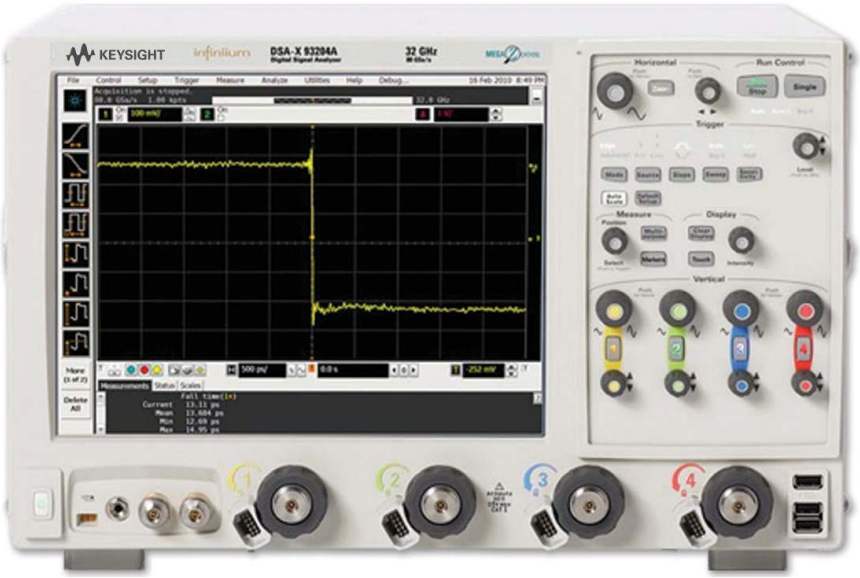
Keysight Technologies

Virtual Flight Testing of Radar System Performance Using SystemVue and STK

White Paper



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Introduction

Taking a system-level approach to a complex design often requires upfront integration and analysis, but pays in the long run by focusing time and engineering effort on “winning” design strategies. In this white paper, the Keysight Technologies Inc. SystemVue was integrated with the STK software from Analytical Graphics Inc. (AGI) to take advantage of their respective domain strengths in order to address difficult radar modeling and verification issues. Here are two key items that make this white paper worthy of your attention:

- Keysight SystemVue can control (or be controlled by) other applications, in order to quantify system-level performance metrics under realistic signaling, RF component and environmental conditions.
- In this white paper, SystemVue (communications physical layer design) and STK (3D kinetic scenario modeling) were combined to render RF-accurate signals and results, with terrain-accurate Doppler and fading.

In addition to SystemVue’s flexible API, the W1905 SystemVue Radar model library provides radar signal processing/domain IP to render the final details of this particular system, and a friendly interface to modeling and test equipment. This white paper represents just one of many possible applications of SystemVue to provide a “system-level” approach to a traditional design or test issue.

Problem Statement: Reducing Dependency on Flight Testing

Flight testing is the ultimate way to evaluate the performance of a radar system. During the actual aircraft flight, data such as Probability of Detection, Signal Strength and clutter might be gathered. While effective, this approach does pose a number of challenges. The operational cost of flight testing a radar system using real aircraft can be over $100,000 per hour (Figure 1). Additionally, the results from one flight to the next are not repeatable. Each flight is slightly different, and getting enough flights in to be statistically significant is simply too cost prohibitive.

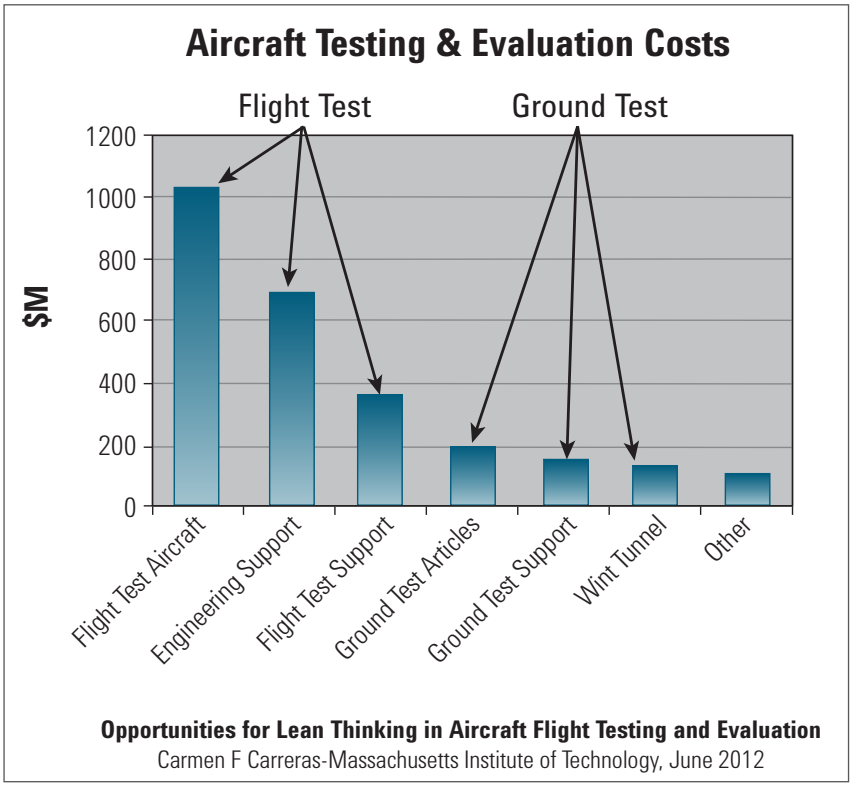

Figure 1. The high cost and time associated with flight testing is an incentive to explore alternative or complementary solutions.

While final operational verification may still be necessary for contractual or legal reasons, "virtual flight testing" is a faster, more cost-effective alternative for earlier stages of R&D, such as algorithm and countermeasures development. In simulation, complex radar systems can be evaluated hundreds of times in an hour, using the same or different scenarios for each run (flight), and at significantly less cost than a single hour on a flight range. By evaluating realistic flight testing scenarios before or in place of physical flight testing, engineers can validate electronic warfare algorithms earlier, saving both time and money.

A Virtual Solution

A virtual flight test solution can be created by marrying the capabilities of Keysight's SystemVue software with those of the AGI STK tool. The W1461BP SystemVue Comms Architect is an electronic-system-level design software that integrates modeling, simulation, reference IP, hardware generation, and measurement links into a single, versatile platform (Figure 2). It enables system architects and algorithm developers to innovate the physical layer (PHY) of wireless and aerospace/defense radar and communications systems and provides unique value to RF, DSP and FPGA/ASIC implementers. The W1905 Radar model library provides baseband signal processing reference models for a variety of radar architectures. STK is a physics-based software geometry engine that accurately displays and analyzes land, sea, air, and space assets in real or simulated time. It can include the aircraft flight dynamics, terrain effects and the aircraft's 3D radar cross section (RCS).

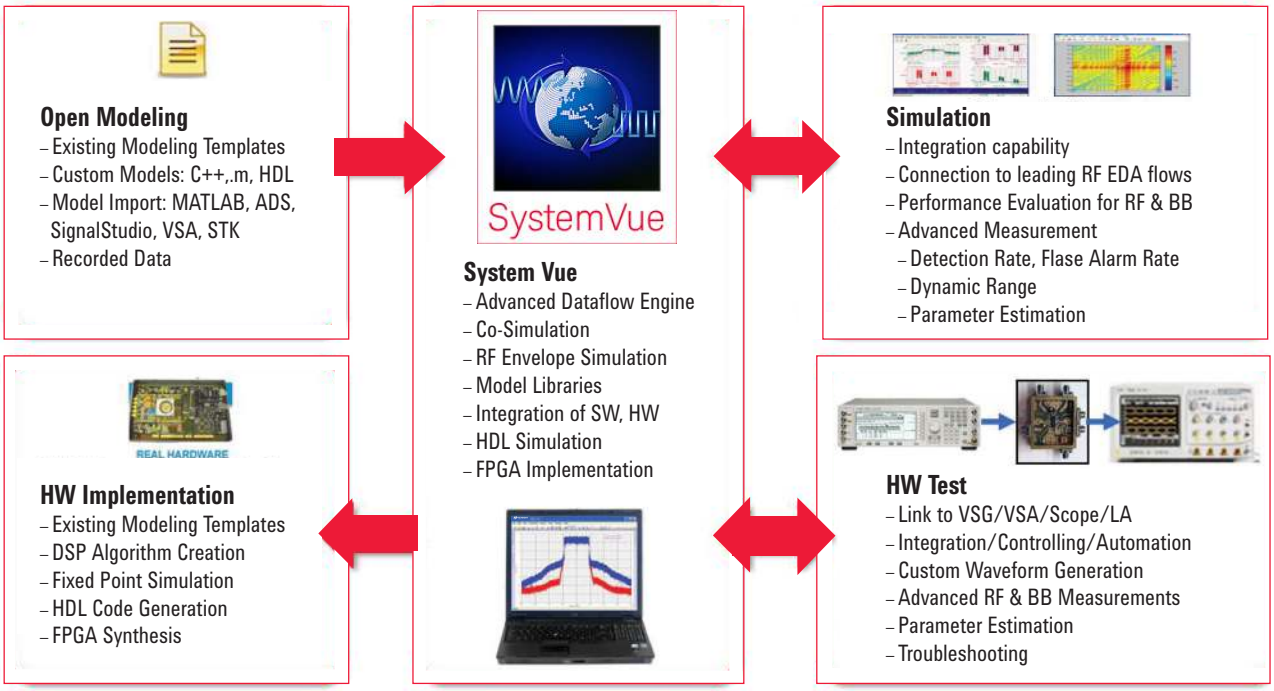

Figure 2. With SystemVue, PHY development is enabled across RF and baseband domains and that development can easily transition from algorithms into hardware verification.

The basic STK process is to define a system link scenario with moving transmitter (Tx), receiver (Rx) and interferer objects. The scenario is then analyzed to obtain system metrics as a function of time (e.g., range, propagation loss, RCS, noise bandwidth, and Rx signal strength). Almost everything in STK can be controlled by third-party tools. However, the software has no inherent ability to process signals from radar/communications applications through the dynamic environment link. Linking STK with SystemVue allows arbitrary Tx/Rx radar/communications systems to be modeled with the STK dynamic environment link characteristics. During virtual flight testing, SystemVue models the radar system including waveform generation, Tx and Rx non-ideal behavior, DSP and RF processing, and radar post-processing, while STK models the flight scenario and signal path characteristics (e.g., path loss, Doppler, aircraft aspect RCS, and atmospheric losses).

Virtual Flight Testing Example

To gain a clearer understanding of the interface between SystemVue and STK and its application to virtual flight testing, consider the 3D STK simulation scenario of a fighter sortie (Figure 3). In this example, assume the sortie starts at 10,000 feet and is detected by radar. To try to get below the radar, it dives down to do low-level terrain-following, sometimes successfully, sometimes not. The same exact run can be repeated hundreds of times, with different radar or electronic countermeasure assets in place as modeled by SystemVue, along with the terrain, aircraft (including 3D RCS) and the radar site characteristics as modeled in STK.

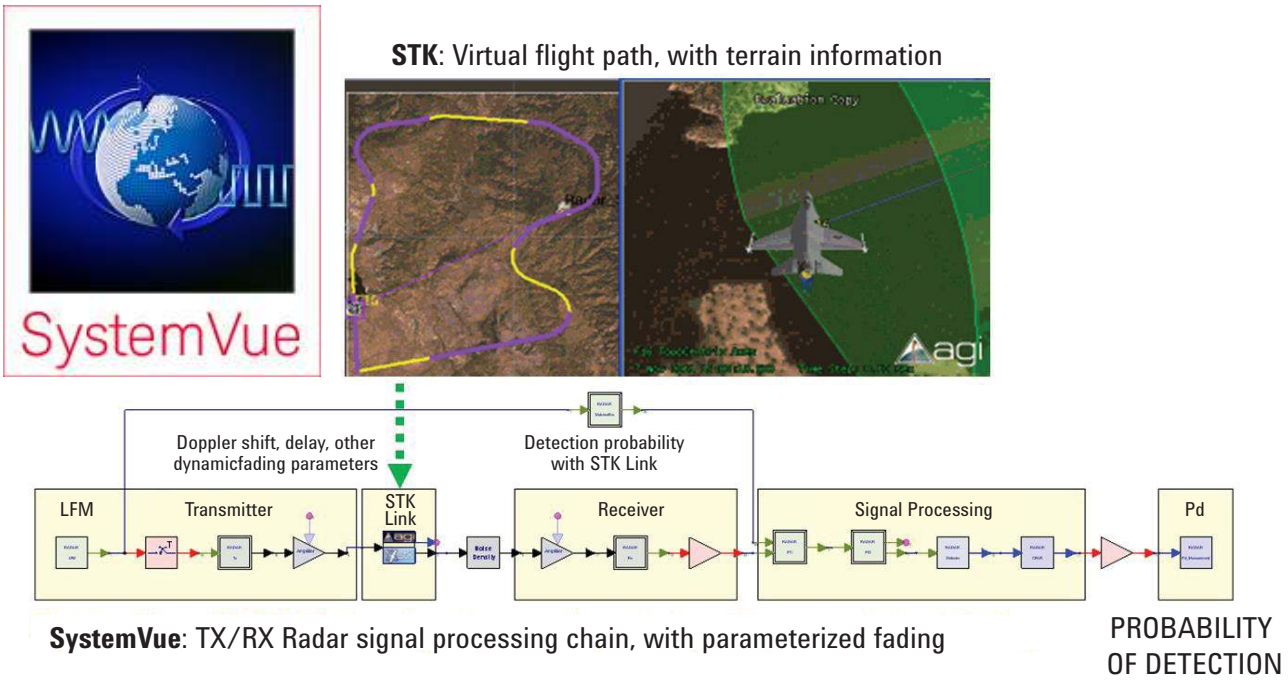

Figure 3. One application of the interface between SystemVue and STK is the ability to do virtual flight testing of radar systems, including DSP, RF impairments, jamming, and interference as an aircraft encounters targets and clutter along a virtual flight plan.

As shown in Figure 4, a custom user interface can be easily implemented within SystemVue to make repetitive tasks and complex measurements much easier to manage. Here, SystemVue creates a radar waveform and passes it through a transmit chain to multiple target models (including jamming and added clutter). The resultant RF waveform can then be input into an arbitrary waveform generator and introduced into a receiver for performance validation. SystemVue also has a tight integration with MATLAB, C++, and HDL simulators so existing radar algorithms can also be integrated into the scenario. Measurement-based data, such as a jammer profile or measured interference, could also be added into the simulation directly through Keysight test equipment links.

Virtual Flight Testing Example

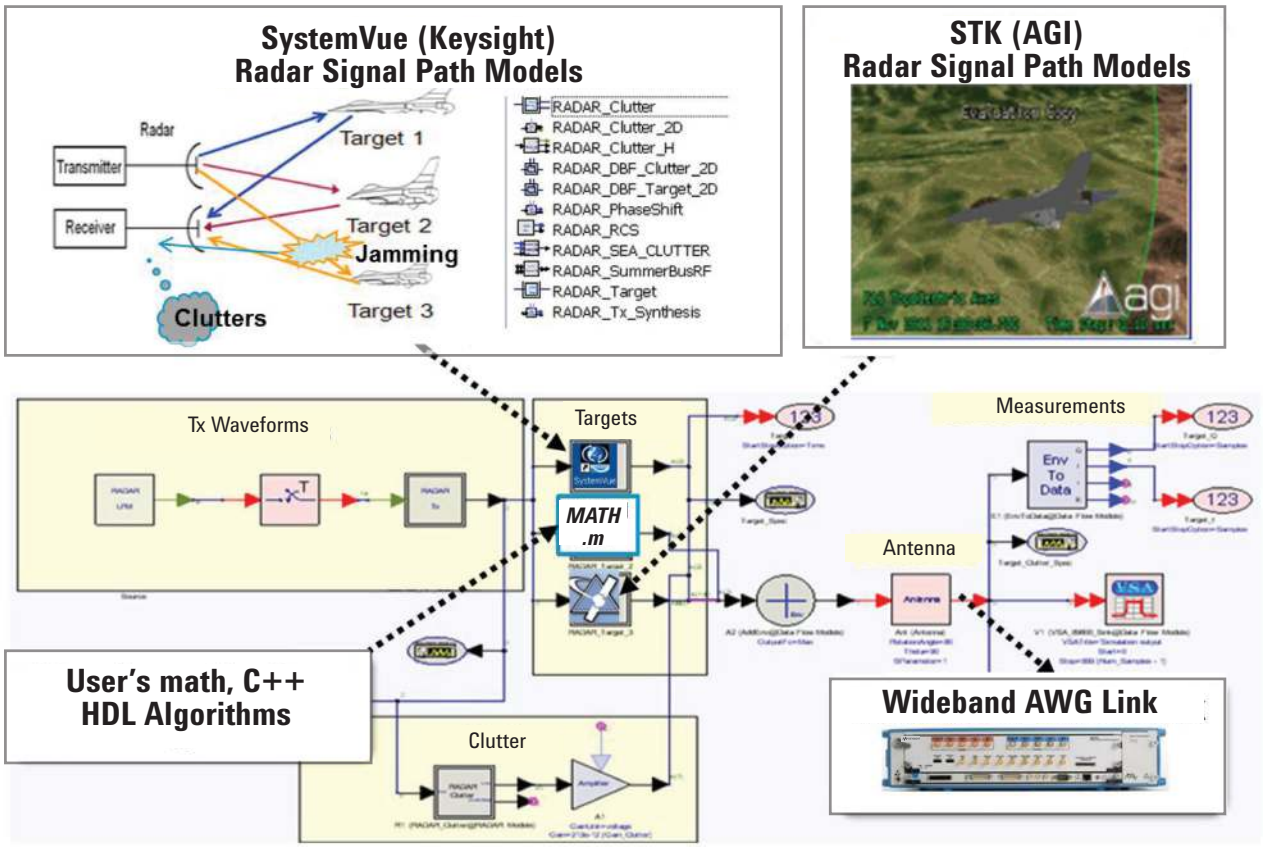

Figure 4. In this multiple target signal emulation example, test entry comes from a custom user interface with hardware text flavor. The user does not have to open a simulation schematic. This approach integrates both signal generation and signal analysis.

Flexible API Enables Custom Applications and Measurements

Linking the SystemVue and STK solutions allows for quick and repeatable validation of multiple realistic radar system scenarios. These scenarios can be evaluated in lieu of physical flight testing or, in cases where operational flight testing is unavoidable, they can be evaluated beforehand to ensure they make the most effective use of resources.

Some applications of virtual testing:

- Evaluate new jamming techniques or threats
- Inject multiple dynamic emitters and targets into your scenarios
- Allow various types of jamming based on a defined set of criteria for dynamic operation
- Modeling and evaluation of cross-domain effects, such as automatic gain control
- Include unintended interference from commercial wireless networks

The interface presented in this White Paper started with the commercially available SystemVue and STK environments, and then used their application programming interfaces (APIs) to link them together.

Try it yourself

Tech support article (login required)

http://edocs.soco.keysight.com/display/eesofkcsysvue/Virtual+Flight+Testing

Includes: STK flight video and other resources that may be updated

YouTube video
www.youtube.com/watch?v=xpBcSmsNlEU

Request a free evaluation
www.keysight.com/find/eesof-systemvue-evaluation

Conclusion

When it comes to testing radar system performance, extensive flight testing using physical aircraft is a prohibitively expensive and time consuming proposition. Virtual flight testing, made possible by the flexible interfaces between the SystemVue and STK software tools, now offers an economical alternative for R&D validation. This allows measurement-hardened algorithms to be deployed quickly, and a minimum of true operational testing to be done with greater confidence, to save costs. By closing the loop between lab-based virtual testing (simulation and test equipment) and operational testing, virtual testing can be made even more effective.

If you are interested in integrating SystemVue with your applications, please contact your local Keysight EEsof EDA sales representative, and inquire about services available in your area.

References

W1461 SystemVue
www.keysight.com/find/eesof-systemvue

W1905 Radar library
www.keysight.com/find/eesof-systemvue-radar-library

AGI STK
www.agi.com/products/by-product-type/applications/stk

For more information about SystemVue, please visit us on the web:

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