Point-cloud digitization of large and featureless composite travel trailer structures towards flexible product design and portfolio management

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Introduction

New and emerging technologies are allowing businesses to digitize their manufacturing processes, unlocking efficiencies and value previous inaccessible. This digitization has allowed businesses to reduce costs, wastes, and defects [1]. These savings and/or increased capacity can be the result of process simulations, tolerance and fitment analysis, and design optimization [2]. However, in order to perform any of these tasks, an accurate and reliable digital model of the product and process is essential.

Small and growing businesses can benefit greatly from these analyses, because of the potential gains in efficiency not normally possible small production numbers. Unfortunately, many of these companies lack the knowledge, capacity and/or infrastructure to perform these analyses. Researchers and universities that are usually relied upon to perform the analysis for these businesses, because of their abundance of expertise and facilities. Often, these researchers are not approached until the businesses have developed some of the infrastructure and models. This can lead them to fall behind in their respective industries. To bridge this gap and help accelerate this process, partnerships with universities can be the solution. The work herein presented has been performed within this framework to help a manufacturer to lay the groundwork for future analysis of their manufacturing process.

Figure 1: Escape Trailer Industries' 19ft trailer for scanning

Escape Trailer Industries (ETI) of Chilliwack, BC, is a manufacturer of highly customized travel trailers. ETI currently produces a range of trailers that are highly customizable to customer needs. In recent years, ETI has seen large and rapid growth (>10% annual increases). To continue this growth and remain competitive as they move to a more global market, ETI has begun, in partnership with the Composites Research Network (CRN) lab at the University of British Columbia, Okanagan Campus, to invest in improving their processes and product. Part of this involves the digitization of their products.

The digitization of the ETI product represents additional challenges because of the size and finish of their product. The travel trailers range in length from 17ft to 21ft, as well as having a white and highly reflective surface. The digitization process involved the creation of a digital point cloud utilizing a scanning system developed by CREAFORM® which uses structured, visible light to determine the 3D geometry of the subject. The reflectivity and color of the trailers were known from previous experience to be a difficult combination for the scanner, while the size of the trailers presented a data management challenge due to the data volumes.

a) b)

Figure 2: a) GoScan 3D scanner from CREAFORM, b) trailer segment ready for scanning, marked with positioning targets to maximize accuracy

Due to these potential difficulties, a two-phase project was conceived, with Phase I to determine the viability of the given scanner to efficiently digitize one trailer from the ETI catalogue, and Phase II to digitize the remaining ETI products using the lessons learnt in Phase I. The following is the results from Phase I of this project and an outline for the how to proceed in Phase II.

Digitization Framework

To minimize the impact ETI's production, a finished trailer body was used for the initial scan. The trailer chosen was a 19ft model which had been taken out of production due to some minor warpage. Initially, scanning of the molds had been planned, but the impact to production was deemed too great.

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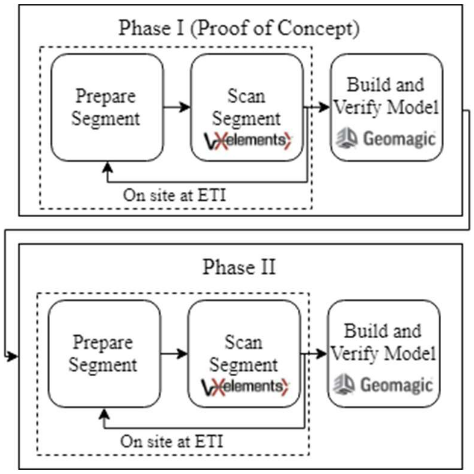

Figure 3: Digitization framework through Phase I and II

To accommodate a part of this size, a multi-scan approach was used. The trailer was subdivided in to 17 segments with each scan ranged from 900 MB to 4.3GB.

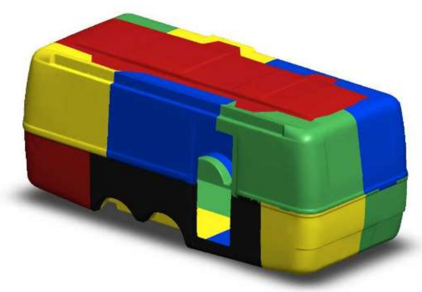

Figure 4: The trailer was segmented into 17 parts for Phase I.

These scans were used to generate a triangular mesh and the meshes from each of the segments were merged using VX Elements from CREAFORM. The mesh was then imported into Geomagic Design X from 3D Systems to clean the mesh and convert it into a parametric model. To create the model, some assumptions needed to be made such as the following:

- All features have some form of symmetry
- Small fillets and features (<100mm) were rounded to the nearest 6.35mm (1/4")
- Large fillets (>100mm) were rounded to the nearest 25mm (~1")
- Overall length, width and height was rounded to the nearest millimeter.

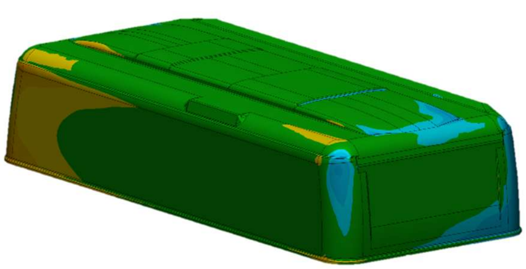

Figure 5: Deviation map of model vs scan. Green areas indicate deviation of less than 6.35mm (1/4"), within tolerance

The finalized model was then compared to the original scan data. With these assumptions, some geometry of the model differs greatly from the scan data. Using some traditional measurements, it appears that these differences are due to accumulation of errors in the scanning.

Phase II Digitization

To minimize these errors and improve scanning accuracy for phase two, a different approach to the scanning will be employed. The principle difference will be to prioritize the areas scanned. In the initial scans, every portion of the trailer was scanned, increasing the size of the data files and requiring more segmentation of the trailer.

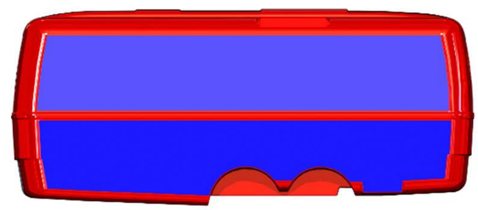

Figure 6: Geometry prioritization, areas in red are considered priority over those shown in blue.

By prioritizing important geometry, such as corners and radii, the number of scans can be reduced by including more of the geometry in each scan. This will hopefully reduce the errors created when aligning multiple scans. Large featureless areas (i.e. the flat sides) will then be framed by the scans and filled in the software afterwards. During the initial scans, these areas represented the greatest difficulty, and by prioritizing the boundaries, each scan would be less time consuming, which would then have a lower impact on ETI's operations.

Conclusions

This article presents the current state of the digitization process for large composite structures, employed in Phase I. As the project proceeds into Phase II, and the remaining trailers in the ETI lineup are digitized, this process will continue to be refined to improve accuracy and reduce disruption to operations. Long term, this project will allow Escape Trailer Industries to increase their digital capabilities to improve quality and reduce costs through process modeling, tolerance analysis and product visualization.

References

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