21st Century
Wire Harness Assembly
Delta Sigma Rolls Out Pilot Program

As featured in the
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With few exceptions, wire harness assemblies have been built using the same methods ever since people have been building wire harnesses. That is about to change. Delta Sigma Company (DSC), working on a USAF grant with several aircraft manufacturers, has just released the next generation of their Augmented Reality (AR) system called HarnessWorks™, this time specifically for building wire harnesses. DSC's CEO Roger Richardson, noted “After seeing enormous savings using AssemblyWorks™ on the F-35 for mechanical assemblies where returns of 4,000% on the initial investment were being generated, the Air Force asked DSC if a similar concept would work for electrical assemblies. We looked into the requirements that such a system would have, found some OEM partners that could define system requirements, and determined that it was not only feasible, but our early indications were that the cost benefits would likely be similar to the benefits seen for mechanical assembly.”

With that, the project was under way. “The data used to build wire harnesses is significantly different today, in most cases, than the data available for mechanical assemblies. Design technology moved faster and has been much more broadly accepted in the mechanical world than the electrical world. The aviation industry is moving fast to catch up, but there are other industries where the only fundamental difference between the documentation methods used by the Egyptians in 3,500 BC to build a fleet of boats and the methods used today is that it is written on paper instead of papyrus. When we first started developing AR work instructions in 2005, technologically speaking, documentation for assembly instructions had not advanced much in 5,500 years” commented Dr. Brett Haisty, Chief Technology Officer at DSC.

The folks at DSC thought that it was time to change that. Virtual Reality (VR) is a computer generated world sometimes containing virtual beings called avatars that move around in an environment that is completely created by a computer. Augmented Reality is the application of VR onto physical reality. That is, physical reality is augmented by virtual reality so that the user sees at the same time things that are real (physically present) and things that are virtual (computer generated). Properly used, AR opens up a world of opportunity never before available to explain things, especially things that are long, tedious, and somewhat complex – yet require absolute perfection in production. Aircraft wire harnesses would be a good example.

“The first issue is scale. It is essential that we display the data in exactly one-to-one scale, so that the virtual part will match the physical part. The process of scaling the data through the optics is called calibration. Once the scaling problem is solved, the next challenge is to place that perfectly scaled virtual object onto a physical object so that they are perfectly aligned – a process called registration. We figured out how to do both of these processes concurrently in 3D and it is very fast and accurate. Migrating that concept from 3D to 2D for wire harnesses was more challenging that we had expected. But, that has been completed for well over a year and our attention has been focused on developing easy-to-use methods of importing data that people already have and converting it into something that can be displayed in an AR for-
High Mix, Low Volume – Fast Reconfigurable Wire Board

But, long and tedious are not the only applications that can benefit from AR. One of the ideas that came up in the earliest concept was the notion of a quickly reconfigurable board. For companies that build just one or a few units of a large number of different harnesses, the reconfigurable board concept can streamline the build process, even for fairly simple harnesses. This was a benefit that was not originally anticipated by the development team, as they we focused on process optimization of harnesses ranging from 20 to 200 hours of assembly time.

One of the development partners had over 4,000 harness boards in storage for aircraft that were no longer in production – all of which must be maintained as long as there is still at least one aircraft of that type flying. The prospect of being able to digitize all those harnesses and replace 4,000 boards with one single board that can be configured to make the needed harness in a couple minutes was extremely appealing.

Later as non-aerospace partners joined the group, DSC quickly realized that even harnesses that take less than one hour to build can benefit from the technology - but for them the bigger benefit is the reconfigurable board. Working on the same board all day and not having to file away a completed board and retrieve the next board can be a real time saver, as well as space saver. In mid-2016 DSC and Panduit teamed up to integrate the Panduit Quick-Build system with HarnessWorks. Panduit made some modifications to some of the Quick-Build components to facilitate the AR instructions, and DSC created a library of Panduit components for fast board layout. The combination makes for a fast system setup that is highly repeatable.

Data Sources

In 2015, DSC partnered with Mentor Graphics using their Capital software to project harness assembly instructions. Work instruction files created in Capital can be executed by HarnessWorks directly, with only a mouse click or two required to generate the entire work sequence. In July 2016, DSC partnered with EPLAN to present their harness assembly instructions in HarnessWorks. That integration is scheduled to be available in 2017 and will even allow legacy documentation that was hand drawn onto a board to be digitized quickly, accurately and easily. Once the information is digitized, the world of Augmented Reality opportunities opens up.

Traditional 2D CAD drawings can also be used along with wire lists in a spreadsheet or csv format to create sequenced work instructions. This process can be somewhat automated with the templating feature in the authoring software package called ManuScript™. This feature allows the manufacturing engineer to create a template by writing a script that defines how to use the selected data and how to sequence the work and display the data. Once legacy data is in a sequenceable format the template can create assembly instructions in a few seconds.

Harness Testing

HarnessWorks can integrate harness testing in with the build as well. An integration with DITMCO is complete, and an interface with Cirris is underway, which will be complete in 2017. HarnessWorks provides instructions where the user can see not only exactly what to do, but exactly when and where to do it. Test data, particularly a failure can be immediately shown, including the wire route of the problem.

Time Saved, Errors Reduced

There is no data yet for how much time can be saved and how much error can be reduced specifically for wire harnesses, but a controlled experiment was conducted by DSC over about 6 months in 2016. The experiment was simply to compare how long it took to build a small assembly and how many errors were made when the same object was built using traditional methods (drawing and words) verses using AR instructions. With 110 participants the results of the experiment are:

- Labor is 0.29x using AR – or 71% less than using traditional methods
- Standard Deviation of build time is 0.28x – or 72% tighter than traditional methods
- Errors were a mind boggling 0.07x – yes, a 93% reduction from traditional methods

“The numbers above can be a bit hard to accept – a person is working over 3 times faster and making well less than
Multiple system usage.

1/10th the errors. But it is true, and the data from this controlled experiment correlates well with actual use on production lines. Not only are technicians faster and make far fewer errors, they are not working as hard, and are less fatigued at the end of a day. Augmented Reality accesses a part of the brain that it not available via traditional documentation methods. Direct access to the visual cortex is what makes these astounding results possible. There is good reason to expect that we will see similar results with harness building” reports Richardson. A white paper on the experiment can be found at www.projectionworks.com/downloads.

Pilot Program

“The Air Force has a rigorous set of rules for a development program like this. We had weekly teleconferences to discuss progress and exchange ideas to keep the direction of the development on track. Things like data input formats, what the users sees, and how the user interacts with the system were discussed regularly to ensure that all stakeholders needs were being met all along the way” noted Haisty.

As the last step before the general rollout of HarnessWorks, DSC has created a beta test program where qualified candidates can participate in the last stage of development. Partner companies can submit the candidate pilot project to DSC for review. DSC will evaluate the projects and select a few that provide a variety of installation scenarios. The selected Partners would purchase the appropriate HarnessWorks hardware/software package for their pilot project. DSC will provide, at no cost, up to 100 hours of engineering support to aid in the integration of the pilot system with the partner’s existing infrastructure. DSC will provide an additional year of warranty support for the pilot system.

“We believe HarnessWorks is ready to go to work in a production environment, but, as with any new product launch, there may be bumps in the road on the first systems. We are looking for partners that are willing to work with us to smooth out those bumps, and save some money doing it. Ideal candidates are companies that already intend to buy HarnessWorks systems, but want to start early and evaluate the system, calculate the ROI, and perhaps provide feedback into product improvement. Once the pilot program has been successfully completed, we will release the system for general sale.” reports Cappai.

If you are interested in becoming a partner in the HarnessWorks pilot program, please contact Craig Cappai at craig@deltasigmacompany.com.