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Application Example: Reverse Engineering

Aerospace: Upgrade of a BLACK HAWK Helicopter

Measuring Systems: ATOS, TRITOP
Keywords: External airframe, Reverse Engineering, CAD data

To upgrade the electronic technology for the Australian Army's fleet of Black Hawk helicopters, BAE Systems Australia needed to establish 3D CAD information. Therefore both external and internal data of a helicopter was measured using photogrammetry and optical digitising.

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Reverse Engineering / Aerospace

Upgrade of a BLACK HAWK Helicopter

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Background

BAE Systems Australia was asked to upgrade the electronic technology for the Australian Army's fleet of Black Hawk helicopters. As part of this project BAE Systems Australia needed to establish 3D CAD information which accurately reflects the current state of build of the airframe and ancillary equipment.

It was decided that the quickest and most efficient method was to digitize an actual aircraft so that real 3D data is captured as a factual basis for design and installation upgrade.

BAE Systems Australia contracted MOSS / Scan-Xpress to undertake 3D Photogrammetry and 3D Scanning of the aircraft. Both external and internal data was required.

Fig. 1: Black Hawk Helicopter from the Australian Army, Fuselage Size: 15.4 x 2.4 x 2.3 meters (Length, width and height)

BLACK HAWK – Objectives & Overview

The objectives for the 3D Scanning project were to:

1. Measure the external airframe and produce 3D scan data to within a verifiable accuracy of 0.1 mm
2. Measure certain internal areas of interest to the same accuracy
3. Produce an integrated set of data with both the external and internal data in the same co-ordinate frame work
4. Complete the work on site and within the required project time frame
5. Model the aircraft using the scan data and produce an integrated 3D model for CAD analysis

Because of the size of the aircraft and tight accuracy requirements, normal digitizing techniques with scanning only could not meet the requirements. A combination of photogrammetry and optical scanning was needed.

A GOM TRITOP (photogrammetry) and ATOS (optical scanning) system was used to carry out the 3D measurement. These systems are accurate and portable, thus allowing data capture on site in the working environment.

The helicopter was mounted in a well defined position and the markers were attached to capture the needed surface using TRITOP only (lines and individual reference markers) or surface scanning by ATOS, as shown in Fig 3.

TRITOP Photogrammetry
The TRITOP system takes high resolution and professional quality two-dimensional pictures of objects to provide an accurate large scale 3D coordinate framework based on digital photogrammetry techniques. This technique is similar as used in large scale construction and land surveying. Coded and uncoded markers are applied to the object to be measured and multiple images are captured by the photogrammetry camera. Then the three-dimensional coordinates of the center of the reference markers are calculated precisely using photogrammetry. These marker positions are then the reference framework to integrate scanning data captured by ATOS into the global coordinate system of the object.

Big coded reference markers are used to establish an accurate global framework in the helicopter coordinate system. Then individual TRITOP measurements define the exact 3D position (outside and inside the helicopter) of the smaller coded and uncoded reference markers.

ATOS Digitizing
The ATOS (Advanced Topometric Sensor) system is a white light optical scanner which scans three-dimensional objects and converts the images to high density point clouds. This allows accurate measurement and capture of the shape and size of the visible surface of almost any 3D object.

The scanning is based on optical triangulation and stereo-viewing. A projector is used to project striped fringe patterns onto the object's surface. These images are captured simultaneously by the two measurement cameras from different angles. This stereo-setup supports an easy and very accurate 3D capturing of the reference markers. With the help of digital image processing, 3D-coordinates are computed fast and with high accuracy for up to 4 million camera pixels using the supplied high end System PCs.
The captured scan data is then automatically integrated in the predefined reference marker framework.
The additional data captured with two cameras of the ATOS system are used to verify the calibration of the system, detect movements and high ambient light changes during the measurement and verify the matching accuracy of the individual scans into the global coordinate system. Therefore this system is often used for critical applications and in automotive and aerospace.

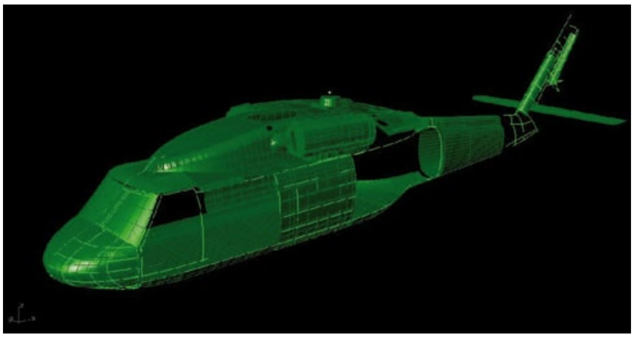

Fig. 2: CAD model developed from scan data (WIP)

Scanning Methodology Preparation

The aircraft structure was prepared with all doors and hatches in place. MOSS / Scan-Xpress then placed coded and un-coded targets onto the airframe.

Reference data were established and accurately measured to support the accurate integration of multiple measurements from outside and inside the helicopter.

In total, 41 scan data files were created covering both external and internal areas of the aircraft. These contained 12 million data points while maintaining an accuracy of 0.1 mm overall.

Fig. 3: Fuselage prepared for scanning

Stage 1 - TRITOP

An accuracy test with the reference targets was set up to compare the TRITOP results with Laser tracker data to make sure the data meet the accuracy expectation and the TRITOP system fit into the existing measuring equipment standard of the Australian Army. This measurement was also used to pre-adjust the coordinate system of the big coded reference markers into the helicopter coordinate system.
Then a photogrammetric survey was carried out with the TRITOP system. The result of this first stage is shown in the screen dump below.

The accuracy of this first stage was in addition checked by confirming several physical measurements using established measuring equipment.

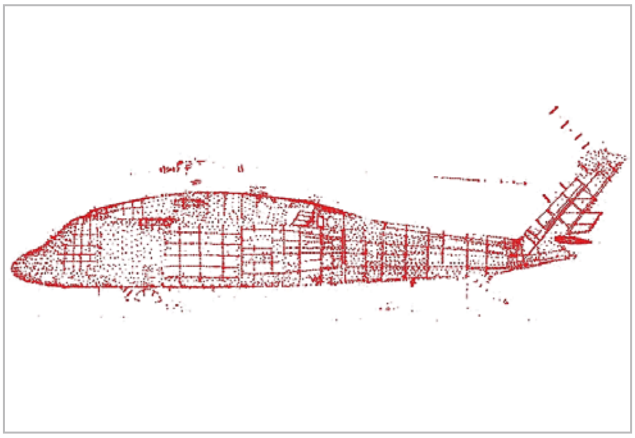

Fig. 4: External skin panels - Scan data established by TRITOP (photogrammetry) (9,000 points, accuracy of 0.1 mm, object size > 15 m)

Stage 2 - ATOS

After the TRITOP stage had been completed, the ATOS 3D scanning stage was started. A typical area which had to be scanned, the nose section, is shown in Figure 5.

Fig. 5: Nose - prepared for scanning with ATOS

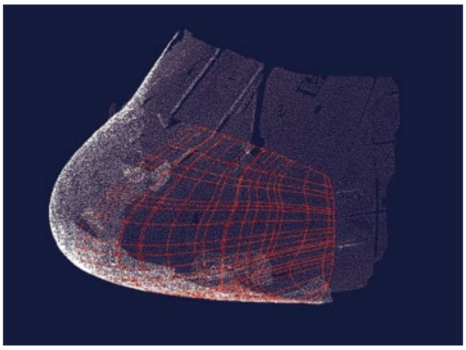

Fig. 6: Nose - ATOS Scan data (optical white light scanner data)

Stage 3 - Modeling

Following the data capture stages, the scan data was processed by the ATOS system into a nice polygon mesh data set in the STL format. The polygon model was then registered to the aircraft data position.

The total project consisted of 24 million polygons and was subdivided into a number of distinct areas for ease of handling.

Each area was then modeled using a combination of 3D CAD packages. To make sure the CAD data fit the scan data in the needed tolerance, ATOS can read in the CAD data and display the deviation of as built to the Reverse Engineered surface as a color coded cloud of data. The resulting and approved overall CAD model was then used by BAE Systems Australia to plan and design the electronic upgrades.

Results and Benefits

1. Quick and accurate data capture of a relatively large object
2. Confidence that the data reflects the "as built" state of the aircraft
3. Data that can readily be imported into the desired CAD software for planning and design purposes
4. Savings in time and cost compared to more traditional methods

We would like to thank MOSS / Scan-Xpress Pty Ltd for this case study and BAE Systems Australia for their support of optical scanning technology.

