Task Title: Scanning Acoustic Microscopy for NDE of Microelectronics and Microelectromechanical Systems (MEMS)

I. Objectives: Development of guidelines and procedures for using the Scanning Acoustic Microscope to perform NDE on microelectronics and microelectromechanical systems.

II. Center Point of Contact:

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III. Technical Methodology/Approach:

Background: Scanning Acoustic Microscopy (SAM) produces images of structural details that are concealed by encapsulation or packaging. It accomplishes this through the analysis of ultra high frequency sound waves that are reflected from concealed layers. The technique is complementary to the use of x-rays in that x-rays provide an image showing dark areas where the high atomic density exists, while acoustic microscopy shows the greatest darkness where the largest amount of acoustic energy is transmitted through the specimen. In doing so, the SAM image shows areas of layer delamination and bond failure. Limitations on the use of SAM imaging arise from the number of variable present and trade offs that exist between these variables. Variables include acoustic frequency, intensity that will trigger a reading, surface follower used and focal length of acoustic lens among others. Trade offs are primarily the effect of frequency on resolution vs. penetration depth and the effect of lens focal length on magnification vs. depth of field. In general, higher frequency and shorter focal length produce a more detailed image but the image quickly loses definition at deeper depths. Because of these constraints, SAM results are more difficult to obtain and interpret than are x-ray results. This is particularly true with specimens possessing multiple bonded layers. As a result, the technique sees most of its use in performing routine tasks examining well characterized parts for delamination.

Methodology: The task will utilize SAM equipment and failure diagnosis facilities already at JPL to build to build a library of defects that occur in microelectronic and MEMS. Samples of failed parts will be obtained from commercial manufacturers and from JPL's Micro Devices Laboratory which is a leading developer of state-of-the-art MEMS technology. Devices will be completely documented using JPL's SAM unit. Images will be taken using a variety of frequencies and focal lengths. If appropriate, the existing complement of lenses (which includes six lenses having various frequency drivers and focal lengths) may be augmented with lenses offering additional capabilities. All data will be archived on CD-ROM. The selection of data points to be taken will employ "Design of Experiments" analytical techniques. Microfocus x-ray documentation will be performed to identify any voids that are visible using this technology. Finally, specimens will be cross sectioned and analyzed to develop a data base of actual defects. The raw data will be used to produce a set of guidelines and procedures in the form of a manual that will guide the NDE

professional in the application of SAM techniques to the evaluation of defective microelectronics and MEMS.

IV. **Customers:** This work will have application to diverse mission work that will be carried out at NASA facilities where microelectronics and MEMS will be utilized. Immediate customers will be the series of unmanned missions to Mars that will begin with Mars '03. As MEMS devices are expected to play a continuing and growing role in NASA programs, it is critical to develop techniques for cost effectively performing NDE on these devices.

V. **Metrics:** Project progress will be reviewed frequently against a plan timeline that will show scheduled activities, milestones and deliverables. Any deviations from plan will be compensated for so as to keep the project on schedule

VI. **Products:** The study will result in a set of guidelines and procedures that will be published in a CD-ROM format. A web site will also be created that will continually detail the progress made in the project and will at the culmination of the project contain a copy of the project output that can be freely downloaded.

VII. **Schedules/Milestones:**

- Form working partnership with suppliers of microelectronics and MEMS (2/02).
- Identify and begin to assemble quantities of test structures. (4/02).
- Begin to evaluate components using SAM and x-ray. (5/02)
- Begin to perform destructive physical analysis of SAM characterized samples. (9/02)
- Complete SAM and x-ray evaluations (2/03)
- Complete all testing and destructive analysis (6/03).
- Complete analysis of data and publish final report on CD-ROM and web site (9/03).