SPEAKEASY - A NEW DIRECTION IN TACTICAL COMMUNICATIONS FOR THE 21ST CENTURY

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INTRODUCTION

Operation Desert Storm spotlighted a number of operational weaknesses in our battlefield communications capability. One such weakness is our inadequate joint forces communications interoperability. This problem can't be solved by simply deploying more radios: the physical and logistical burden would deny the mobility and agility needed in modern warfare.

Another identified weakness is the poor interference tolerance of many of our most operationally important radios — even some touted as jam resistant — a reflection of technology limitations when these radios were developed. In particular, they often cannot withstand mutual interference, especially from nearby radios. This is a critical shortcoming when one considers the formidable co-site interference conditions created by interoperability requirements.

Future tactical communications will also need marked improvements in the speed and flexibility of deployment, simplification of system support, and resistance to signal interception and exploitation.

Finally, given the present and projected defense budget shrinkage, a major objective in developing future communication systems is a need to significantly reduce the life cycle cost of future battlefield communications.

Speakeasy is a joint service program to develop such a system. The program is in its Advanced Development Model (ADM) phase, with Rome Laboratories the manager and Hazeltine the prime contractor.

OVERVIEW OF THE SPEAKEASY CONCEPT

As presently specified, Speakeasy will be able to communicate with any of the 15 presently fielded radio types listed in Table 1: a waveform ensemble spanning HF through X-Band and comprising skywave, line-of-sight, tropo and satellite communications media. In addition, Speakeasy contains a new, advanced, waveform which, together with advanced receiver processing and automatic link reconfiguration/control, provides unprecedentedly high resistance to interception, exploitation, interference, and propagation impairments such as multipath.

The Speakeasy system is based on a "library" of common standardized modules. Each deployment is composed of a particular combination of modules according to the platform and mission. The manpack, because of the relatively large number envisioned for the future battlefield, is the determiner of the module designs and standards. This permits other platform types to enjoy reduced initial and life cycle costs from module commonality with the numerically dominant manpack.

The Speakeasy manpack design goal is to be able to communicate simultaneously with any combination of four of the radios in Table 1, including radios of the same type. This is functionally equivalent to 4x15=60 conventional (that is, single waveform) radios. Larger platform types would acquire greater simultaneity by incorporating an appropriate number of redundant modules.

Speakeasy achieves its extensive waveform variety in a small, light-weight, low power

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TABLE 1. Speakeasy Waveform Compatibility

HF	VHF	UHF	L-BAND	C-BAND (TROPO)	X-BAND (SHF-SATCOM)
HF MODEM (MIL-STD-188-110A) PACER BOUNCE HF ALE (MIL-STD-188-141A) STAJ (MIL-STD-188-148A)	SINCGARS MSRT FUGER-A/VHF PR4G	HAVE QUICK I HAVE QUICK II HAVE QUICK IIA SATURN	JTIDS	TRC-170	TSC-94A

package by virtue of three main features: (1) an integrated architecture in which all waveforms share the same modules, (2) a highly advanced Digital Signal Processor (DSP) that enables most of the signal processing to be done in software, and (3) leading-edge-of-the-art hardware technology. This contrasts with the relatively common federated approach which is based primarily on feature (3): replacing a collection of existing radios with, in essence, a collection of miniaturized versions of these radios. Besides the much greater waveform "density" (number per unit size, weight and power) achieved, features (1) and (2) enable Speakeasy to add waveforms without the hardware redesign and repackaging entailed by the federated approach. Further, Speakeasy composes much of its signal processing software as parametric, or "generic", modules, constituting a systematic form of software reuse that substantially reduces the cost and time to add waveforms.

Speakeasy's hardware architecture is "open", with standardized physical, electrical and logical interfaces for all modules. This enables Speakeasy performance upgrading and capabilities expansion in step with technology advances, considerably extending Speakeasy's service life. It is notable that — while Speakeasy is an open-ended vehicle for evolution by periodic introduction of new waveforms, media, and capabilities — its backward compatibility, as per the waveforms in Table 1, permits Speakeasy's introduction without disrupting existing communications.

Speakeasy life cycle costs are reduced by the use of sophisticated built-in-testing together with self-healing made possible by Speakeasy's inherent reconfigurability and programmability. This extends the average time between critical failures and reduces the number of maintenance levels to two. Eventually, if Speakeasy were to replace — rather than merely interoperate with — the radios to which it is functionally equivalent, there would be a further, dramatic, life cycle cost reduction from collapsing the training, maintenance, and management costs of these radio systems into that of a single system.

SPEAKEASY FUNCTIONAL DESIGN CONCEPT OVERVIEW

Figure 1 illustrates Speakeasy's functional design concept.

The frequency conversion, filtering and amplification, or "RF", subsystem constitutes the translation between the digital world of the main signal processing and the analog world of the antenna subsystem. Two paramount issues in the design of this RF subsystem are achieving the small size, weight, and power consistent with Speakeasy objectives, and curing the notorious co-site interference problems that plague current multi-radio deployments. During the ADM program, the first issue is being

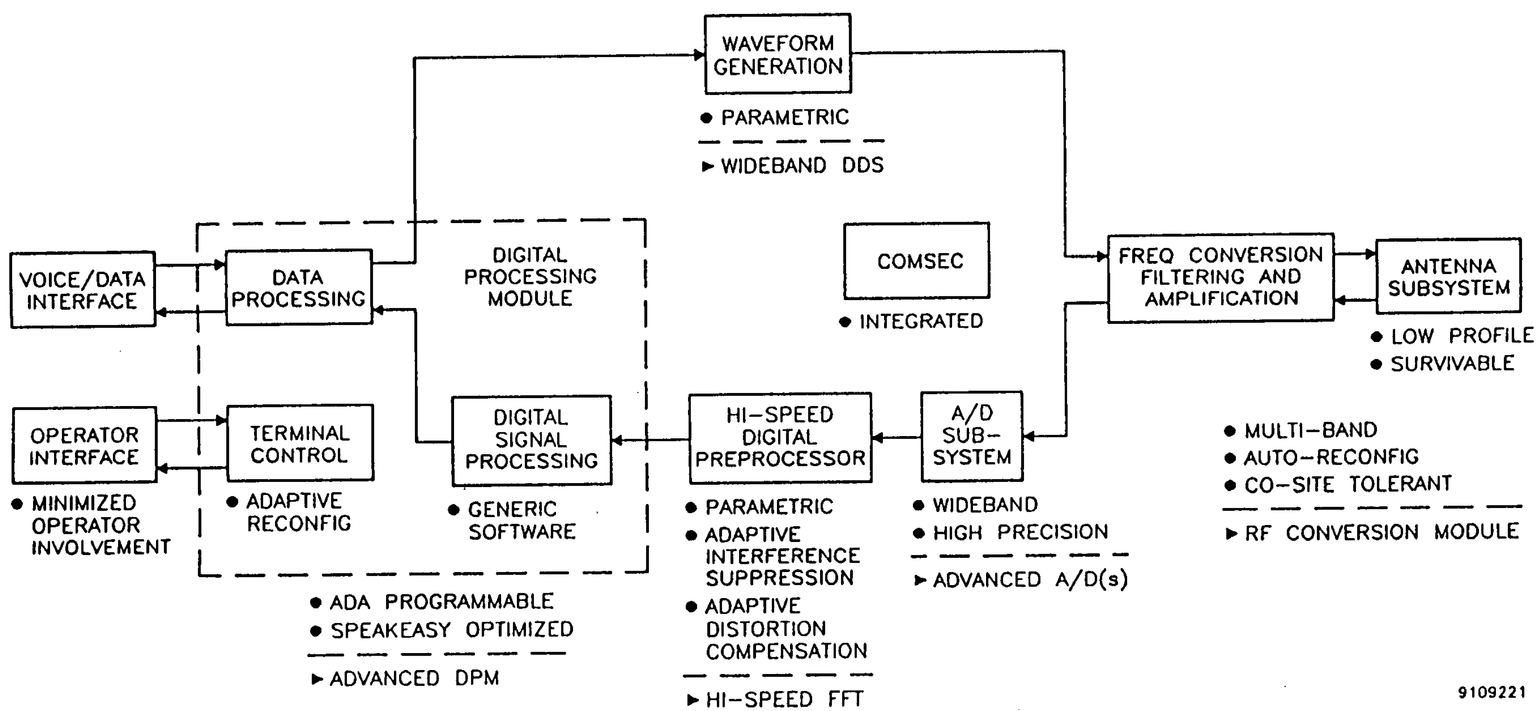

FIGURE 1. SPEAKEASY FUNCTIONAL BLOCK DIAGRAM

addressed by development of a miniaturized band-independent "RF conversion module" comprising all RF subsystem elements but the power amplifier and multicoupler. (The RF antenna subsystem is being developed on a companion CECOM program). The co-site interference problem is being attacked systematically based on a comprehensive set of mitigation techniques involving all elements of the Speakeasy system design. In addition, the aforementioned advanced waveform included in Speakeasy features inherent co-site interference resistance by virtue of its frequency hop diversity design. For Speakeasy, co-site interference resistance will be designed-in.

A critical element of the Speakeasy receiver design is the position of the analog-to-digital conversion (A/D). Desirably, the A/D should be as close as possible to the antenna subsystem interface, maximizing the extent of the digital, particularly the programmable, signal processing. The ADM is investigating advanced dual-mode A/D designs to meet the high-bandwidth moderate-dynamic range requirements of the pseudo-noise (PN) spread waveforms and the low-bandwidth high dynamic range requirements of non-PN waveforms.

A major task of the ADM design is to develop the framework for the aforementioned open system architecture. Among other benefits, this will allow progressively more functions to become programmable as technology advances.

In line with this objective of maximizing programmability, the program is supporting the development of an advanced DSP multi-chip module which will be the heart of the Speakeasy system. Ideally, this DSP would embody all of Speakeasy's digital processing. However, waveforms having relatively wide instantaneous bandwidths still require special purpose high speed digital circuits.

Accordingly, Speakeasy will generate the waveforms of interest via a Waveform Synthesis subsystem based on a state-of-the-art direct digital synthesis (DDS) device. In addition, the receiver includes a high speed digital preprocessor for wideband waveforms that contains both time and frequency domain processing, the latter providing wideband PN matched filtering and suppression of multiple narrowband interference signals. A key ADM task is the development of a multichip FFT module which is the core of this frequency domain processing. The preprocessor also includes a nonlinear transformation technique for suppression of wideband interference.

The Speakeasy link/terminal control subsystem automatically adapts the waveform, RF band, transmitted power, data rate, and receiver signal processing according to measured channel conditions and/or high level direction. This subsystem also controls the extensive built-in testing which accesses the particular subset of measurements and reconfiguration algorithms used to monitor and respond to equipment, as well as external, conditions.

The automatic configuration control limits operator involvement to selection from a predefined waveform list and high-level observation of the operating configuration and status. There are provisions for manual override/change of certain operating features.

A menu-driven Man Machine Interface (MMI) is being developed for the ADM to explore the interaction of the various waveforms, signal processing, and operating modes of the Speakeasy system. This interface will also be used to construct ADM operator-defined waveforms to aid the development of future waveforms and functions. A final MMI satisfying operational requirements for the respective Speakeasy platforms of interest will be developed after requirements become finalized.