

BUILD VS. BUY

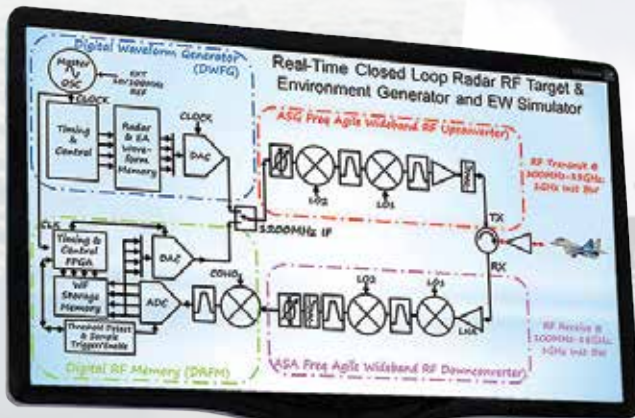
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White Paper

Radar Target Generation and Electronic Warfare Simulation Test Suite Development - Considering "Build vs. Buy" Decision



Giga-tronics

Solution for Next Gen EW / Radar Test & Deployment



OVERVIEW

Nearly every single Military Tactical Radar program, whether well-established and fielded for many years or under development today, needs an RF Target Generator (RTG) and Electronic Warfare (EW) Simulation test capability. The relevant questions are “How quickly can we get one?” and “Should we Build or Buy?”. The same is true for every Radar Jammer/ EW program which needs a capability and testing environment to stimulate the EW system and provide a means to test and evaluate the EW system function and performance.

Costs of specifying, designing, building or buying complex microwave test solutions can have a significant impact on maintaining existing defense contracts and winning new contracts for EW and Radar programs.

From an engineering perspective, most prime contractors, research institutes and government agencies have a rich but aging heritage of test system designs. In a post-Sequestration US Defense Industry, *Capabilities, Cost and Time to Test all need to be addressed*. There is no longer patience nor the budget for costly closed system architectures that do not provide an easy path to upgrade as technology evolves. This can be said for both the End User and EW/Radar Program Customer as well as the Defense Contractor(s) working on both the EW and Radar

programs and providing the EW and Radar T&E Environment, Capability, and Test Solution.

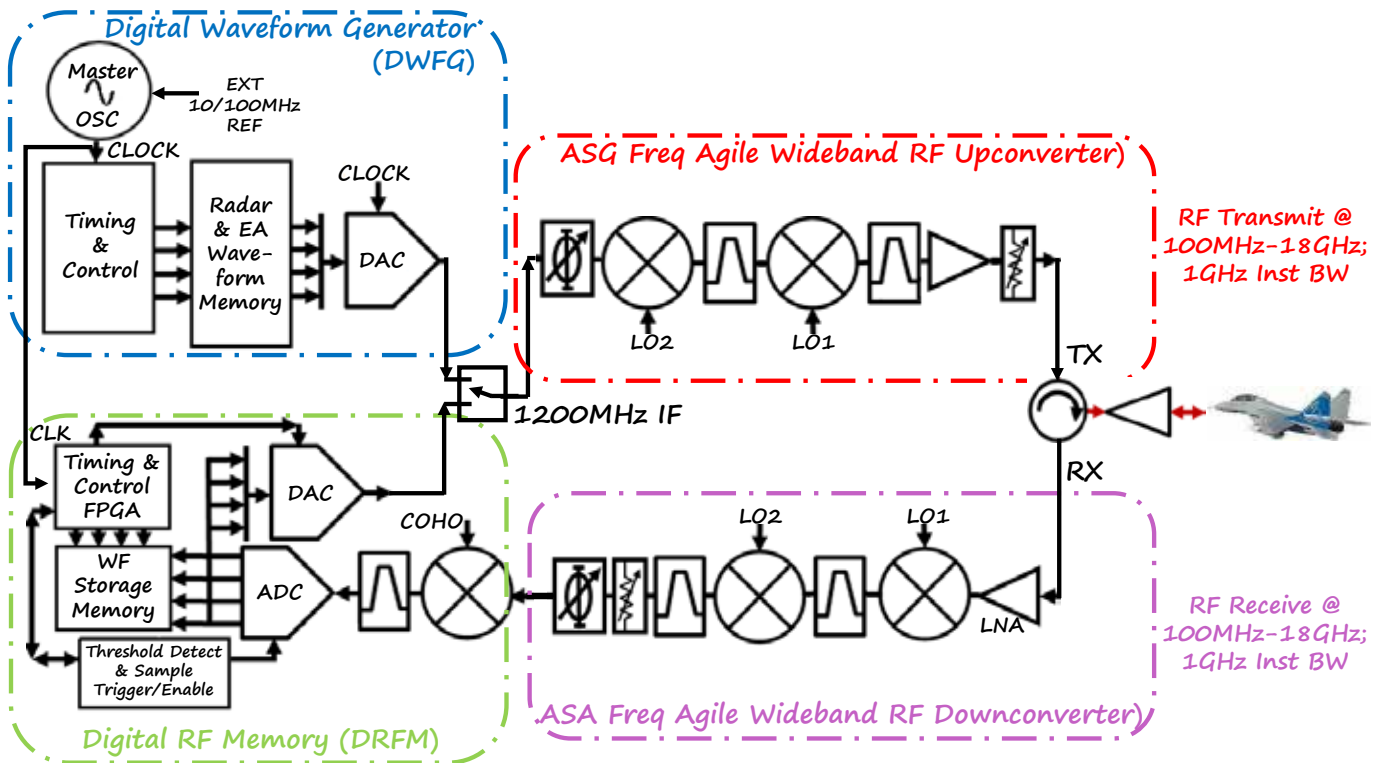
This paper will explore and discuss the following:

1. Historic Perspective: RF/Microwave Test Solutions; Alternatives for EW and Radar Programs
2. Technology Evolution Cycles: How old is your Test Suite?
3. Modularity & Scalability: COTS vs. Custom
4. Cost, Time and Risk Considerations for “Build vs. Buy”
5. A checklist of things to consider when making a “Build vs. Buy” decision

Radar Target Generation and Electronic Warfare Simulation Test Suite Development: “Build vs. Buy”

A generic, complete, end-to-end Radar RF Target Generator (RTG) and Electronic Warfare Simulator (EW Sim) test suite and testing environment that can be designed to be “Closed Loop” to operate in a Real-Time. “Simulation Over Live” fashion is shown in the notional block diagram below, utilizing the Giga-tronics Agile, Wideband GT-ASGM18A RF Synthesizer & Up-converter and GT-ASAM18A RF Synthesizer & Down-converter as major building blocks or major assemblies in a partially custom design with other “home-grown” or vendor items but a custom designed controller.

used, even if it did not completely meet the needs of that program or was more capable than needed. Some Radar and EW system contractors either did not have the expertise or the manpower to design and develop the integrated test solutions at the same time as the Radar, Missile, or EW system itself. The contractor or the customer would subcontract the development of the test suite to a Sub. Most often, this led to its own host of problems, none of which saved any program, money, schedule, or delivered more capability for the original program.



Historically, Radar and EW Programs that could afford the cost and time to develop an RTG or EW Sim did one of two things: they either architected and designed a completely Custom Test Solution for the specific needs of that one program, or they decided that an established piece of existing GFE equipment should be

The large, complex, and expensive piece of custom or GFE RTG/EW Sim test suite was by far more capable than the needs of most programs. There were no alternatives, or their customer or government oversight agency, program office, or test directorate dictated the use of a specific piece of equipment that was seen to



be an acceptable, certified piece of test equipment. Most of these custom or GFE items were physically large, as in 6-10 bays of 19" standard test equipment racks, usually necessitating a complete environmentally controlled room with a significant amount of input power. Very few were designed or could be ruggedized for mobile use at a remote test site and could only operate in a totally benign environment. Very few test suite or systems were designed with Commercial Off The Shelf (COTS) products from major suppliers, instead relying on custom designs using commercial components for all Digital and RF portions. Newer designs and ones more adaptable could be made of a majority of COTS assemblies above the component level. This brings a higher integrated level of complexity while the custom designers maintained the responsibility for the majority of the external interfaces and some of the major Digital Timing & Control (T&C) hardware (HW) and Software (SW) functions.

Many of the prime contractors decided to architect and design their own fully custom test equipment and test environment were convinced that they had the engineering expertise and experienced, skilled personnel that could execute on the Radar, Missile or EW Systems program itself and they should also build their own RTG/EW Sim test suite for their own program. This is sound judgment in most cases, except where the drain on personnel and program funds away from the main program jeopardized the proper architecture and design or the execution of delivering on the prime contract itself. Some programs were led by a program

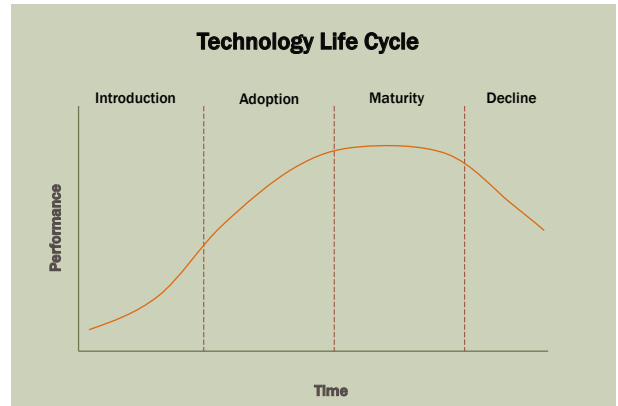
office who also "sold off" to an established test directorate that either demanded the use of a third party piece of RTG/EW Sim test equipment, or the test directorate itself was the designer and developer of the test suite.

Technology Evolution Cycles: How Old is your Test Suite?

The established norm in the Defense and Aerospace industry is that the useful life cycle of RF technology is in the 10-15 year time frame before minor and major components and assemblies are either worn out or obsolete. This is glacially slow compared to the development cycles of both the Digital Hardware (HW) and the Software (SW) driving and controlling the RF electronics. The rapidly advancing capability, year after year, of the Digital Timing & Control (T&C) hardware (HW) and Processing power of the non-RF portions of an integrated test suite or integrated solution rarely stayed on top of the state of the art, except for one or two minor updates after years of obsolescence.

While the Digital T&C HW often changes three to four times faster than the RF components, but usually is/was not updated that often as in this integrated application. It rarely adds value or more capability as much as leveraging the rapidly advancing Digital Signal Processing (DSP) and SW controls embedded in these behemoth test suites. SW and DSP advance in

even shorter timelines of just one to three years. Those advances were often not leveraged to add incremental capability to the test suite. The cost of formally and properly handling engineering changes and different configurations is non-trivial and adds up over time.



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Modularity & Scalability: COTS vs. Custom

It is no longer a question whether or not that RTG and EW Sim Test and Evaluation (T&E) capability is “Nice to Have”. The more relevant questions in light of the rapid increase in the proliferation of advanced EW systems in enemy hands is “How quickly can we get one?” and “Should we Build or Buy?”.

When answering those two questions, major considerations should be the length of time. It would take to Architect a solution, Design the system, code the Software and Firmware, procure all the components and/or major assemblies from vendors, fabricate the entire system, and then start Integration, Verification and finally Validation actions. The normal timeline is very lengthy even for simpler systems and gets worse for more sophisticated, complex and capable systems when done as a purely Custom Design.

Two major ways to shorten that Readiness Timeline is to either Buy a complete Integrated Test Solution from a qualified supplier, or to design and build a solution yourself made up of Modular COTS products,

leveraging the best of each supplier’s product offerings.

The high cost of the Non-Recurring Engineering (NRE) reduces significantly, as does the design timecycle. This allows more time to properly plan and execute Integration and Test (I&T) activities, reducing Cost and Risk to the overall program.

Buying COTS modular components also diminishes the usual concern about System Interfaces. Most COTS components are designed around well-known and accepted industry standard with highly predictable and reliable Interfaces, reducing or removing major stumbling blocks in system level I&T.

The reasons mentioned above to go with Modular COTS components or a completely integrated high-level solution from industry suppliers will reduce the time to test capability readiness and almost always reduce cost while simultaneously reducing risk.



Example Configuration - two Giga-tronics Advanced Signal Generation and Analysis Systems containing RF Signal Generators, RF Upconverters, RF Downconverters, Arbitrary Waveform Generators and Digitizers all in a self-contained AXIe standard chassis

TWO KEY FACTORS - UPGRADABILITY AND SCALABILITY

When considering the entire lifecycle of some defense programs, it's important to design a solution that is both Upgradeable and Scalable. Modular COTS Components are designed with that in mind. And by "Scalable" it's accepted that it means not only more RF Channels, Emitters, Jammers, etc, but also can be "Scaled Up" from an emerging capability need over the years or "Scaled Down" to meet a program with system needs and requirements where reuse of an existing "One Massive Size Fits All" behemoth is Overkill from both a Cost and Complexity/ Capability standpoint.

Cost, Time and Risk Considerations for "Build vs. Buy"

Major factors in the "Build vs. Buy" decision process are Development Cost, Time, and Risk. Some of the costs are obvious as in hardware component costs and engineering labor. Some hidden factors also affect the Cost, Time and overall Risk of programs, such as the need to dedicate experienced and skilled engineering talent to the test equipment design and not the prime program itself. We'll explore some of these considerations below.

Obvious Costs -

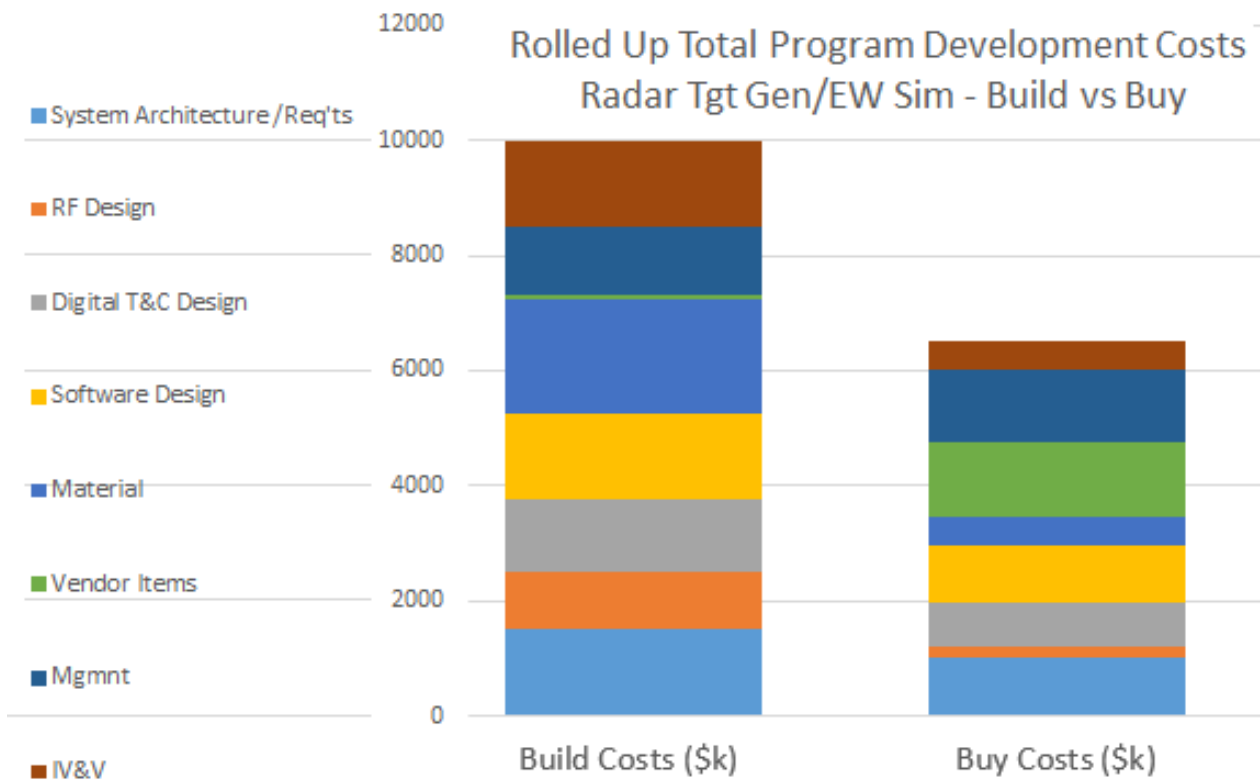
Obvious costs to the Fully Custom development of integrated test suites include tangible items like the Material costs associated with all the Hardware Componentry needed like RF Components, Digital T&C Boards, Racks and Cables, Computing environments and the licensed Operating Systems and Software

programs running on the test suite. It includes all the Non-Recurring Engineering (NRE) Labor to Architect, Design, Document, Procure, Fabricate, Integrate, Verify and Validate the overall test environment. There is a significant cost associated with the proper Configuration Control of the custom test suite, including all necessary Engineering Changes to the design to make it function properly and perform to spec, plus even more as upgrades and capability updates are made to the test suite. Worse, if there are multiple concurrent configurations for multiple customers, like some common GFE items pushed on or selected by the primes, the costs escalate and the program risk does as well.

Hidden Costs -

Some hidden costs to a custom design done in house versus procured include the cost to maintain configuration management of your custom system hardware and software. There are other “sustaining engineering” costs to maintain and stock spares and to have concurrent parts engineering to research alternates when parts go obsolete. Hidden costs include the software and system regression testing when new software capability is added or new hardware is introduced. All these hidden costs rarely are considered and added during the “Trade Study” and “Build vs Buy” stage before the program decisions are made and the test suites are custom designed. This can adversely affect the major supported program by drawing funds to the test equipment and test environment and away from the weapon system and its prime items.

Below is a cost comparison for Tasks representative for a national development of a Radar Target Generator/ EW Simulator. The tasks are normalized to a program totaling \$10M for a fully custom in-house design with costs compared to an equivalent program that decides to buy a completely integrated solution (minus the specific digital timing and control HW tailored for the system under test) or major assemblies from qualified suppliers. The highlights are that the Design costs and Integration, Verification and Validation costs are significantly less as the suppliers themselves have invested their own company funds into the NRE design and development of those items and the ensuing IV&V task is significantly shorter and less costly as most all functionality and performance has already been demonstrated by the supplier.



Time -

Most often, the design of a custom, or the choice of or directed use of a GFE “One Size Fits All” test suite comes at the detriment of the prime program developing the Radar, Missile or EW Suite itself and therefore becomes the embodiment of the “Tail Wagging the Dog” scenario.

One major contributor to slower development timelines for the prime contract system under development is the “Brain Drain” of experienced engineering talent within a defense company not working the prime contract but the test equipment itself. While “Test Equipment” also takes an incredibly skilled and experienced engineering talent base, it’s often of a slightly different nature and more focused on the verification and validation specialties of the prime item development, not the design of tactical hardware and systems themselves. Historically many of the major defense contractors in the Radar and EW arena also had an engineering group dedicated solely to the design of RF test equipment.

Unless a company has a group experienced and dedicated to the architecture and design of custom, specific test equipment and test suites, the delays in delivering that complex test environment can sometimes drive the overall program schedule for the prime contract and the prime items making it up – the “tail wagging the dog” scenario. Even when deciding to “Build”, it’s often better to have the most experienced Test Engineering (TE) talent “Buy” major assemblies and functions from suppliers that have already invested their own company NRE funds into the Design and I&T of major assemblies, allowing the TE group to focus on program specific T&C HW and SW and plan for a longer Systems I&T phase with greater manpower availability.



Risk -

Beyond Cost and Schedule, a major factor in the “Build vs Buy” decision or Trade Study should include Risk. Risk comes in many forms, some more obvious than others. These risks should be considered not just as the design and implementation is fresh, but for the duration of the Lifecycle of the program.

In the later years of a program risk in the design of a custom RTG/EW Sim test suite includes many factors. These include obvious concerns such as the technology and component Obsolescence and the Long Term Support. Long Term Support is almost always better when purchasing vendor items from suppliers dedicated to their product lines for their livelihood, not just “one-off” designs make Custom units that can support the economies of scale to keep components and major assemblies available for the long term. Less obvious are many programs and companies that decide to design their own custom solution. They often ignore succession planning for Engineering Core Competencies, where the Design and systems I&T crew of today retire without ever having passed on the intricate knowledge of the design due to very long product and test suite lifecycles. When the time comes to update and/or upgrade the custom solution, there is often a steep learning curve for unfamiliar engineers even when old systems are well-documented. This becomes a deadly cliff when poorly documented and maintained.

A major risk is that a company evaluating whether to design and build their own Custom RTG/EW Sim test suite may not legitimately have the engineering talent in hand with the right skillset and experience in designing and integrating the test suite with the prime items. A lot of companies do have this talent. Fewer have the experience doing it in a fully interactive, Hardware In the Loop (HWIL) or Real-Time, “Simulation-Over-Live” Closed Loop configuration which is an entire order of magnitude more complex than a repeatable, scripted

Open Loop test environment. Even those companies with that engineering experience and talent may not actually be able to draw off the main program system development at the time that the test suite needs to be architected, designed and integrated with the prime items.

Another risk is the likely fact that the test suite may not either “Scale Up” to the technical demands and performance specifications of a constantly evolving radar or jammer program due to its inherent fully customized nature. This risk is exacerbated by the very likely use of components and assemblies that will be obsolete in a relative short time. Some custom designs are not adaptable or an upgradeable risk the prime contractor needing to constantly upgrade the test suite or to develop a newer, more flexible or capable test suite. Those development funds could instead be directed at the prime items themselves or just realized as a higher profit margin.

Program risks include shrinking defense budgets and programs that can’t run efficiently or “lean and mean,” losing business in an increasingly competitive, open bid market of fewer sole source contracts. Nothing in the industry is less efficient than a fully custom, one-off test suite that is useless for more than one program within that company and obsolete the next year. Integrated test solutions that either already fill the needs of numerous radar programs, like wideband systems that already cover multiple radar frequency bands are an infinitely better investment of either program or capital funds within a company trying to improve their competitive stance in the industry. Integrated solution from third party suppliers trying to sell to the entire industry are designed with inherent risk-reducing modularity plus scalability (both larger and smaller) that can easily adapt to the program needs.

Shown below are two “Risk Register” Charts, one an industry standard interpretation of how to quantify and manage Risk in a program, the other showing a national allocation of Risks associated with a company deciding to do the entire Design and IV&V of a complex, real time closed loop test suite. While different companies, with different levels of engineering core competencies and experience will certainly place those risks in different cells in the risk cube, this is a fairly representative and

realistic distribution of risk for all but the most experienced at real time closed loop HWIL test environment design and implementation. The takeaway is a significant amount of real risk to a program deciding to go it alone and that proper Risk Management of all those “Red and Yellow” items can be addressed through the judicious procurement of all or major portions of the test suite from the specific experts in the supplier base.

Exhibit 1: Standard “Risk Register” Chart of Risk Consequence vs Likelihood

Risk Register Chart		Consequences				
		Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood	Almost Certain (> 90% Chance)	HIGH	HIGH	EXTREME	EXTREME	EXTREME
	Likely (50% - 90% Chance)	MODERATE	HIGH	HIGH	EXTREME	EXTREME
	Moderate (10% - 50% Chance)	LOW	MODERATE	HIGH	EXTREME	EXTREME
	Unlikely (5% - 10% Chance)	LOW	LOW	MODERATE	HIGH	EXTREME
	Rare (< 5% Chance)	LOW	LOW	MODERATE	HIGH	HIGH

Exhibit 2: Notional “Risk Register” for Architecture, Design + IV&V of Custom Solutions

Risk Register Chart		Consequences				
		Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood	Almost Certain (> 90% Chance)		Customer Scope Creep	SW Architecture Design & Test		Real Time Closed Loop Implementation
	Likely (50% - 90% Chance)		Radar Sim Function	Digital Timing & Control Design	Agile Wideband RF Assemblies	RTG/EW Sim Digital Control FPGA
	Moderate (10% - 50% Chance)	RF Design & Test	Program Funding Issues	EW Sim Function	Agile Wideband RF Components	Vendor Major Assembly Deliveries
	Unlikely (5% - 10% Chance)	Operator / System Control GUI		Test System Architecture & Design	Vendor Component Deliveries	
	Rare (< 5% Chance)					

Customer Perspective

From the perspective of the end user or the customer for the Radar, Missile, or EW System, the most important concern to the capability of the desired RTG and EW Sim test environment is either cost or program risk, which are sometimes so interrelated as to be one and the same. If the customer spends an inordinate amount on an overly complex and sophisticated test environment, those funds usually come at the expense of the program prime items themselves to include less capability or fewer units procured for the warfighter. To spend good money on a test system that is established and so capable to the point of being technical overkill, but still carries a high price tag, is a drain to a major weapon system's program office or test directorate. The perspective of many of today's weapons programs is that a less capable, less complex, smaller and less expensive system to procure and maintain that still meets the program requirements is the best solution if allowed. That also leaves the program the ability to "Scale Up" in the future or "Scale Down" at the onset as needed.

The other major concern for the customer, user or program office of a major weapon system is the inherent risk that a new design for an integrated test suite will not be delivered at all, or proven both functional and with demonstrated performance in time for being the useful integration and test tool it was created and funded to be. This risk or concern can be mitigated by procuring devices and complete solutions from suppliers in the industry that have already spent the time and funds to create the design, prove it functional and have already verified and validated the performance of the integrated test solutions. This leaves the weapons program to focus on the specifics of their prime contract system's interfaces and controls, and not the internal controls and interfaces among major assemblies making up the integrated test suite.



Conclusion -

In conclusion, the days of designing or procuring very expensive, behemoth RTG and EW Sim test sets is over. The new paradigm is to focus your manpower and funds solely on the controls and specific interfaces of your weapon system and to interface that with an integrated test solution providing a complete closed loop test and simulation suite from a supplier that has not only already spent their own NRE on their designs but has already shown the function and performance by supplying their highly integrated test suite in the field and on multiple programs with multiple users. End even when the hesitation to do so cannot be overcome by some experienced companies with a legacy of doing the entire design and I&T themselves, it is still wiser to buy major assemblies like agile wideband RF Synthesizers, Up/Downconverters and components from these same suppliers and focus efforts and funds on other internal details and designs.

Because you don't have 2 years and \$20M for your next EW / Radar Test Cycle...

Rethink purchasing custom systems or building single platform solutions

Giga-tronics Scalable COTS Solutions

- ✓ Broadband Up/Down Conversion (100 MHz to 18 GHz)
- ✓ Coherent Fast-tuning (< 1μs)
- ✓ Wide Instantaneous Bandwidth (1 to 2 GHz)
- ✓ Integrated Chassis Support for 3rd party hardware
- ✓ Turnkey Solutions for Threat Simulation



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CHECKLIST for making a “Build vs. Buy” Decision:

If you answer “No” to any of these questions, then you shouldn’t even THINK of Designing and Building it yourself:

- Do we have the proper RF Design Experience to:
 - Design an Agile, Fast Switching Coherent RF Synthesizer?
 - Design an Agile, Fast Switching Coherent Wideband RF Upconverter and Downconverter with dual frequency conversion?
 - Design all three items mentioned above with superior Spur and Phase noise performance across RF outputs from 100MHz to 18 GHz?
 - Coherently Phase Lock multiple independent RF output channels to a single 10MHz/100MHz External Reference Input from the User?
- Do you have the proper Digital Design Experience to:
 - Code FPGA Firmware to handle Quick Update/High Speed Digital Waveform Generators
 - Code FPGA Firmware to handle High-Speed Digitizers
 - Code FPGA Firmware to handle High-Speed/Quick Turn Digital Signal Processing
 - Code FPGA Digital Timing and Control Boards to handle extreme low latency, Real-Time “Simulation-Over-Live” operation w/ no pre-scripted apriori knowledge of the next mode or action to be taken by the Radar or EW System Under Test (SUT)?
- Do you have more than one Radar or EW system/contract/program in house that would benefit from a ‘single architecture/single design/single piece of equipment’ Radar RF Target and Environment Generator and EW Simulator?
- Do you want to assume the Time, Cost and Risk to Architecture, Design, Procure, Fabricate, Integrate, Verify and Validate multiple Target Gens/EW Sims across multiple radar bands for multiple programs with multiple non-common parts lists?
- Do you want to ensure that your self-designed RTG/EW test suite can be used for one program and one program only?
- Do you want to assume the risk and cost of calibrating and repairing that equipment for the entirety of the Radar/EW Program life cycle?

If you answer “**YES**” to any of the questions below, you really should seriously consider to Buy (from an experienced supplier) rather than Building your own completely Custom, Single Program solution:

- Do you want to maximize potential program coverage across multiple radar bands by buying a single design/piece of equipment from an industry leader with recognized technical expertise in the exact arena you are trying to enter or remain relevant?
- Do you want to maximize Reuse across programs and minimize Design/Procurement/Fab/IV&V Costs?
- Do you want to maximize Potential Profits from both the prime contract system as well as the test suite development contract?
- Do you want to minimize Risk and minimize Time to Market or time to supply your Customer w/ a fully integrated, fully verified and validated Solution?
- Do you want to provide your Customer w/ Modular pieces of equipment and Expandable Solutions that can be ordered off the shelf w/ minimal Lead Time to satisfy your Customer’s needs?
- Do you want to be able to order a single Solution that satisfies one or more program needs to be any or all of the following?:
 - Radar RF Target Generator to provide multiple “quiet” skin target returns for Radar Test
 - EW Simulator to provide Jammer Techniques/Waveforms for Radar Electronic Attack (EA) Susceptibility Evaluation and Electronic Protection (EP) Development
 - Radar Environment Simulator to Stimulate EW/Jammer Equipment under Development and/or Test?
 - Radar System Operation and Emulation for Advanced Algorithm Development
- Will the number of Labor Hours for the Design/Fab/IV&V needed to provide an integrated, acceptance-tested custom unit plus material costs exceed the off-the-shelf cost of a proven solution already in use by multiple defense contractors supplying the advanced needs of multiple programs/users/customers?
- Can you justify designing custom equipment for each program in house?
- Do you want to be able to provide a Radar and EW RF Test Environment to multiple programs that previously could never afford to have such a sophisticated solution?
- Do you want to provide that solution in all the multiple locations that the User may want that Test and Evaluation Capability at a Cost that makes it Affordable to do so?

If you answer “Yes” to **ALL** the questions below, then perhaps you can confidently tell management that it’s best to Build it yourself:

- Do we have all the RF, Digital and SW engineering Design and System I&T talent, skills and experience to execute this home-grown sophisticated design development and are they all available to the effort when needed?
- Do I want to tell senior company and Program Management that the Technical Risk is minimal, manageable and under my control?
- Do I want to Assume all the technical challenge of the function and performance plus the development costs of a brand new one-off design for my single program while telling company management why we should not be pursuing an integrated solution with complete to major reuse of major end items/assemblies for multiple programs/contracts in house or being bid?
- Do I accept the need and cost to Calibrate, Maintain and Repair, and properly Configuration Manage this complex Test Environment for the next 20-30 years or more over the entire Life Cycle of the program?
- Nobody does it better than we do. Not now, not ever.

We hope this white paper helps you on your coming EW / Radar Test Suite Development decision making. For more insight into the advanced EW / Radar test system solution, visit the go-asg.gigatronics.com or contact us for free consultation or demonstration.

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