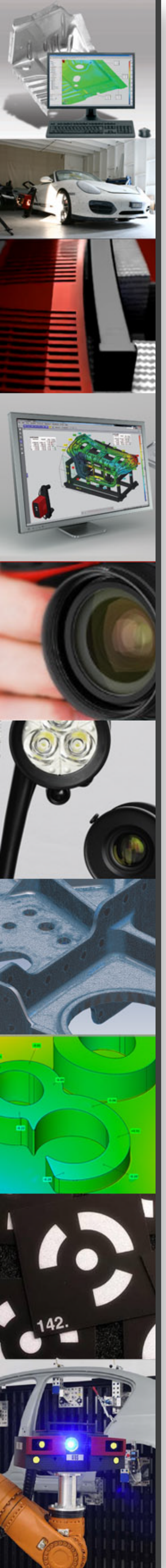


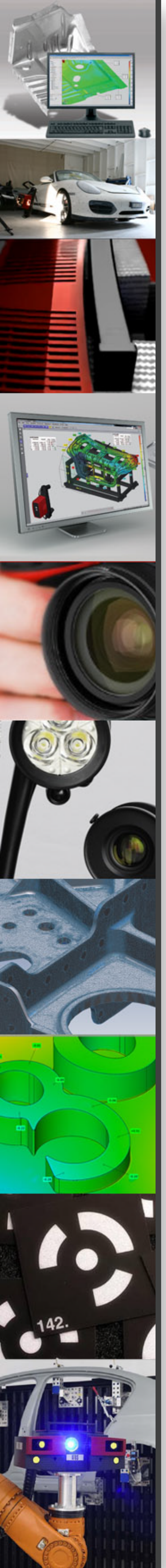
EXCELLENCE IN 3D MEASUREMENT

Application Example: Reverse Engineering

Aerospace: Digitizing of a Full Scale Falcon 20 "Zero G" Jet Aircraft

Measuring Systems: ATOS, TRITOP
Keywords: Life time enhancement, airplane

The National Research Council (NRC) Institute for Aerospace Research had a requirement to digitize their Falcon 20 parabolic aircraft to capture its "As Built" condition for CFD analysis, moveable aero surfaces positions and aircraft symmetry checks.



SCAN-XPRESS

EXCELLENCE IN 3D MEASUREMENT

Reverse Engineering / Aerospace

Digitizing of a Full Scale Falcon 20 "Zero G" Jet Aircraft

Measuring Systems: ATOS, TRITOP
Keywords: Life time enhancement, airplane

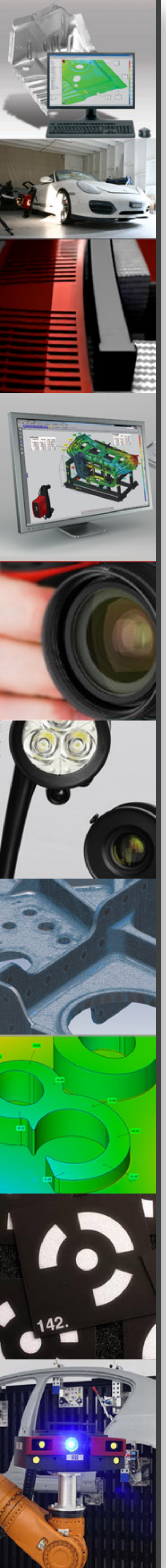
The National Research Council (NRC) Institute for Aerospace Research had a requirement to digitize their Falcon 20 parabolic aircraft to capture it's "As Built" condition for CFD analysis, moveable aero surfaces positions and aircraft symmetry checks.

The NRC Falcon 20 was only available for a 2.5 day period for the data acquisition process.

Previous to the Falcon 20 project the team at NRC had already worked with "point cloud" data which was acquired on a different aircraft. Knowing their downstream surfacing processes, NRC wanted both a dense scan data to support rapid surfacing techniques (surfacing on STL data) and on surface measured data (versus data collected with an offset from the surface) to expedite downstream processing.

Capture 3D utilized two complimentary non-contact data acquisition devices, ATOS II Structured White Light and TRITOP Digital Photogrammetry, to capture the Falcon 20 in the allotted 2.5 days. This article describes the process and displays various images of the resultant large scale scan project.

NRC's Falcon 20 Parabolic Flight Aircraft
The Falcon 20 supports the Canadian Space Agency by providing near "Zero G" conditions for a limited time-span.



SCAN-XPRESS

EXCELLENCE IN 3D MEASUREMENT

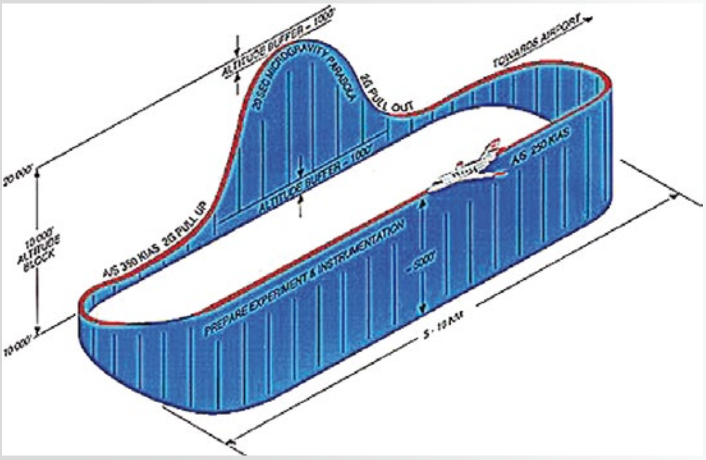
A few interesting specifications: Manufactured by Dassault (France):

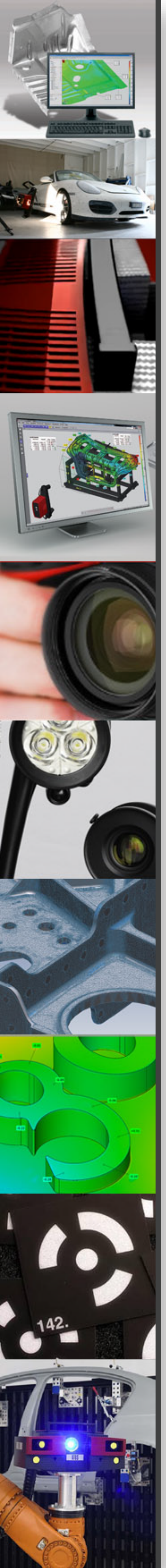
- Span 16.3m (53ft 6in), Length 17.15m (56ft 3in), Height 5.32m (17ft 5in)
- 18 - 22 seconds of near zero "G" time
- Usual engagement includes four parabolas
- Three minutes between parabolas
- Usual flight test duration 45 minutes
- 10,000 Ft altitude drop and rise
- Fuel and hydraulic systems modified for zero G
- Materials such as high quality glass and super-conducting materials created in absence of gravity have unique properties

NRC Project Goals

The NRC Institute for Aerospace Research - Aerodynamics Laboratory in Ottawa, Canada, specializes in various stages of flight testing and training. They perform onboard experiments, scale-model wind tunnel testing and computer physics simulation. To ensure a valid computer simulation, NRC's input data for the simulations needs to match the physical experimental set up. "As Built" data acquisition and Reverse Engineering play key roles as the link between the physical and the digital model environment.

NRC has performed Reverse Engineering projects in the past to generate CFD and CAD models. Prior approaches involved contact metrology techniques (portable CMMs or laser trackers) which provided data points offset from the actual aircraft surface. Offsetting the data of complex areas of an aircraft can be a time-consuming and a quality-limiting task sometimes subject to the CAD designer's interpretation. In an ongoing process improvement effort the NRC wanted to increase data collection throughput and acquired surface data definition and reduce post processing time and effort.





NCR investigated the metrology marketplace to find the tools that would help them to improve on the previous aircraft data acquisition and post processing effort. They selected Capture 3D Inc. with their ATOS II and TRITOP Digital Photogrammetry systems to capture the full exterior aero surfaces for digital definition creation. The goals of the data acquisition process:

- Full aero surfaces for CFD model creation - aircraft on jacks with bay doors closed
- Scan past centerline - assuming aircraft symmetry, checks done for validation
- Symmetry check - key features measured on "Non Master" side to perform symmetry checks
- On aircraft scan data required - On surface data eliminated the offset of data requirement
- Full definition of complex blended surfaces - ensure wing to fuselage mates fully captured
- Confidence of full definition of aircraft - Real time visualization displays project status
- Measure the full aircraft in one coordinate system - supports digital assembly
- Capture various positions of the moveable control surfaces
- Fast and easy integration into downstream processing requirements - creation of STL file to support rapid surfacing
- Time effective data acquisition process - Aggressive 2.5 day window to capture the Falcon 20
- Cost effective process needed - Reduced data acquisition cost over previous project

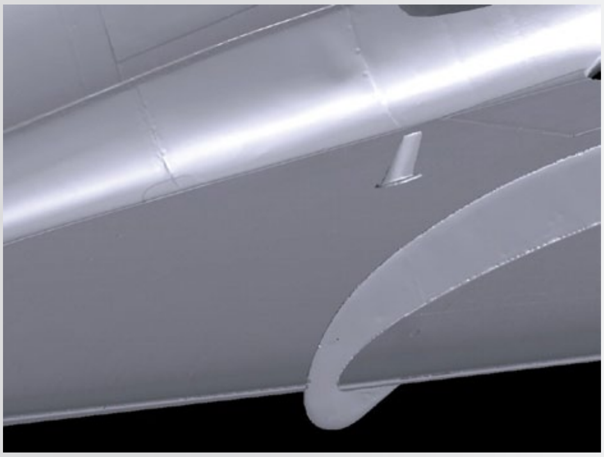
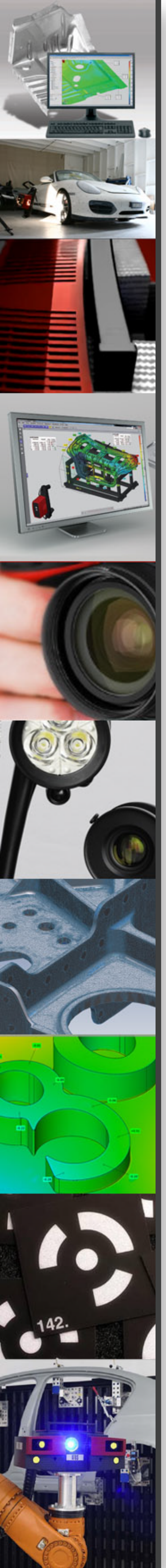


Fig. 1: Shown is the needed detail coverage, of the actual surface (no offset)

Falcon 20 Data Acquisition Process

Due to the size of the object being scanned, Capture 3D performed a two step data acquisition process (TRITOP Digital Photogrammetry and ATOS II Optical Scan) to complete the scanning task.

This was done to both expedite the project and deliver the highest accuracy of data. The Falcon 20 was put on jacks and all bay doors were closed to create the required aero surfaces configuration. The movable aero surfaces were set at a certain position for the initial scan. The moveable aero surfaces will be repositioned at various degrees and measured after the initial scan.



SCAN-XPRESS

EXCELLENCE IN 3D MEASUREMENT

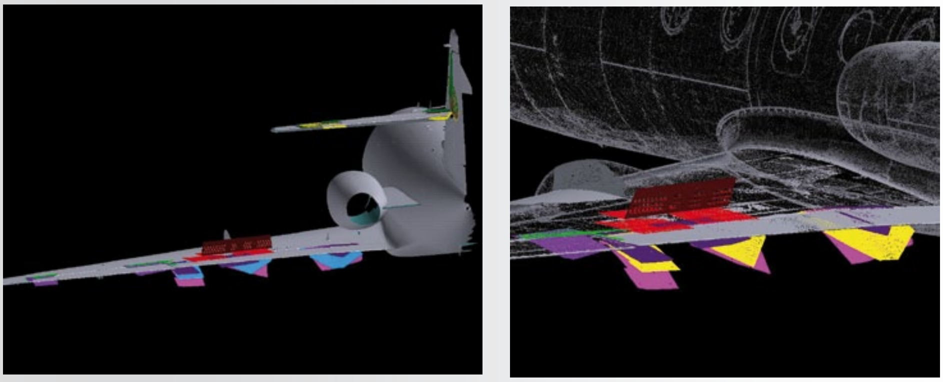


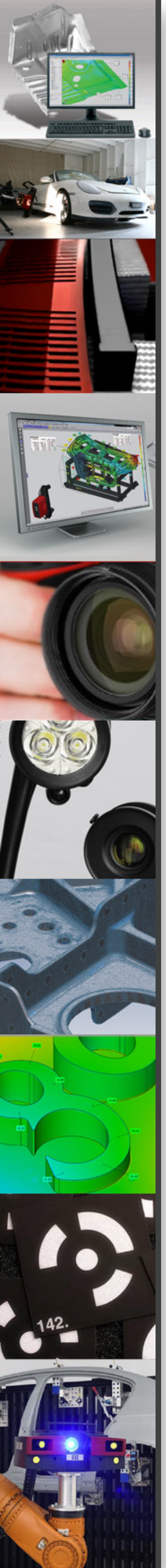
Fig 2: Surface in a predefined coordinate system, with various positions of the movable control surfaces and the pre-processing to allow an efficient downstream process.

TRITOP Digital Photogrammetry Process

Once the aircraft was stabilized on jacks the Capture 3D team placed markers on the aircraft, which will be utilized for both, the TRITOP and ATOS II scan process. A TRITOP session is performed via the use of a hand held high resolution digital camera. The user takes multiple pictures from varying positions around the aircraft, camera locations depicted in yellow (Figure 4).

Fig. 3: Shown is the application of the markers on the plane.

These images are then automatically triangulated and bundled together producing a highly accurate reference file of the marker centers (X,Y & Z) to be utilized by the ATOS II scanner for accurate and automatic scan patch placement. The TRITOP process utilizes uniquely coded markers that are automatically identified by the processing software. These markers are the reference grid for the individual ATOS scans needed to cover the full surface.



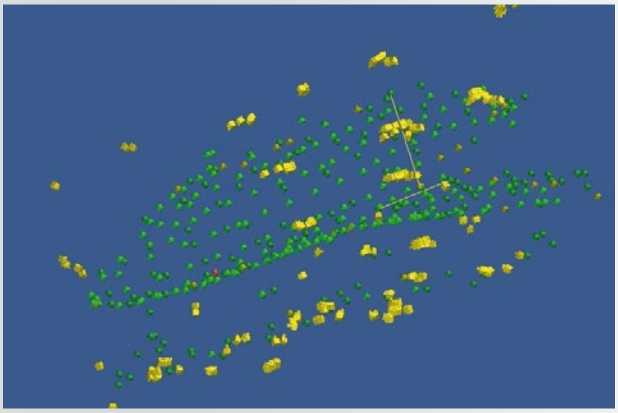


Fig.4: Marker and reconstructed camera positions.

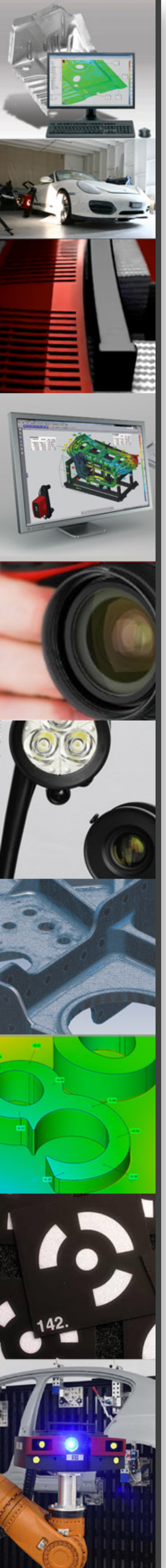
ATOS II Optical Scanning Process

The Falcon 20 aero surfaces were captured utilizing the Dual 1.3M pixel ATOS II Optical Scanning system, mounted on the articulating stand or on a cherry picker. The ATOS system utilized the TRITOP generated reference file for automatic scan patch orientation. A TRITOP value add is the ability to scan at various locations on the aircraft and having the scan data placed in the appropriate location via the TRITOP generated global reference system.

Fig. 5: Digitizing of the object using the ATOS II system

The ATOS II has a variable scanning envelope to ensure proper scan data resolution, point density / spacing, for the object being scanned. The Falcon 20 was scanned utilizing a 1.2 x 0.96 x 0.96 M (approx. 47 x 37 x 37 in) per scan measuring volume capable of delivering a point spacing of typically 1 mm (0.037 in). The same system can be increased to a 1.7 x 1.3 x 1.3 M (approx. 67 x 53 x 53 in) per scan volume all the way down to a 45 x 36 x 25 mm (approx. 1.8 x 1.6 x 1.0 in) per scan volume if necessary to accommodate part feature capture.

As each scan is taken the ATOS software responds with information on the quality of the scan and the fit of the scan patch in the global reference system. This lets the user know if the part has moved or flexed and if there has been environmental condition changes during that scan. The system will then automatically merge that scan into the reference system and existing point cloud.



The user sees a real-time build of the point cloud on the screen as the Falcon 20 is scanned. This helps to ensure complete and effective scanning. After the aircraft has been scanned, the ATOS polygonizing module will fine tune the alignment and generate the point cloud STL file in the requested density / resolution. This data can then be processed in various ways and exported out in ASCII, STL, IGES or VDA formats.

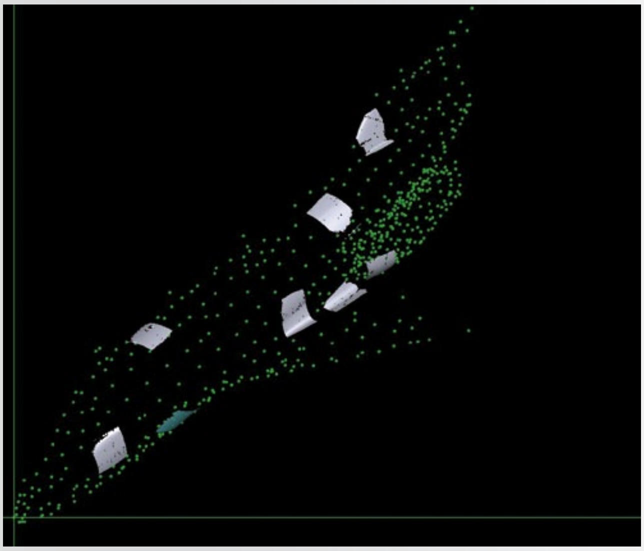


Fig. 6: Individual ATOS scans are shown in their global position. The automatic scan placement and matching of each ATOS scan into the accurately defined TRITOP generated reference grid, is a key feature in both the delivery of an accurate project and promotes time effective digitizing.

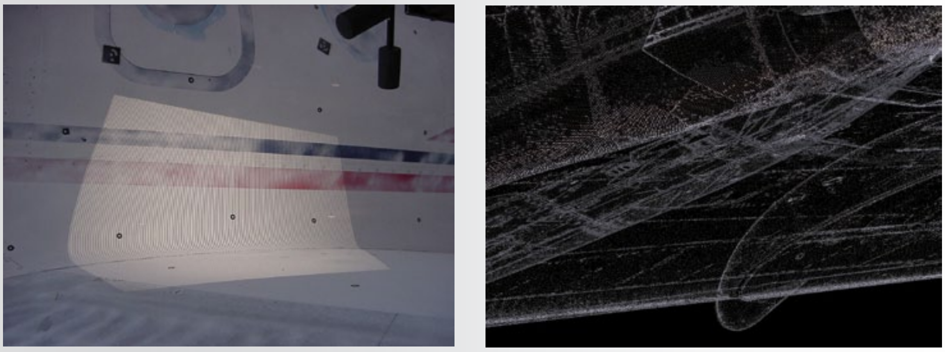


Fig. 7: ATOS II projected pattern and resulting point cloud with high data resolution at the skin seams

Aircraft Symmetry Check and Movable Aero Surfaces Position Check

The NRC requested that areas on the opposite "non master" side of the Falcon 20 be scanned to perform aircraft symmetry checks as well as the movable control surfaces be captured in various positions. This required the TRITOP session to be performed encompassing both the entire wings and tail section from tip to tip. The movable aero surfaces were captured in each position and referenced back to the original global reference system to perform the range of motion studies. Figure 8 and 9 are showing both the data acquired for the symmetry check and the various positions of the movable aero surfaces of the plane.

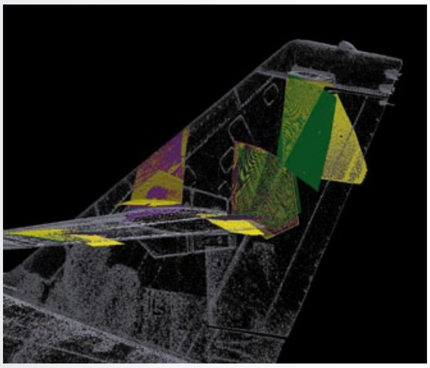


Fig. 8: Wing tip data to check for symmetry and allow an accurate mirroring to create a full aero model.

Fig. 9: The capturing of the needed positions of the flaps and airbrake are shown.

Resulting Images from the Scanning of the Falcon Test Plane

Fig. 10: Shown are different views of the gathered data, in the both right images in comparison to a digitized real size car. ATOS XL is proven for car manufacturers and is increasingly used also for much bigger objects, if dense and high accurate data is needed.

We would like to thank Capture 3D and NRC to allow us to share their work with us.