The Case for Synthetic Instrumentation

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1. Introduction

A recent GAO study revealed that the Department of Defense (DOD) employs more than 400 unique types of test systems to test and diagnose anomalies in various DOD avionic and weapon systems **[1].** DOD spent more than $50 billion in its acquisition and support of Automatic Test Equipment (ATE) from 1980 through 1992, and these procurements often resulted in a proliferation of special purpose testers designed to support a specific weapon system or group of Weapon Replaceable or Shop Replaceable Assemblies. The Navy alone has spent approximately $1.5 billion from fiscal years 1990 through 2002 in the acquisition of its primary family of testers (i.e., CASS) and plans to spend by 2007 an additional $430 million on acquisition, $584 million on Test Program Set (TPS) maintenance upgrades, and an additional $584 million to develop Test Program Sets for new weapon system testers. In addition, DOD and the services face growing concerns regarding obsolete ATE, given the high cost of modernizing or replacing this type of equipment. ATE acquired in the 1970s and 1980s is becoming increasingly out of date and more difficult to support, especially instruments for which equivalent form/fit/function replacements cannot be found in the Test and Measurement (T&M) marketplace. These obsolescence issues are further exacerbated by new technologies that in some cases make ATE obsolete even before the new testers can be fielded. The current situation has resulted in a pool of DOD testers that are old, often inflexible and special purpose, have large footprints, and in an aggregate are costly both to DOD and our taxpayers. The situation will not get much better in the out years unless DOD can affect test and measurement commonality across all of DOD that employ T&M technologies that are more generic/flexible, smaller, faster, less costly, easier to maintain/upgrade, and are less prone to become obsolete than conventional/discrete instrumentation technology.

Sparked by the current situation, both Government and industry alike have over the past few years been searching for new T&M paradigms that would alleviate the current dire state of affairs and improve the posture of ATE throughout DOD. One potential solution to the overall problem is the emergence of a new technology called "Synthetic Instruments" or SI **[2]**. The concept of SI was born out of a DOD initiative called NxTest; the primary goals of NxTest were to reduce the total cost of ownership of DOD Automatic Test Systems (ATS) and provide greater flexibility to the war fighter through Joint Services interoperable ATS **[3][4]**.

2. Synthetic Instrumentation Overview

A Synthetic Instrument (SI) synthesizes the stimulus and/or measurement functionality found in traditional instruments via employing a combination of core hardware and Digital Signal Processing (DSP) software building blocks in a modular open architecture environment **[5]**. SI is substantially different from a classical instrument, or even a Virtual Instrument (VI), in that stimulus and measurement functions are synthesized from a limited set of "generic" SI components as opposed to discrete instrument types, such as a spectrum analyzer **[6].** A SI is similar to its VI cousins in that it is optimized for computer control and does not have any physical interfaces, such as knobs or buttons. Users typically interact with a SI via a software –defined graphical user interface which simulates a front panel for an entire SI, or its constituent components, by providing software "widgets" that emulate physical knobs, buttons, and displays of classical instrumentation.. SI is a paradigm shift that forever changes the way Automatic Test Systems are designed, built, fielded, and supported. The concept of synthetic instrumentation goes back over a number of years and was briefly explored by the military in programs such as Equate and Universal Pin Electronics in the late 1970s and early 1980s. At that time, the technology was not available to render the concept into a commercial reality and the resulting implementations were primarily focused on low frequency analog, digital, and base-band, as opposed to RF/Microwave (RF/μW) applications.

The genesis of Modern Day instantiations of synthetic instruments find their roots in the communications revolution of the past decade and the emergence of a concept called "Software Defined Radios," or SDRs. Simply defined, a SDR consists of a Digital Signal Processor or DSP, a Transmitter, a Receiver, and a transmission antenna. The transmitter and receiver convert digital data to and from modulated radio waves for wireless communication purposes. The DSP provides the radio functionality, via its software component, whereby application specific algorithms generate or process digitally represented signals for transmission or reception by the SDR. The paradigm of SDR provides both modularity in design and flexibility, in terms of programmability, to rapidly accommodate emerging communication protocols/modulation, functions, and user needs. The concept of Synthetic Instruments leverages the SDR paradigm. SI is predicated on the concept that most stimulus and measurement functions can be implemented in software employing "Core" SI hardware & software components (Frequency Up/Down Converters, Digital to Analog Converters (DACs), Analog to Digital Converters (ADCs), DSP hardware/software) and supplemented, as required by the user's envelope of test requirements, by COTS hardware (i.e., Power Supplies, fixturing, loads, and switching) and software.

A high level block diagram **(Fig. 1)** of a test system's test and measurement capability predicated on SI looks very similar to that of an SDR. The receiving or RF-to-Digital circuitry link/ path is comprised of signal conditioning, frequency down-conversion, and analog-to-digital conversion circuitry. The signal conditioning circuitry provides the requisite tasks of automatic gain control. The automatic gain control process controls amplifiers and attenuators in the measurement signal path to scale the analog signal level to the dynamic range of the subsequent processing units. The down converter functional block is perhaps the most critical component in the measurement path **[7].** The down converter must provide the frequency translation/filtering function and, via a combination of mixing and filtering, faithfully reproduce the target baseband signal that was modulated onto the microwave carrier signal. If the down converter's conversion loss, IF filtering, and associated phase characteristics are not properly specified, designed, and controlled the down-converted Intermediate Frequency (IF) signal being digitized and analyzed by the A/D converter and DSP software respectively will bear erroneous results. The ADC in the receiving or measurement processing path is the interface between the continuous analog and discrete sampled digital domain, and limits both the dynamic range and instantaneous bandwidth of the SI. The operating range and speed of the ADC is often the limiting factor in affecting the accuracy and bandwidth of the measurement to be performed, assuming the down converter block is providing the ADC with a faithful reproduction of the target IF baseband signal to be digitized.

A key issue/design parameter in the SI paradigm is the ability of the ADC functional block to perform the digitization process and transmit digital data to the DSP software, residing on a host embedded or external PC, for analysis in a timely manner. This data transmission must occur at a high data rate to ensure that the DSP software does not miss needed data points and can perform analysis on streaming digitized data in real time or in a near real-time environment for embedded applications. A SI`s overall conversion/data transfer rate is a function of the down converter's frequency conversion rate, the ADC's sampling rate and sample size, and the SI implementation environment or data transport/bus mechanism employed (i.e., PXI, PXI Express, LAN, LXI, VXI). If the SI measurement conversion / data transfer rate is not acceptable for a particular application, the designer may have to pursue an alternative course of action and host the DSP software on the ADC via the employment of firmware on a Field Programmable Gate Array (FPGA) or similar programmable device, and thus possibly diluting the obsolescence proofing potential of a particular SI instantiation.

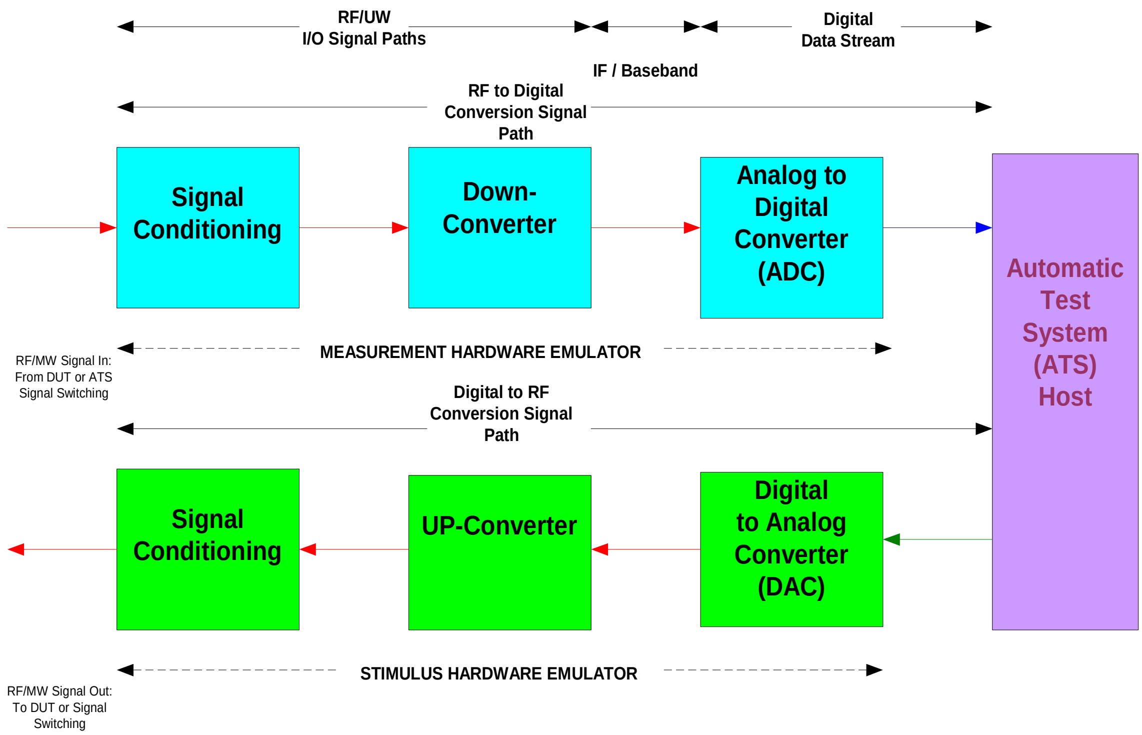

Fig. 1 Synthetic Instrument Based ATS: Notional Block Diagram

3. Attributes of Synthetic Instrumentation

Some of the primary attributes of SI are listed below:

- Test flexibility
- Reduction in ATS size/footprint
- Reduction of ATS hardware logistics and ATS/instrument calibration costs
- Mitigation of obsolescence risk & promotes long service life
- Ease of ATS upgrade
- Reduction in ATS self test/ maintenance costs
- Reduced /streamlined ATS development time
- Increase in measurement speed/efficiency
- Promotes ATS interoperability between DOD users and reduces ATS training costs among users

A brief discussion of each of these SI attributes is provided in the ensuing paragraphs.

From an operational and user perspective, SI has unlimited potential. By virtue of its flexibility to synthesize any stimulus or measurement function utilizing a limited set of generic hardware and software components, SI can replace racks of conventional test instruments and reduce overall ATS size/footprint, hardware logistics(sparing) costs, and associated instrument /ATS calibration costs **[8].**

Also, since it is composed of a limited set of generic components, ATS obsolescence risk is substantially mitigated and ATS upgrade is easily facilitated via software as opposed to a lengthy hardware acquisition process; non-recurring ATS self-test costs and recurring maintenance costs for ATS should also be lower due to the shear reduction of discrete instrumentation types to be supported vs. conventional rack & stack instrumentation architecture.

It can also be argued that utilizing SI reduces ATS test software development time and increases measurement speed and testing efficiency. This statement is substantiated by the primary premise/ attribute of SI. That is, SI is primarily a signal based stimulus & measurement paradigm. For example, measurements utilizing SI are predicated on digitizing a down converted or base band IF (relatively low frequency signal) signal and storing that information in a measurement map (Value (ordinate) vs. ATS state (abscissa)) or database **[9].** From that storage bin, multiple operations on the digitized data can be performed by applying various algorithms to affect one or more measurements. By virtue of being signal based, measurements which use the same data set can be affected in a shorter period of time than classical measurements performed with traditional instrumentation which repetitively acquire, analyze and present results for each unique measurement (i.e., rise time, fall time, pulse width, frequency).

Finally, since SI can be utilized as a common component to any DOD ATS system, the utilization of SI promotes and fosters T&M interoperability and potentially can reduce training costs among the services. Since SI-based ATS capability is primarily software based and not instrument based, the same hardware asset employing a generic set of core components (up converters, down converters, ADCs, DACs) can be utilized to support a broad cross-section of Units Under Test (UUT). Each service can tailor a SI-based ATS per their unique requirements via UUT specific Interface devices/signal conditioning and application specific software employing either text or graphical based programming tools employed in a SI context.

4. Classes/ Types of Synthetic Instrumentation

At the current time there exist three classes or types of Synthetic Instruments in the marketplace **[10]**. For the sake of simplicity, we have defined the three classes as follows:

- *Class A: Modular /Loosely Coupled Open Architecture SI*
- *Class B: Integrated SI Subsystem*
- *Class C: Application Specific SI*

Modular /Loosely Coupled Open Architecture SI pertains to those SI systems which are synthesized via applying modular standards such as PXI & VXI to synthesize an SI solution employing SI components (i.e., ADCs, DACS, Down Converters, Up Converters/Synthesizers). Test equipment manufacturers or users employing this approach typically utilize multivendor products to affect a solution which satisfies their unique needs. The SI developer usually spins his own SI stimulus and measurement system software employing tools/programming languages such as C, C++, ATLAS, LabVIEW, and LabWindows/CVI.

For those users who do not want to spin their own SI, but prefer to buy a commercial-off-the-shelf (COTS) out of the box generic solution, an *Integrated SI Subsystem* is perhaps their best bet to reap the benefits of the SI paradigm. Users who select this route are somewhat dependent on the “canned” software capabilities as well as the robustness, flexibility, and ease of use of the software system provided by the COTS supplier. In this approach, the SI sub-system supplier is responsible for doing the appropriate tradeoffs for selecting the appropriate SI hardware/software architecture to affect a generic solution that is applicable to the mass marketplace. In effect, this approach mimics the “one size fits all” T&M paradigm.

For those applications that require a little bit of tuning or adaptability to accommodate both new and legacy Units Under Test, an *Application Specific SI* (ASSI) solution is perhaps the way to go. This approach is especially appealing in complex Test and Measurement applications such as those typically experienced by DOD users who desire to reap the benefits/attributes of SI on one hand but need to preserve their investment in legacy TPS hardware & software at the same time. In these types of applications/situations, the SI subsystem supplier often accommodates the DOD user’s unique needs by supplementing its generic SI hardware /software architecture with application specific hardware and software modules. This application specific or hybrid approach is often employed when a testing application requires hardware

/software specific functionality and switching to enable SI to meet the user's needs. The application of Network Analysis in a SI context is an example of such an application. Although an SI purist may argue that employing such a hybrid approach starts to depart from the generic SI paradigm , the application specific approach still can result in delivering on the attributes of the SI paradigm while at the same time be able to be adaptable and tunable to the real world/specific testing needs of the user.

5. Where does SI fit in the T&M Continuum?

This is a question that is often asked by users who are considering use of this technology and the three classes /types of SI previously discussed. If you're in a "new start" application environment that is rapidly changing and/or you need to support a broad cross-section of Units Under Tests over a number of years, perhaps SI is the right choice for you. Adoption of the SI paradigm will in all likelihood reduce the need for different / unique types of test stations and/or instruments as well as training and other associated logistics costs as discussed in Section 3. Also, if your test requirements are ill defined or emerging, SI provides the testing flexibility to define as you go "just in time" test scripts which are software based and not dependent on the inflexible embedded firmware of a discrete instrument. Typically, an SI-based system is provided with a baseline/generic capability of Spectrum Analysis and a Time Domain based analysis capability to jump start an ATS TPS development activity. As unique testing requirements are identified the SI supplier may enhance /augment existing baseline test capability or develop unique APIs & Test Sequences/routines to accommodate the customer's peculiar testing requirements.

Conversely, if your testing application supports a limited number of UUTs, your test requirements are well defined and can be supported by traditional COTS instrumentation/software, the longevity of your testing solution spans one or two years as to opposed five years or more, and your testing solution satisfies the size/footprint requirements of its intended environment - then SI in all likelihood is not a good fit. This is predicated on the fact that SI invariably requires somewhat higher initial software cost over traditional approaches to affect a generic long term solution that can be re-used over many ATS applications.

In some instances a hybrid solution encompassing both SI-based instrumentation and classical instruments may be the answer where a user is trying to optimize ATS cost, test flexibility, and size. This approach fits very well in support of large DOD test systems or commercial depots which are commissioned to service a broad cross-section of UUTs. For example, in this scenario SI-based instrumentation may be targeted to service the testing needs of UUTs via employing the following functional test capabilities:

- Spectrum Analysis
- Scalar Network Analysis
- Waveform Analysis
- Time-domain analysis
- RF/μW Power Measurement & Analysis
- RF/μW Complex Signal Generation
- Digital Bus Emulation

On the other hand, classical instruments may be employed as part of the hybrid system configuration to affect commodity based measurements that are more cost effectively implemented utilizing traditional instruments , supplemented by traditional signal switching, such as:

- Digital Multimeters
- Time/Frequency Counters
- Arbitrary Waveform Generators

What about supporting legacy applications? In many Automatic Test System (ATS) programs, especially in the DOD arena, the Automatic Test System prime contractor will be called upon to provide ATS support for both new and legacy UUTs. For legacy UUTs, if the test requirements (i.e., Test Requirements Document or Test Requirements Specification) from which the original test programs were written have been documented and reside in a configuration control depository, the SI developer can then affect an SI test solution predicated on a well formulated set of requirements with the proviso that the SI possesses an equal or greater functional test capability than that provided by the original test instrumentation. Specifically, the user should undertake "do diligence" of the following test related considerations before embarking on an SI endeavor in support of both legacy and new UUTs:

- Signal Conditioning/UUT Interface Requirements
- T&M Frequency Range
- T&M Analysis Bandwidth
- T&M Measurement Speed
- Dynamic Range
- Resolution/Accuracy
- Noise Floor Requirements

In many instances however, the prime is tasked to preserve the customer's previous investment in test programs. This situation requires the user to carefully formulate his SI strategy: especially for Class A and Class B SI systems. For older UUTs, test programs are sometimes written around the capabilities of the previous generation ATS and its associated instrumentation suite – not the "functional" test requirements of the target UUTs. In these instances, sometimes the prime ATS integrator or SI provider is burdened by the constraint of rendering the SI to emulate the hardware response of the legacy/obsoleted test equipment in order to preserve legacy TPSs, *and their associated test limits*. This is not the most optimum or forward thinking way of affecting an ATS support strategy going forward **[11].** By virtue of pursuing this approach, the ATS prime will be perpetuating a set of "test requirements", and associated test limits, over a number of decades and associated system upgrades that are legacy instrument based as opposed to being predicated on the functional test requirements of the target UUTs. *No good can come from this situation.*

One classic case in point comes to mind which exemplifies this dilemma. For example, consider a test implemented on a Spectrum Analyzer (which is part of a legacy test system) which performs a "Spur Search "over a given frequency span: say 2 GHz to 26.5 GHz at a specified Resolution Bandwidth (RBW),Sweep Speed, and employs Video Averaging. Also assume that the legacy spectrum analyzer has a dynamic range of 80 dB and a noise floor of ~ -160dBm. The dynamic range of a frequency domain measurement is the difference (in dB) between the largest and the smallest signal that can be reliably measured at the same time. The noise floor of the measurement determines the smallest signal that can be reliably measured. Any signal below the noise floor cannot be detected. The use of video averaging generally increases the dynamic range of the Spectrum Analyzer measurement by lowering the variance of the noise floor of an instrument.

First of all, a Synthetic instrument does not directly employ all of these Spectrum Analyzer (SA) specific instrument attributes and therefore these SA controllable attributes are not directly programmable in a SI-based system. Secondly, there will be noise floor differences between the legacy Spectrum Analyzer and the SI. For example if the noise floor of the SI-based system is -156 dBm with the same dynamic range (80db)as the legacy Spectrum Analyzer, it is possible that the SI will detect fewer spur responses over the frequency search range than that detected by the legacy spectrum analyzer **.** *The question that begs to be answered is that do the spurs buried in that -4 dBm of noise floor make a difference? Are those spur responses meaningful from a diagnostics perspective of the UUT or did they wind up in the TPS pass/fail criteria because of the noise floor characteristics of the legacy spectrum analyzer?*

The bottom line is that requiring a Class A or B SI to be a direct replacement for a legacy instrument and requiring (ideally) an ATS integrator or SI supplier to utilize legacy Test Program Sets (TPSs) without modification in a SI context is wrought with traps and risk and is a detriment to the SI paradigm. In those instances where TPSs are not provided with a TRD or TRS, it is recommended that the TPS be utilized as engineering input as to the implied test requirements of the target UUT. It is true that some modification/re-engineering of the TPS will be required employing this approach. However, it is a better approach and utilization of engineering time than perpetuating a SI/TPS re-host solution that is fundamentally flawed and wrought with testing requirements that are not traceable back to the target UUT. Employment of a re-engineering approach utilizing a qualitative understanding of the implied test requirements gleamed from a legacy TPS will ultimately result in specific measurement requirements that are not test instrument specific but fit within the context of a SI-based testing paradigm.

That said from an SI purist perspective, Class 3 Application Specific SI is an emerging instrument class which is primarily targeted at those SI applications which are focused on legacy DOD TPS transportability programs. Class 3 ASSI provides TPS transportability by virtue of software techniques which emulate legacy instrument specific stimulus & measurement functions with SI equivalent algorithmic techniques to achieve the desired functionality (i.e., Spectrum Analysis Spur Search). This technique is usually affected via middleware software at the driver level utilizing the IVI Measurement and Stimulus Subsystem (IVI-MSS) architectural approach and its associated Role Control SW modules **[12].** A Role Control Module (RCM) is a piece of software that sits between a stimulus or measurement software server and an instrument or SI component (i.e., Down Converter) hardware driver. A RCM provides a specific functionality to affect a specific role or function in the emulation of a legacy measurement function. For example, an RCM for a Down Converter in support of a legacy spectrum analyzer measurement would provide just enough functionality to affect the frequency translation but not the display functionality of a Spectrum Analyzer. As mentioned previously in section 4, this approach is not a generic approach but a tuned application specific approach which on the one hand preserves to the maximum extent possible the customer's investment in legacy TPSs while at the same time reduces ATS footprint and associated training and logistics costs for the downsized ATS system.

6. SI - A Disruptive Technology

There should be no doubt that the concept of Synthetic Instrumentation represents a "Sea Change" or fundamental paradigm shift in thinking about affecting T&M solutions in support of the needs of the ATS marketplace. The mere thought of transforming the Test and Measurement industrial business model from discrete RF/μW Hardware Instrument types/classes to an open architecture solution space predicated on PC hosted Software & a limited set of functional hardware building blocks is both exciting and at times somewhat perplexing to say the least to the RF T&M supplier and potential user as well.

As with any new or emerging technology, there are" knowns and unknowns." What we know about SI right now is that it is an "emerging technology" which at the operational (use model) and conceptual levels of T&M abstraction provides an enormous amount of promise and benefit to the user. We also know that SI potentially represents a disruptive change in instrument technology and the current RF/μW T&M market place.

It is a well known fact that commercial T&M technologies can often progress faster in terms of feature sets and performance than customer demand. Clayton Christensen in his watershed book, *The Innovator's Dilemma*, was the first to recognize this phenomenon [**13].** In their quest to provide better products than their competitors and earn higher profits and margins, suppliers often "overshoot" their market: they give their customers more functionality than they need or ultimately are willing to pay for via the process of continuing/sustaining product improvement of their established/mainstream technology. Disruptive technologies that are introduced to supplant these more established technologies may under perform relative to what users expect / require today, but may ultimately become fully performance –compliant in terms of traditional product specifications. **Fig. 2** depicts a notional representation of Christensen's premise in an SI context.

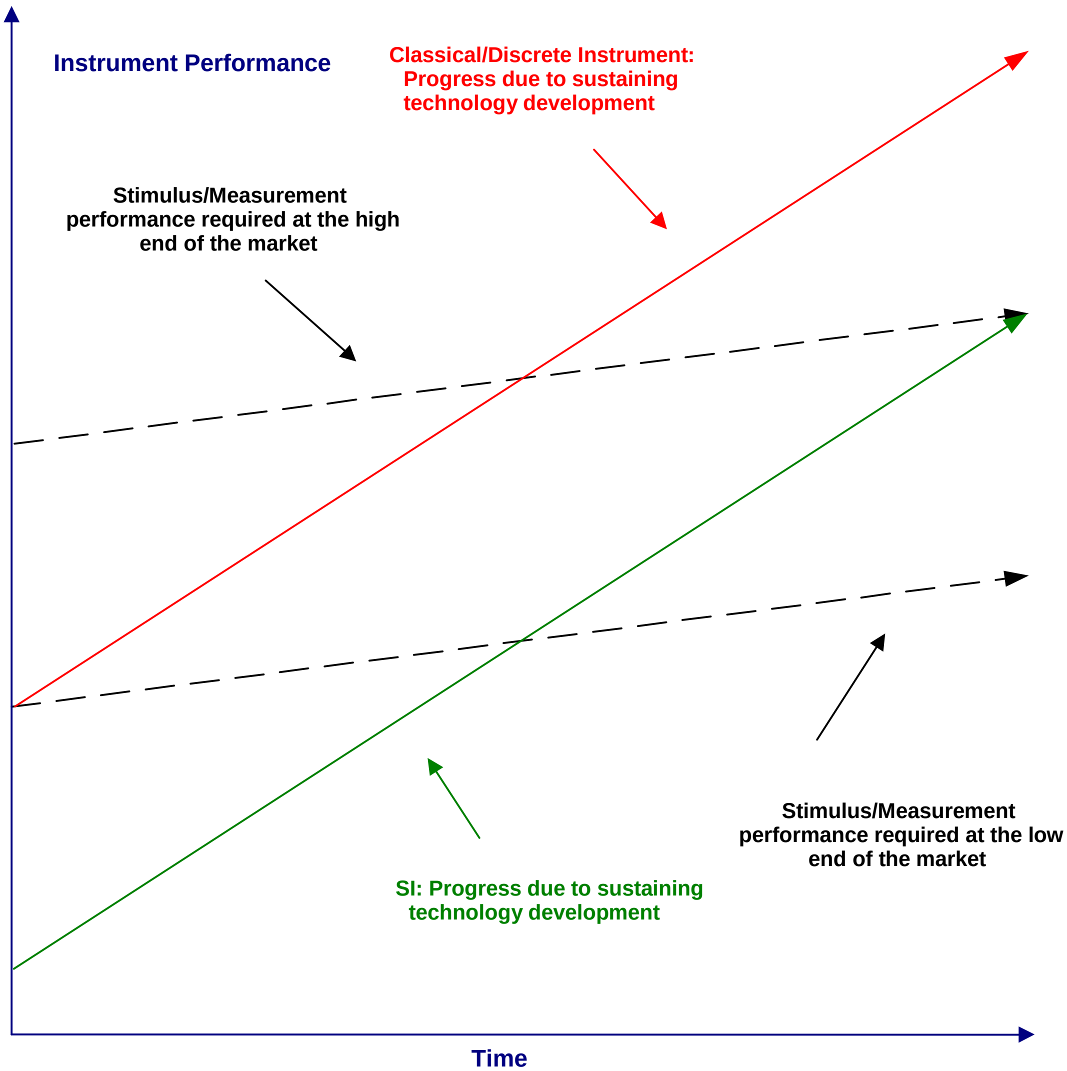

Fig. 2 Synthetic Instruments: A Disruptive Technology

This is an extremely important point. SI technology is in limited use right now, especially in the commercial T&M community, because main-stream customers perceive limited performance (i.e., bandwidth, dynamic range, accuracy, etc) and limited sources of supply of the technology as compared to conventional instrumentation solutions (Spectrum Analyzers, Network Analyzers, Oscilloscopes) which are targeted for specific test applications **[14].** As mentioned previously, this is often the case in the early stages of the development and marketing of any disruptive technology where its potential has not been fully realized. Success in making a disruptive technology such as SI a viable main-stream technology lies in continually evolving and investing in the lower-performing technology via continuous improvement in support of a targeted application/applications or niche until the customer's minimal but essential technical and operational needs have been satisfied **(See Fig.2)** at a comparable or lower cost.

However, the case for SI being a disruptive technology is more powerful than that portrayed in Fig.2. SI has the potential of displacing not one test instrument technology (i.e. Spectrum Analyzers) but a whole cross section of application specific test technologies and their associated functions. How is this possible? How can this occur? As mentioned previously, test instrument manufacturers have continuously evolved their T&M instruments with features and test capabilities which far exceed in many instances the testing needs of their users. A case in point is "high performance" spectrum analyzers which contain literally hundreds of functions many of which are never used by the user. Over time the customer is lulled into a false sense of security in knowing that he does not have to rigorously define his test requirement because his favorite T&M vendor will provide an excess of capability from which he can tap his testing needs .The customer in essence becomes technology driven as opposed to requirements driven.

This approach only works if you have the deep pockets and rack space to accommodate the latest and greatest instrument specific technologies; and the logistics support tail to keep a myriad of test instruments maintained and calibrated and your people trained on instrument specific operations and applications.

SI provides the opportunity to satisfy a customer's application specific test requirements via test scripting of needed functions (i.e., FFT spur search, modulation analysis, etc.) and the employment of Graphical User Interface (GUI) software such as LabVIEW or LabWindows/CVI. No more paying for more T&M than you need; the user only pays for the hardware and software that he needs in support of his/her test applications. Incremental/ just in time test software functional capability can be added by the user predicated on his real as opposed to perceived testing needs. Need to upgrade because you want to extend the frequency range or improve the accuracy of your test system because of advancing technology of your target UUTs? Swap out your old Up Converter and or Down Converter with new COTS technology; or upgrade your ADC/DAC to the latest high speed /high resolution offering that satisfies your requirements. This pragmatic approach is easily affected using modular technologies such as VXI & PXI; especially in VXI/PXI hybrid systems where the incorporation of the best technologies from both of these mainstream T&M architectures can be integrated to affect small, high speed, & cost effective SI systems.

7. Current/Future Market Situation & Trends

At the present time early adopters of the SI paradigm are primarily in the DOD market sector. The reason for this is understandable since the genesis for SI (section 1) was born primarily out of the DOD`s NxTest program. Currently elements of SI are either being developed or fielded in support of a number of mainstream DOD programs including the Air Force's IAIS program, USMC`s Viper program, and the Joint Service ARGCS program.

The SI landscape in the commercial community is quite different. Although commercially available SI systems and components are available in the marketplace, the Commercial T&M community is currently in a wait and see attitude with respect to this emerging technology. In a number of instances adoption of the SI paradigm may counter long established business models of how a company finances and implements an ATS support strategy in both the factory in the field. Adoption of SI requires a long term strategy of continuously evolving and improving your T&M capability via incremental hardware technology upgrades and functional test capability (i.e., software) based on evolving current and future needs. *In the long term SI may prove to be both a cheaper and more tractable support strategy than that currently employed in the industry today; but SI requires more of a system engineering and strategic approach to product test and support than that employed by a majority of manufacturers today.* The current paradigm employed by many commercial manufacturers of "stove piping" factory and field support based on the specific short term (i.e., < ~ 3-5 years) testing needs of a product or group of products may need an overhaul. In order to be successful, employment of a SI paradigm requires a commitment and seamless continuum of evolving product improvement (both hardware and software) to keep up with the technology gallop of emerging products to be supported in the future; especially in the fast moving Software Defined Radio (SDR) arena.

What are the future trends affecting this marketplace? As one observes the current state of the marketplace and future R&D activity which is occurring, one observation becomes abundantly clear. If the SI marketplace grows and evolves as some proponents predict, the T&M industry may ultimately over the next decade transform or morph into a subset of the broader Information technology marketplace. How do I draw such a radical conclusion?

For one thing SI systems are becoming more dependent on Digital Signal Processing (DSP) and FPGA processing techniques and the employment of high speed ADCs and DACs. Customers are becoming excited about the possibility of Up-converting baseband /IF signals to the RF/μW spectrum, down converting RF/μW signals to base band IF signals, and subsequently digitizing the IF signals and writing measurement and analysis algorithms to operate and manipulate this data. The SI paradigm is morphing more and more of the RF/μW world into the digital domain (Fig.1) and the benefits that can be accrued in the employment/utilization of digital hardware components and associated baseband data collection and measurement/analysis algorithms. In this regard, RF/μW signal generation and analysis is becoming a more tractable endeavor when implemented within a SI context.

8. Summary & Conclusions

SI is an emerging technology that will not go away. It is in synch with the Modern Day "digital revolution". We in the Test and Measurement industry must come to the realization that customer focus is on information, not data, and that SI is a technology enabler which satisfies this need. In order for the SI paradigm to transform itself from an emerging technology to a "prime time" global real world solution will require acceptance, incremental development, and support by a supply chain of leading T&M hardware manufacturers and test software suppliers. This transformation will not be easy but will be necessary to satisfy customer need for faster, smaller, supportable, and more information intensive Automatic Test Systems which have long service lives and are compatible with the ubiquitous PC paradigm, and its associated visual programming & data presentation tools.

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