INTRODUCTION

During the last 10 years, TASC has undertaken several digital image enhancement projects based on nondestructive evaluation (NDE) applications. Most of these projects involved analyzing NDE imagery to determine why a critical part failed to operate as expected, or trying to recover from a failure which degraded NDE imagery or made it difficult to obtain. Examples include our studies of the Inertial Upper Stage nozzle nose cap following the unsuccessful launch of a Tracking Data Relay Satellite in the summer of 1983 [1] and our development of a video data image processing system to enhance, in real time, unevenly lit, poor-contrast signals from within the contaminated Number 2 reactor vessel at Three Mile Island [2].

This paper describes another image enhancement project at TASC, but this effort involved a rather unique application. The problem was to determine the contents of a 100-year old time capsule before it was opened.

The organization of this paper is as follows. First, the origin of the time capsule is discussed. Next, the use of computed tomography at NASA's Marshall Space Flight Center to scan the interior of the capsule and provide a first-look at its contents is described. The enhancement of the resultant tomograms at TASC is then presented. We show how basic signal processing methods were used to improve image quality using some interesting examples from the imagery of the capsule. The highlights of the time capsule opening are summarized and the paper concludes with a discussion of how NDE techniques were used to advantage in this application.

BACKGROUND

In the fall of 1988, Benjamin P. Field V asked the National Geographic Society to observe the opening of his time capsule. The time capsule was a box about 20 inches long, 15 inches wide, and 8 inches deep with the words “OPEN IN 1989”
inscribed on it. It was rumored to contain mementoes from the Centennial Celebration of George Washington’s inauguration which took place in New York City on April 30, 1889, and possibly even contain objects from that first inauguration [3]. In order to verify the authenticity of Ben’s story and to ensure that whatever was in the box would not be damaged during the opening, the Society arranged for the application of NDE techniques to the sealed box.

On January 19 and 20, 1989, laboratory personnel at NASA’s Marshall Space Flight Center in Huntsville, Alabama scanned the box using the Advanced Computed Tomography Inspection System (ACTIS). This is a translate-rotate (second-generation) x-ray computed tomography (CT) imaging system used in the inspection of spacecraft and associated propulsion system components. The ACTIS allows the distance between source and detectors to be varied to optimize the geometry for each test object. Three radiation sources spanning the energy range from 150 keV to 15 MeV accommodate the scanning of a variety of material thicknesses and densities, while a large number of focusing detectors positioned in a dense array contributes to a high x-ray collection efficiency. The variable geometry, multiple energy sources, and multiple focusing detectors allow the user to optimize the spatial, density, and temporal resolution of the scanner for each application [4,5].

Scans were taken at a beam energy of 2 MeV with the box positioned on the ACTIS turntable so that its 20 by 15 inch dimensions were at the top and bottom. Cross-sectional slices were taken horizontally from top to bottom of the box at a nominal 4-mm spacing. The integration thickness of each slice was also 4 mm. The spacing between slice centers was reduced to 1 or 2 mm in areas of special interest. The reconstruction field of view was slightly greater than the larger horizontal dimension of the box and most of the resulting tomograms were sized at 1024 by 1024 pixels. The ACTIS was also capable of producing “zoom reconstructions” of enhanced resolution at 2048 by 2048 pixels. At the end of the scanning session, approximately 45 tomograms were available for closer examination.

Review of the tomograms at NASA/Marshall provided the first clear look at the contents of the time capsule. In general, observable detail was very good. The capsule consisted of an outer galvanized cover, an inner wooden box made of pine or cedar boards nailed together over an inner metal lining. Woodgrain, planking, several metallic objects appearing to be medallions, pins, or coins, and a number of metal/wood discontinuities were noted. Artifacts were only evident around the nails holding the planks of the box together. These nails were generally the smallest high-density contrast objects observed.

The majority of the contents was printed material, precisely fitted in the box, but mostly still undecipherable except for size and shape details. Legends on some of the items were observed, but significant detailed information about the nature and contents of the documents could not be recovered. An artist’s rendering of the interior of Ben Field’s time capsule was prepared upon completion of the scanning process. This picture, which reflected the study team’s understanding of the box’s contents, appeared in the May issue of National Geographic [3].

ENHANCEMENT TECHNIQUES AND EXAMPLES

Enhancement of selected tomograms was performed in the Computing Technology Center at TASC. Our goal was to bring out more detail in the images which