CREATING 3D MODELS FOR AIRCRAFT COMPONENTS AND SYSTEMS FOR SUPPORT IN AIRCRAFT ACCIDENT INVESTIGATION

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ABSTRACT

This paper describes the procedures used in 3D modeling of aircraft wire bundles and components, including cockpit and interior details of a wide body aircraft. A combination of several methods are used in the data collection and modeling. Systems used are servo controlled reflectorless total stations and digital photogrammetry. The paper describes the photogrammetric targeting techniques using projected binary targets and projected laser patterns. The automated feature extraction, and automated target reading procedure used to create the 3d models will be described. The paper will also discuss time comparisons between the various methods and time to 3D models. Also discussed are the problems of working in the interior of aircraft and the stabilization problems inside the aircraft. Several examples are discussed and illustrated from small controls, instruments and major interior components of the aircraft that were measured and modeled in and outside of the aircraft.

1 INTRODUCTION

Photogrammetry has been used for the last two decades in aerospace manufacturing and quality assurance. The procedures remain somewhat the same, with a drastic change in equipment and 3dmodelling capabilities. Although automated target reading and has been around for some time as reported by (Robertson, Wyatt, 1984), (Robertson, 1986) it required large format photogrammetric cameras and expensive precession scanners and computing power. Now with smaller hand held digital cameras and new total station technology and expanded software capabilities now offers not only first order accuracy but also 3d modeling in near real time.

1.1 Aircraft Interiors

The problem of working in a large aircraft during assembly or inspection is movement with numerous work groups walking in the aircraft. This obviously presents a stability problem not so much for the acquiring the images but for the survey and any type of target projection. This particular project required us to create 3d models of wiring bundles in a wide body jet, in addition to develop 3d models of the cockpit and interior elements. Some of these interior elements were recorded outside the aircraft. For the photogrammetric recording of the interior several approaches were used. Convergent digital images would be used for the wire bundle and use of projected target patterns for automated target measurement. This would also augment the data acquired with the survey procedure with the total station. For the projected target pattern we used a laser and a projected precision dot pattern that we have used with a modified raster technique as reported in (Robertson, 1988)

1.1.1 Survey Control. The instrument used in the aircraft was a Leica TCRM1103, a motorized 3-second total station, featuring Leica's unique visible red laser EDM. One of the very significant advantages of the visible red laser used by Leica is the small spot size (approximately 8X24mm) that makes it possible to use the spot itself for aiming the theodolite at target points (Figure 1 Figure 2). This proved to be a very important feature, especially in the cockpit area, were a lot of points were well under 1m from the instrument. Since this distance is well under the minimum focussing distance for nearly all-total stations, the visible red laser allowed us to make measurements that would not have been possible otherwise, due to an inability to focus on the target point. The small spot size also minimized the impact of adjacent surfaces on the distance measurements to the target points.

Figure 1

Figure 2

We used Leica's Local Resection, Free Station and Orientation & Height Transfer applications, running onboard the TCRM1103, to facilitate setting the instrument into the aircraft coordinate frame of reference initially, and as we moved the instrument around the aircraft. The applications automatically used the motors of the instrument to drive to the third and successive points during the orientation processes, and even inverted the telescope and re-pointed to all the target points, allowing easy measurements in both instrument faces. The short distances involved did not warrant the accuracy potential of inverting the telescope, but doing so allowed us to better cope with the continual motion of the aircraft as we worked.

Figure 3

Scanning of one of the wall panels in the first class cabin was performed using Leica's Face Scan application. Face Scan allowed us to measure thousands of points to develop an accurate digital model of the panel, and it performed the measurements unattended. All that was required was to switch the instrument off at the end of the measurements. These same panels were also measured using an automated photogrammetric procedure.

1.2   Photogrammetric Measurement and Modeling the Interior of the Aircraft The measurement and modeling phase of the aircraft interior was accomplished using ShapeCapture software. The ShapeCapture software provides for accurate 3D measurement, full camera calibration and modeling and automatic target extraction, matching, and measurement. For a portion of the photogrammetric work automated target extraction, matching, and measurement was used. We found that the laser-projected points were in most case's poor. The problem was the illumination and the number of points that could be used with the power requirements of the laser. Figure 4 illustrates the projected laser on the interior wiring. The raster steel slide was also used it produces binary targets, we use various combinations where one slide can project up to 5,460 points on the object see Figure 5.0. An additional slide format projects 1,395 points with a larger diameter. 3D models were created of the overhead wire bundles, (Figure 6) cockpit and other key interior features of the aircraft. Figures 7 to 11.
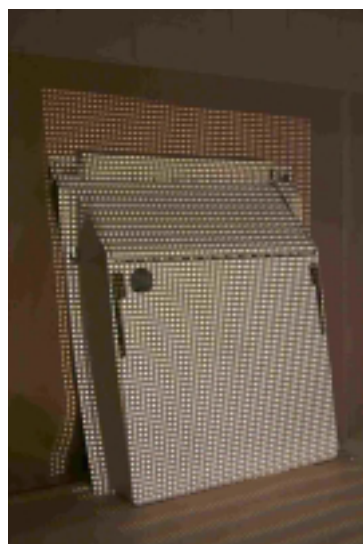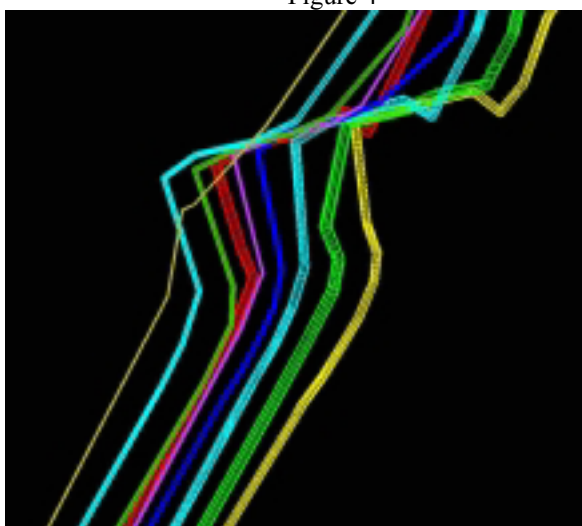
Figure 4

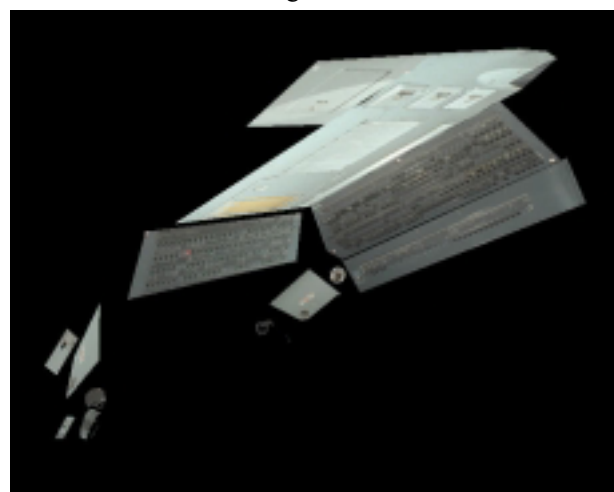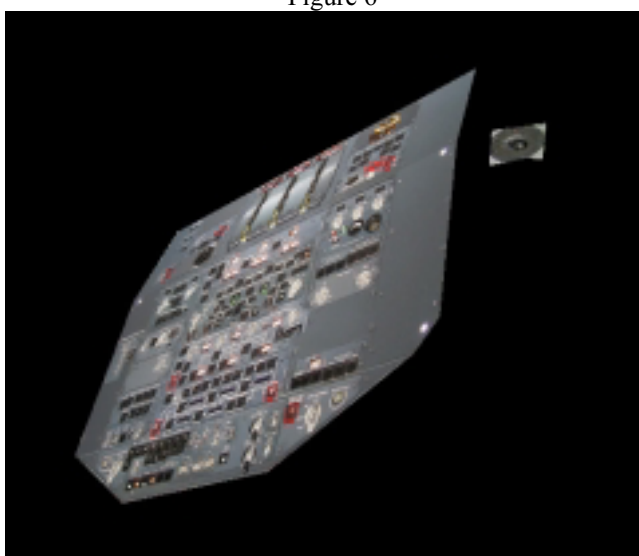Figure 5

Figure 6

Figure 7
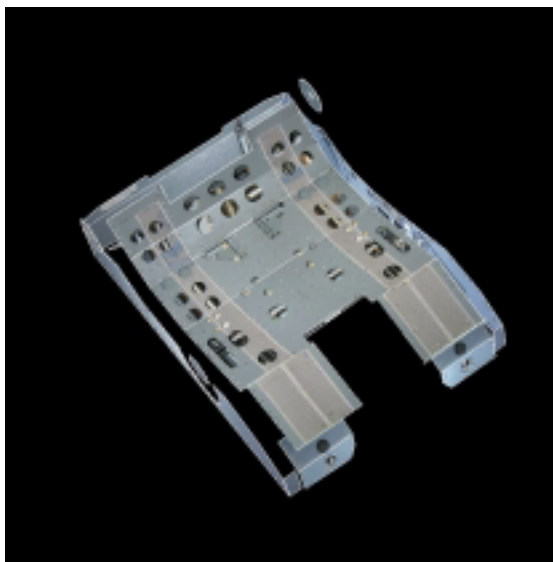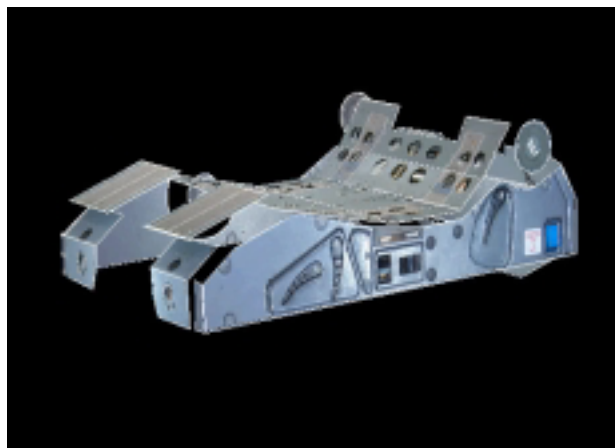

Figure 8

Figure 9

Figure 10

Figure 11

In addition interior modules were imaged outside the aircraft such as galleys and lavatory module. The ShapeCapture program provided 3d models that were placed in MicroStation Cad program for indexing. In addition full texture mapped models were created in ShapeCapture as shown in Figures 12, 13. The Figures 14, 15, 16, 17 illustrate the models that were indexed and rendered inside of MicroStation.
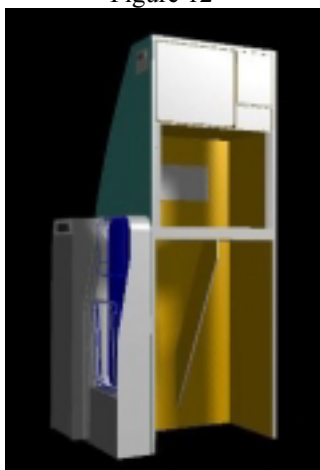

Figure 12

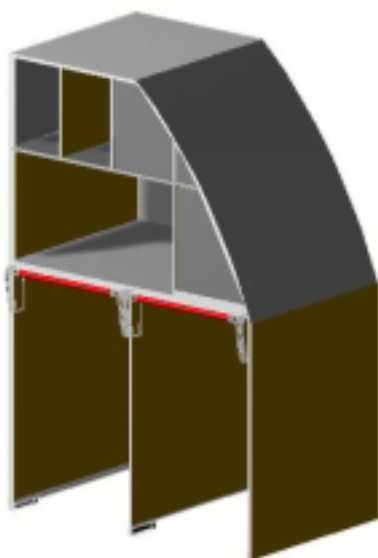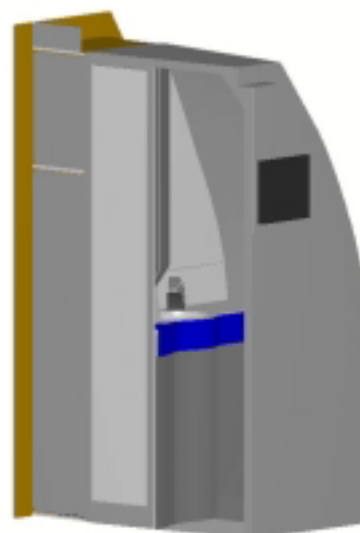
Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

2.0   Automated Measurement and Modeling

The interior panel that was measured with the Leica TCRM1103 (Figure 3) was also measured outside the aircraft (Figure 19) along with other parts with The ShapeCapture program.
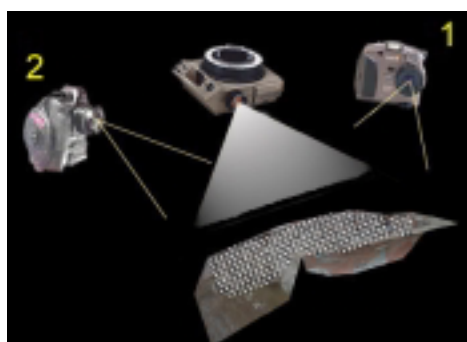

Figure 18

Figure 19

Figure 18 illustrate the procedure of the projected dot pattern on the surface with the camera positions shown. Figure 19 shows the window panel with the projected pattern. ShapeCapture reads the projected targets automatically and using stereo matching computes the 3d coordinate geometry and then allows you to assign it a set for automated modeling of the data. Figure 20 and 21 illustrates the 3956 points and 4339 target points being measured and matching 3666 points in seconds.
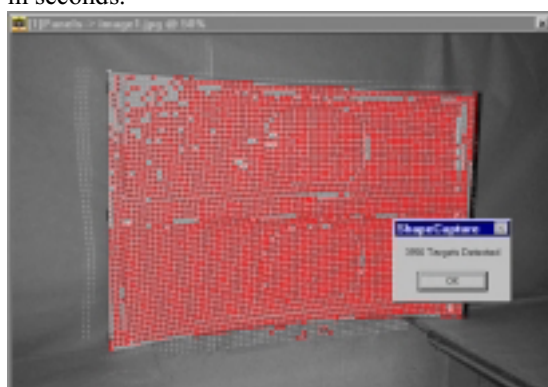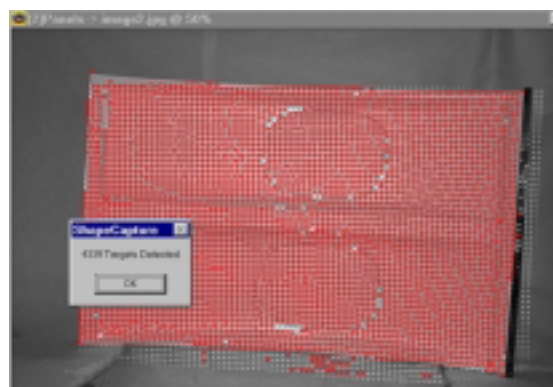

Figure 20

Figure 21

The completed model is illustrated in Figure 22. A modified version could yield accurate 3d measurement and matching in near real time.

Figure 22

3 Conclusions

With the advancement of new automated systems, utilizing the latest in motorized laser total stations, and digital cameras and photogrammetric software with automated measurement and matching, reduces the field time and data acquisition time substantially. The most important aspect of this is the modeling, and CAD side with the abilities of accurate surface fitting and texture mapping. During the earlier nineteen eighties we developed a system to measure targeted points automatically and with great accuracy but could not created 3d models. It was expensive and slow as to the standards of today. We now have the capabilities of first order type accuracy with full accurate 3D modeling automatically.

ACKNOWLEDGEMENTS

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