice assessment	
2. Characterization	
3. Casting variable selection	
4. Test casting production	
5. Casting analysis	
6. Report	

Sector IV - Agile Manufacturing, Track A - Adaptive, Open Architecture Welding Applications

The responsibilities and tasks were primarily shared by two DOE facilities — INEL and Y12. The coordinating lab function was assigned to INEL. The coordinating-lab role was to ensure that the appropriate technologies were used and that the appropriate participating lab was chosen with the best capability for a particular part inspection requirement. During the first year, six laboratories and plants participated in the development of hardware/software standards.

The project included the following tasks:

1. Develop/document hardware and software standards
2. Demonstrate specifications for industrial, open-architecture, modular approach, standard interface
3. Coordinate with interagency program activities
4. Transfer applicable technological development to other LEP programs
5. Integrate technology transfer of TEAM and LEP activities

Sector V - Predictive Maintenance, Track A - Predictive Maintenance

The responsibilities and tasks were shared across the DOE facilities. These included the 4DP labs and ASKCD. The coordinating lab was assigned to LLNL for DOE defense program (DP) funding. The coordinating-lab role was to ensure that the appropriate technologies were used and that the appropriate participating lab was chosen with the best capability for a particular part inspection requirement. For the first year, the program identified two key laboratory or plant participants. They are Y12 and Lawrence Livermore National Lab This report covers only the work done at LLNL.

TASK

Subtask

Predictive Maintenance	
1. Summarize current technology	
2. Summarize predictive maintenance for drilling/milling	
3. Supply specifications, materials, parts	
4. Facilities evaluation of monitoring tool wear	
5. Tool machine suppliers qualify	
6. Implement state-of-the-art predictive maintenance	x

F. Documents/Reference List

CRADA reports and other topic/periodic reports published for the project

None

Patent/copyright activity or pending applications.

None

Subject inventions disclosed by either the industrial partner or LLNL

None

Licensing status of Background Intellectual Property (BIP) and subject inventions

None of the parties (LLNL, GM, Ford, and Chrysler) provided any Background Intellectual Property to this Program.

G. Acknowledgement

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 generated by his/her respective company and attributable to the project have been disclosed and included in Section E or are included on a list attached to this report.
4) The Participant certifies that if tangible personal 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.

Charles Gough — Date
General Motors Corporation

Jonathan Johnson — Date
Ford Motor Company

Michael Royce — Date
Chrysler Corporation (now DaimlerChrysler Corporation)

6/15/01
Jerry Haskins — Date
Lawrence Livermore National Laboratory

Attachment I – Final Abstract
Attachment II – Project Accomplishments Summary

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Charles Gough — Date
General Motors Corporation

17 APRIL 01

Jonathan Johnson — Date
Ford Motor Company

Michael Royce — Date
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Charles Gough — Date
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4-26-2001

Michael Royce — Date
Chrysler Corporation (now DaimlerChrysler Corporation)

6/15/01

Jerry Haskins — Date
Lawrence Livermore National Laboratory

Attachment I – Final Abstract
Attachment II – Project Accomplishments Summary

Advanced Manufacturing

Final Abstract (Attachment I)
CRADA No. TC-0880-94

Date: October 24, 2000 Revision: 3

A.. Parties

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Advanced Manufacturing

Project Accomplishments Summary (Attachment II)
CRADA No. TC-0880-94

Date: February 14, 2001 Revision: 5

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B. Background

AlliedSignal Kansas City Division, Idaho National Engineering Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Martin Marietta Energy Systems-Y-12, and the Sandia National Laboratories (contractors) entered into an Advanced Manufacturing Cooperative Research and Development Agreement (CRADA) with the USCAR Low Emissions Partnership (LEP), Engine System Support Technology (ESST), composed of Chrysler Corporation, Ford Motor Company and General Motors.

This CRADA was in direct support of Goal I of the Partnership for a New Generation of Vehicles (PNGV). The program was directed to manufacturing technologies that would have the potential of reducing emissions and increasing the efficiency of automotive products while reducing product development time and enhancing the technology base with the DOE complex.

C. Description

The work was divided among the Contractors and LEP so that each party concentrated in those areas where they had demonstrated proficiency. Each party was responsible only for its specific task. The scope of the work was divided into five separate projects:

1. Part Integrity
2. Powertrain Components
3. Powertrain Assembly
4. Agile Manufacturing
5. Predictive Maintenance

In the first phases of this project we evaluated NDE methodologies as an enabling technology for measuring and improving part integrity. In the remaining phases we concentrated on evaluating specific components.

The final phase of the project which primarily involved transmitting the data to the partners, generating a final report, and helping the partners to implement the technology in their own plants, was not completed because funding was cut off.

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Chrysler PTPE	Develop means to read edited STL code into FIRE CFD code supporting engine flow analysis

D. Expected Economic Impact

The overall purpose of this project was to materially aid in the maintenance of a viable, competitive automotive manufacturing capability in the U.S. This assurance was a prerequisite for equally significant goals of maintaining manufacturing-related jobs in this country. LLNL expected that the collaborations to be established in this program would continue into other research projects that would also benefit the automotive industry. We anticipated that other interactions between the DOE laboratories and the US auto makers would also result from this work.

Tangible benefits were the development of significantly enhanced experience, capabilities, and demonstration of superplastic stainless steel through evaluation of laser modeling and prototype demonstrations. Intellectual Property developed was expected to include processing enhancements which could be patentable.

E. Benefits to DOE

The DOE program was a primary beneficiary of the dual-use nature of the technology developed by this Program. The results established the framework for applying this material and processing technology to the DOE concerns including reduction of potentially harmful emissions from automobile sources, complex components, and structures performance in loading extremes, and significantly enhanced the industrial base available to DOE and its National Laboratories.

F. Industry Area

Automotive

G. Project Status

The project funding was discontinued in 1998.

H. LLNL Point of Contact for Project Information

The Regents of the University of California
Lawrence Livermore National Laboratory
7000 East Avenue
Jerry Haskins
Principal Investigator
Phone: (925) 423-4267
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I. Company Size and Point(s) of Contact

General Motors' annual sales are $177 billion, and the company employs 388,000 people.

General Motors Corporation
Powertrain Government Contracts
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Charles Gough
Phone: (248) 857-2841
Fax: (248) 857-4761

Ford Motor Company's annual sales are $122 billion, and the company employs 363,892 people.

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Fax: (313) 592-2489

Chrysler Corporation's annual sales are $61 billion, and the company employs 121,000 people.

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800 Chrysler Drive East, CIMS 482-01-07
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Michael Royce
Phone: (248) 576-4996
Fax: (248) 576-2182

J. Project Examples

There are no project examples.

K. Release of Information

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

Karena McKinley 6/19/01

Karena McKinley, Director — Date
Industrial Partnerships and Commercialization

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.

Charles Gough 5/29/01

Charles Gough — Date
General Motors Corporation

Jonathan Johnson — Date
Ford Motor Company

Michael Royce — Date
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6/19/01

Karena McKinley, Director
Industrial Partnerships and Commercialization — Date

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