GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 2/10/79

Project Title: Analysis and Design of Intercept Device

Project No: A-2323

Project Director: Mr. C. S. Wilson

Sponsor: USAF; Rome Air Development Center

Agreement Period: From 2/5/79 Until ~~2/4/80 (R&D Period)~~ 4/8/80

Type Agreement: Contract No. F30602-79-C-0094

Amount: $81,936 (Fixed Price, Level of Effort)

Reports Required: R&D Status Reports; Final Technical Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Capt. T. R. Hunter/PKRL
Rome Air Development Ctr.
Griffiss AFB, NY 13441

Defense Priority Rating:

Assigned to: Electronics Technology Laboratory (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
- School/Laboratory Director
- Dean/Director–EES
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- Project File (OCA)
- Project Code (GTRI)
- Other

CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

B-11
2.

Date: 8/14/80

Project Title: Analysis and Design of Intercept Device

Project No: A-2323

Project Director: Mr. C.S. Wilson

Sponsor: USAF; Rome Air Development Center

Effective Termination Date: 4/8/80

Clearance of Accounting Charges: 5/8/80 (for reporting purposes)

Grant/Contract Closeout Actions Remaining:

- X Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other _____

Assigned to: ETL/CSG (School/Laboratory)

COPIES TO:

Project Director
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EES Information Office
Project File (OCA)
Project Code (GTRI)
Other _____

CA—4 (1/79)

A-2323

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

March 16, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, N.Y. 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 1
Contract F30602-79-C-0094

Gentlemen:

During this first reporting period the project efforts have, in general, been directed to an overall analysis of the tasks to be accomplished under the program. Plans are being formulated as to specific methods and techniques for achieving the goals and objectives in a timely manner.

Major initial efforts are being directed to Task 1, i.e., compilation of data on computer/microprocessor controlled HF receiving equipment. Information is being acquired on both commerical and military equipment. It is our intent to not only compile data on existing receivers and receiving systems but to also determine status on in-development and, where possible, future-planned receivers. As a part of this compilation process we will also acquire information on conventional (i.e., non-computer controlled) receivers. The rationale here being that (1) a possibility always exists that a so-called conventional receiver could be retrofitted to perform the intercept device function and (2) more importantly, performance characteristics and specifications on conventional receivers will be useful as a baseline measure of performance of the more sophisticated computer controlled receiving systems. It is important to ensure that typical receiver performance characteristics (e.g., intermodulation, noise figure, selectivity, etc.) have not been compromised in any way as a result of design emphasis on computer control.

Some initial consideration is also being given to problems associated with analysis of switched channel concepts (Task 3). We consider this task a key aspect of the entire program. Switching speeds, specific implementation techniques and potential problems with aliasing and intermodulation are of vital concern. It is our intention to give considerable emphasis to this area during the early part of the program.

A meeting was held at RADC the early part of this week between cognizant Georgia Tech and RADC/IRAA personnel. The primary purpose of the meeting was to establish firm directions for the project efforts and to ensure that a mutual understanding exists between concerned parties as to specific goals and objectives. During the course of the meeting many specific areas relating to intercept device concepts

were discussed, clarification was achieved on a number of points, and firm project directions were established. Tentative plans were also made to visit Air Force Security Service , San Antonio, Texas for the purpose of achieving a better understanding of intercept methods and procedures, which in turn will assist in the analysis and design of a specific intercept device. This visit will likely occur within a month to six weeks.

During the coming month the project efforts will continue in the direction of acquiring receiver information with some emphasis also given to an analysis of basic concepts for a switched intercept device.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW/lb

Approved:

D. W. Robertson, Director
Electronics Technology Laboratory

Level of Effort and Expenditure Data

Report No. 1 for the period: 5 February 1979 to 4 March 1979
Contract F30602-79-C-0094

PROJECTED CONTRACTOR DATA

Month	Labor Categories (Hours)				Expenditure
	PRS*	SRS	RS	ARS	
February	5	10	15	15	$1230
March	5	10	20	20	1640
April	10	25	40	35	3275
May	20	40	75	60	5735
June	30	60	105	85	8195
July	35	70	125	105	9835
August	40	85	145	125	11470
September	40	85	145	125	11470
October	35	70	125	105	9830
November	30	65	105	80	8195
December	20	40	75	60	5735
January	18	32	60	55	4916
February	2	3	5	5	410

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 1.5%
Projections for effort expenditure are being met

A-2323

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

April 13, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, N.Y. 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 2
Contract F30602-79-C-0094

Gentlemen:

Project efforts during this reporting period have been primarily directed to (1) continued compilation of data on computer/microprocessor controlled HF receivers and (2) consideration of switched channel concepts.

Data has been acquired on a number of computer/microprocessor controlled receivers. To assure a thorough search, however, letters are being sent to approximately 100 receiver manufacturers, both domestic and foreign. It is likely only a small percentage of these manufacturers produce digitally controlled receivers; however, we feel it wise to attempt to cover all possible sources. The letter makes several requests from the manufacturers: (1) specific data on existing digitally controlled receivers, (2) information on any receivers which could, in some manner, be retrofitted for digital control, (3) data on conventional HF receivers which can serve as a base-line measure-of-performance, (4) information regarding any in-development or planned-development of a digitally controlled receiver, and (5) the name of an individual within the company who we could contact for additional technical information. We expect to begin receiving this information over the next several weeks and, based on past experience, should have replies from about 90 percent of the eventual respondents in a month-to-six-weeks.

Some effort has also been expended in the area of switching concepts. The potential problems for intermodulation and aliasing are of vital concern. In addition there are other basic considerations even for the case where adjacent channel signals do not represent a difficult problem. Consider a fundamental situation where a digitally controlled receiver is used to "simultaneously" monitor only two signals; but the two signals are not only at different frequencies but have different azimuthal coordinates (requiring antenna switching), occupy different bandwidths, and are at significantly different signal strengths. Therefore, the microprocessor must perform a number of operations between each high-speed scan. There is also the additional consideration of build-up and

decay characteristics of the receiver IF filters. For wideband IF, the buildup and decay times are short but as the IF bandwidth is decreased these times increase correspondingly. Table I presents some typical step response times for several IF filter bandwidths.

TABLE I

TYPICAL FILTER RESPONSE TIMES

IF Filter Bandwidth	IF Filter Settling Time
100 Hz	16 m sec
200 Hz	8 m sec
400 Hz	4 m sec
800 Hz	2 m sec
1.6 KHz	1 m sec
3.2 KHz	500 μsec
6.4 KHz	250 μsec
12.8 KHz	125 μsec
25.6 KHz	62.5 μsec
51.2 KHz	31.2 μsec
102.4 KHz	15.6 μsec
204.8 KHz	7.8 μsec
409.6 KHz	3.95 μsec

In one particular spectrum surveillance receiving system designed under an FCC contract, the scanning speed was increased by use of electronic switches in parallel with each of the IF filters. The switches were activated at the end of each sampling interval, thus reducing decay time to a minimum.

There are numerous aspects which must, and will, be considered to ensure optimum performance of the switched intercept device; the areas discussed above are representative.

During the coming month, project efforts will continue in the area of acquiring receiver data and in the analysis of basic switching concepts. Some effort will also be directed to the microprocessor control aspects of the program.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW/lb

Approved

D. W. Robertson, Director
Electronics Technology Laboratory

Level of Effort and Expenditure Data

Report No. 2 for the period: 5 March 1979 to 4 April 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hours Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	9	17
SRS	595	17	20
RS	1040	43	68
ARS	875	20	20

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 4.5%
Projections for effort expenditures are being met

A-2323

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

May 11, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 3
Contract F30602-79-0094

Gentlemen:

During the current reporting period, project efforts have been primarily directed to (1) continued compilation and evaluation of data on computer controlled HF receivers, (2) analysis of switched channel concepts, and (3) obtaining additional information regarding HF monitoring systems and techniques which will be useful to overall program goals and objectives.

In response to our numerous letter inquiries to receiver manufacturers, information continues to be received with a large amount of data expected over the next several weeks. In addition to information received through the mail, some verbal communication has also occured and it is expected that considerable more person-to-person contact will take place, particularly during the current month. The various literature and technical data being received will be very helpful toward ahcieving project goals; personal contacts will significantly aid in this effort.

During the early part of this month a meeting was held aat USAFSS, San Antonio, Texas for the purpose of obtaining additional information regarding HF monitoring systems and procedures. Portions of the meeting were also directed to determining future needs that could be fulfilled under the subject contract. Considerable information of significant value was obtained during the course of the meeting with portions of the information being new while other information obtained either added to, or reinforced subject areas discussed at the earlier meeting held at RADC on 14 March 1979. We certainly feel the visit to USAFSS was valuable and will provide positive guidance to our current efforts.

Efforts are also continuing in the area of switched channel concepts. Consideration is being given to various approaches and general concepts. We recognize this as being one of the more difficult technical areas in the current effort and that serious consideration must be given to the problem and its potential impact on overall signal quality.

During the coming month, project efforts will continue in the present general direction. We also plan to do further literature search to obtain additional information regarding signal commutation techniques and in particular as it applies to needs and requirements under the current effort.

Respectfully submitted,

Charles S. Wilson
Project Director

APPROVED:

D. W. Robertson, Director
Electronics Technology Laboratory

Level of Effort and Expenditure Data

Report No. 3 for the period: 5 April 1979 to 4 May 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hours Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	9	26
SRS	595	9	29
RS	1040	26	94
ARS	875	17	37

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 7%
Projections for effort expenditures are being met

A-2323

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

June 26, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 4
Contract F30602-79-0094

Gentlemen:

The project efforts during this reporting period have been directed to several specific activities. These activities have included (1) literature search and analysis of switched channel concepts, (2) investigation of receiver microprocessor control techniques, and (3) analysis and summary of state-of-the-art in digitally controlled HF receivers.

A significant portion of the expected information from various manufacturers of digitally controlled HF receivers has been obtained. Of the large number of inquiries which were mailed, the response to date has been about 25 percent. We do expect a few additional responses within the next several weeks, although anything close to 100 percent in such a general inquiry as this should not be expected. Many of the smaller companies who received these letters-of-inquiry do not manufacture receivers of such complexity (as would be expected) and thus will simply not respond.

In evaluating manufacturers data which has been received, there are two factors which are particularly evident. First, there is a fairly wide selection of digitally controlled HF receivers and at various levels of complexity. In some cases only limited control of receiver functions are available, whereas for other systems a high degree of control over essentially all receiver functions is attained. In addition, digital control capability exists both as an integral part of the receiver for some systems and for other systems, major emphasis is on control via an external microprocessor or minicomputer. In reviewing the general specifications for these digitally controlled receivers and in a comparison with conventional HF communications equipment it is evident that such performance characteristics as intermodulation levels, image rejection, cross modulation, and receiver sensitivity have not been compromised as a result of including a high degree of digital control.

The second factor which becomes evident in a review of the specifications is that these receivers are not intended for "simultaneous" operation on two or more frequencies since the manufacturers data indicates

channel switching speeds less than would be required for rapid commutation. In some cases frequency scanning operation is intended in order to perform spectrum monitoring, but even here the normal function is to sweep over a portion of the HF spectrum, recording various parameters of signals occupying specific bands according to time and frequency; rapid commutation between two or more signals is not a part of this scenario.

The usual approach to "simultaneous" intercept of two or more signals is through use of channelized receivers which, in its basic form, is N receivers within a single chassis. Portions of such receivers are common to each channnel and thus the overall system is less complex and more cost-effective than N individual receivers; however, this channelized approach would likely not provide the same overall effective capability as the commutation approach.

A literature search has been performed in an attempt to determine the extent of prior work either directly or indirectly related to the concept of a commutation approach to "simultaneous" monitoring of multiple signals. This literature search, though not complete at this time, has encompassed a number of major subject headings including:

- switching systems
- digital tuning
- commutation
- receivers, frequency hopping
- receivers, channelized
- receivers, surveillance
- receivers, monitoring
- digital communication systems.

A number of papers, articles, patents, etc. containing information related to the intercept device concept have been located. None of the papers located thus far, however, deal directly or exclusively with a commutation process as envisioned for use with the intercept device. Additional literature search is planned with emphasis on frequency hopping receivers as well as other related subjects. It is expected that portions of the additional literature search will involve access to classified material.

The literature search has also uncovered information regarding microprocessor control of communication receivers; additional material is expected. It is anticipated that this material will be useful toward achieving project goals.

During the coming reporting period, project efforts will continue in the present general direction. Particular emphasis will be directed to switched channel concepts and to microprocesssor control.

Respectfully submitted,

Charles S. Wilson
Project Director

Level of Effort and Expenditure Data

Report No. 4 for the period: 5 May 1979 to 4 June 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hours Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	9	34
SRS	595	9	37
RS	1040	48	141
ARS	875	119	156

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 14%
Projections for effort expenditures are being met

A-232

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

July 25, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 5
Contract F30602-79-0094

Gentlemen:

During the current reporting period the project efforts have been directed primarly to (1) evaluation of switched channel concepts and (2) receiver microprocessor control techniques. In addition to this activity some material is continuing to be received on currently available, commercial and military HF receivers; this total data base thus continues to grow.

Evaluation and analysis of state-of-the-art in EW receiver techniques is an important ongoing project effort and is being performed in light of requirements imposed by the switched channel approach to "simultaneous" reception of multiple signals. There exists a number of techniques in the general area of EW receiver technology, and as specifically related to signal surveillance, for rapid or simultaneous acquisition of multiple signals or signal components. These techniques include such signal acquisition systems as (1) Instantaneous Frequency Measurement (IFM) receivers, (2) channelized receivers, (3) compressive receivers, and (4) the so-called smart scan superhetrodyne receivers. Although these receiver systems are primarily used for such EW activities as radar signal acquisition and identification and as a part of spread spectrum systems, the technologies involved have potential application for our switched channel concept. As a result of this potential, project efforts are being directed to a comprehensive analysis of these various receiver techniques for the specific purpose of technology transfer to the switched channel intercept device. Considerable information exists in the open literature regarding these EW receivers and associated technologies. However, much of the information regarding such systems is, of course, contained in the classified literature; this area is also being explored to assure a comprehensive study and evaluation of these important receiver techniques.

In addition to specific receiver technologies, efforts are also being directed in such related areas as spread spectrum techniques and the rapidly emerging area of Surface Acoustic Wave (SAW) technology. SAW devices are finding increased use in sophisticated signal processing schemes serving in such capacities as bandpass filters, dispersive delay lines, and pulse compressive filters. Such devices and technologies may well be directly applicable to our specific requirements.

Much of the ongoing project efforts are also being directed to receiver, microprocessor control. This effort concerns both an evaluation and analysis of microprocessor control, as it currently exists and is implemented in commercial and military receivers, and also planning and design of a microprocessor controller specifically for the switched channel intercept device.

At present, the cumulative project efforts are somewhat below original projections; these efforts include both level of effort and costs. However, technical accomplishments under the project are consistent with funds expended. During the current month, as well as coming months, the level of effort has and will be increased in order to meet original projections. This departure from preliminary projections will not be detrimental to the overall project goals.

During the coming month, project efforts will be directed primarly to (1) a continued analysis of receiver techniques applicable to the switched channel intercept device, (2) investigations and analysis of the general switched channel concept and methods for reducing or eliminating potential intermodulation problems, and (3) microprocessor control techniques.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW:lsl

Approved:

R. W. Moss, Head
Communications Systems Branch

Level of Effort and Expenditure Data

Report No. 5 for the period: 5 June 1979 to 4 July 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hour Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	7	41
SRS	595	17	54
RS	1040	34	175
ARS	875	104	260

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 18%
Projections for effort and cost expenditures are somewhat below original plans; plans are currently underway to increase the level of effort.

A-2323

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

August 23, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 6
Contract F30602-79-C-0094

Gentlemen:

Project efforts during the current reporting period continue to be directed primarly to (1) study and analysis of switched channel concepts and, (2) investigation of microprocessor control of a switched channel HF receiver.

The area of switched channel concepts continues to be pursued along a number of parallel paths. This specific task, being perhaps the most difficult of the program, is receiving, at present, major emphasis. There would, of course, be some general difficulties in implementing the high speed, commutating receiver concept such as a fast hopping local oscillator and ringing of IF filters. The major problem, however, results from the fact that the HF spectrum does not, by any means, represent an ideal signal environment because of the large number of closely spaced signals and of the resulting problems with intermodulation and aliasing which can be expected through use of simple commutation techniques. Because of this fundamental difficulty it will likely be necessary to devise unique approaches to overcome problems associated with the overall commutation process. To this end a number of technology areas are being investigated.

The general approach is directed both to various forms of signal processing and to specific devices. Surface Acoustic Wave (SAW) devices and optical processing (in the form of Bragg cells, for example) are representative concepts. In addition, use of digital filtering in conjunction with up/down frequency translation techniques are being considered. Further areas of consideration include various form of orthogonal signal processing and use of chirp techniques for enhancing switched channel concepts. In a similar vein, consideration is being given to active filter techniques that can be applied directly at RF. This latter technique in recognition of the fact that if pratical active filter technqiues can be devised for narrowband preselection (e.g. 100Hz) directly at RF, then major problems associated with applying a high speed commutation function (e.g., intermodulation) would be essentially circumvented.

During the coming reporting period project efforts will continue to be directed primarly to various aspects of the overall switched channel concept. Efforts will also be directed to microprocessor control of HF receiver functions.

Respectfully submitted,

Charles S. Wilson
Project Director

Level of Effort and Expenditure Data

Report No. 6 for the period: 5 July 1979 to 4 August 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hour Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	17	58
SRS	595	0	54
RS	1040	68	243
ARS	875	70	330

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 25%
Projections for effort and cost expenditures are somewhat below original plans; efforts are currently in effect for restoring original projections.

A-2323

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

1 October 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/INAA

Subject: Monthly Progress Report No. 7
Contract F30602-79-C-0094
Project A-2323

Gentlemen:

During this reporting period project efforts have been directed primarily to the areas of (1) study and analysis of methods and techniques for realizing workable switched channel concepts and (2) pursuance of microprocessor control techniques for the switched channel HF receiver.

The study and analysis of switched channel concepts has been concerned with both techniques as well as specific devices (e.g., modular signal processing subsystems). In the general area of techniques, a number of concepts are being evaluated. The major thrust of these concepts is for realization of an ability to commutate between N signals while minimizing the degree of intermodulation between the numerous received signals and the locally generated switching function.

To minimize intermodulation it will be necessary to provide smooth amplitude and phase transitions in the switching process; this opposed to an abrupt process. One possible approach is to provide switching circuitry such that the switching is not abrupt but rather a commutation process which varies smoothly and continuously between the RF channels. Utilizing such a so-called blending function can be expected to provide improved performance over a generally used abrupt switching process. Such techniques and methods are being investigated.

In addition to an analytical investigation of the various commutation processes, laboratory evaluations are also being performed. As a result of our in-house instrumentation capability, numerous experiments, tests, and simulated conditions can be readily performed. The purpose of these laboratory tests will be to verify analytical results and to determine feasibility of both specific approaches (as identified analytically) as well as variations and modifications to these specific approaches.

Consideration also continues to be directed to specific devices and associated techniques which may be utilized to achieve the switched channel receiver concept. Some of these devices are in present use to a considerable degree in IFM receiver concepts. The possibility of technology transfer is being investigated.

For this reason a broad review of the literature under SAW devices was instituted with emphasis on filters, and a short review of most recent work in optical processing using Bragg cells was conducted. Several observations may be made at this time. SAW filters offer promise in their VHF operating range with their sharp selectivity and reliability characteristics (among others). Their application to an up-converted 1st IF would appear to be justified. However, fabrication and aging characteristics could be a problem. Optical processing via Bragg cells is an interesting technique for IFM at microwave frequencies but appears impractical for our relatively narrow frequency range. Implementation of the hardware is another limitation for equipment in the field.

Other investigations are in the area of digital signal processing in hybrid analog/digital receivers. Several designs exist which employ analog RF front ends but perform matched filtering and detection using digital filters of elliptic function design and processing algorithms. These designs are being studied for useful content and possible applicability to the present effort.

Microprocessor control continues as an area of current investigation. Emphasis is being given to specific receiver functions which must be controlled, rates involved and interface required. Information and data on new microprocessors continues to be added to our existing files in order that a final selection process on the microprocess to be used will provide an optimum capability for this receiver application.

During the coming reporting period, project emphasis will continue along the general present course. We expect to make significant progress in the laboratory evaluation of the various concepts. In addition, increased effort is planned in the specifics of microprocessor control methods and techniques.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW:gh

Approved:

R. W. Moss, Head
Communications Systems Branch

Level of Effort and Expenditure Data

Report No. 7 for the period: 5 August 1979 to 4 September 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hours Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	22	80
SRS	595	0	54
RS	1040	119	445
ARS	875	170	449

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 38%

Projections for effort expenditures are somewhat below original plans; current levels of effort are moving toward original projections.

A-2323

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

31 October 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/INAA

Subject: Monthly Progress Report No. 8
Contract F30602-79-C-0094
Project A-2323

Gentlemen:

Project efforts during this reporting period have been directed primarily to (1) investigation and design of microprocessor control of multiple, or switched channel, HF receivers and (2) continued study and analysis of switched channel concepts.

Current thrust of the switched channel studies is directed to two general areas: (1) continued study and analysis of methods for achieving a workable switched channel concept, (2) use of a channelized receiver approach for realizing the same end-capability but without the problems associated with high speed commutation.

There are two primary areas of difficulty associated with high speed commutation of a special purpose, single channel receiver which is to perform as a pseudo, multichannel equivalent. One area is that of intermodulation between the commutating signal, the HF signal of interest, and all other HF signals within the band-limited portion of the spectrum. Analysis and study of this intermodulation aspect of the switched channel receiver continues in an attempt to achieve a workable solution, specifically a commutation technique which will not corrupt the intelligibility of the receiver's baseband or audio output signal.

The second area of prime consideration relates to build-up (or attack) and decay time of the receiver's IF bandpass filters. This attack and decay time problem becomes particularly acute when, for example, the requirement is to commutate between two signals which require significantly different IF bandwidths. Consider the case where one signal type is A1, the second signal type is A3a. Appropriate IF bandwidths may then be

100 Hz and 3 kHz respectively. Therefore, to meet Nyquist sampling criterion, the minimum sampling rates must be 200 Hz for the A1 signal and 6 kHz for the A3a signal, assuming an information bandwidth equal to the IF bandwidth. To accommodate these sampling rates the first requirement then is for the IF bandwidth to be essentially doubled. The major disadvantage of increasing the IF bandwidth, in excess of that needed for the signal, is the increased possibility for "adjacent channel" interference and, as a minimum, certainly an increase in output signal-to-noise ratio, an important consideration for the congested HF spectrum. The major problem, however, in the example here presented concerns the attack and decay time of the IF filter and of the interrelationship between attack/decay time and sampling rates.

Assume that the IF bandwidths have been increased to 200 Hz and 6 kHz as discussed above. Since attack and decay times are approximately equal to the reciprocal of the bandwidth, we thus have times of about 5 ms and 0.17 ms respectively. Now, because the wideband signal (i.e., 3 kHz) must be sampled at 0.17 ms intervals, if aliasing is to be avoided, then attempting to achieve a sample of the narrowband signal becomes a problem because of the long attack and decay times of the narrowband filter. Specifically, the time required for sampling of the narrowband signal is sufficiently long that information contained in the wideband signal is lost in the intervening period.

Decay time in a bandpass filter can be shortened considerably by use of electronic analog switches in parallel with the filters for momentarily achieving a crowbar effect (can only be done for non-distributive filters). Attack time, however, is determined solely by filter characteristics.

Solutions are being sought to overcome these problem areas. In view of the potential for continued difficulty in achieving a true, switched channel receiver, efforts are also being directed to channelized concepts and specifically to microprocessor control capabilities. Many of these microprocessor control aspects do apply to switched channel concepts as well as a channelized receiver approach.

Considerable progress has been made thus far in the design of a microprocessor controlled receiver having increased capabilities over existing HF receivers, specifically as it relates to signal monitoring requirements.

The general approach to this microprocessor receiver design has been toward development of a dual-function receiver package. This dual-function capability is in the form of both a multi-channel monitoring

capability in conjunction with a user-selectable, channel surveillance capability. The multi-channel monitoring portion of the receiver system would be in primary use by the operator for normal monitoring and recording processes. With microprocessor control, however, this monitoring process is enhanced in such a manner as to make more effective use of the operator's time and potential capabilities. This increase in effectiveness will allow the operator to monitor a larger number of channels and to record all necessary data obtained from these various channel frequencies.

The surveillance portion of the receiver package would continually and automatically scan a number of user-designated frequencies for occupancy. The user-designated frequencies would be assigned priorities relating to their expected level of importance. In addition to each surveillance frequency being assigned a priority number, the monitor frequencies would also be assigned priority numbers. This number assignment process would be such that while the operator's activities and interest are being directed to the monitoring portion of the receiver (i.e., his normal duties) and a signal of high priority becomes active on one of the surveillance channels then automatic signal transfer could occur between the two elements of the receiver system. For this automatic transfer to occur, the surveillance channel priority assignment would have to be greater than the priority assignment of at least one channel within the monitoring portion of the receiver system.

The major thrust of this monitor/surveillance concept is to significantly enhance operator proficiency and to increase the overall data collection capability; microprocessor control is the key to this increased capability.

During the coming reporting period, project efforts will continue toward development of the microprocessor control capability and to further analysis of methods and techniques for realization of workable switched channel concepts.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW:gh

Approved:

R. W. Moss, Head
Communications Systems Branch

Level of Effort and Expenditure Data

Report No. 8 for the period: 5 September to 4 October 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hours Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	34	115
SRS	595	0	55
RS	1040	122	485
ARS	875	150	650

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 48%
Projections for effort expenditures are somewhat below original plans; current levels of effort are moving toward original projections.

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

November 30, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T.R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/INAA

Subject: Monthly Progress Report No. 9
Contract F30602-79-C-0094
Project A-2323

Gentlemen:

During this reporting period project efforts continue to be directed primarily to (1) design of a microprocessor controller leading to an improved HF monitoring/surveillance receiving system and (2) continued study and analysis of switched channel concepts.

Considerable progress has been made toward design of the microprocessor-based controller for the HF monitor/surveillance receiving system. As reported in the previous monthly letter this microprocessor-based controller is being designed around the concept of a dual function HF receiving system which will provide both an active monitoring capability and an on-line surveillance capability having an automatic hand -off feature. The fundamental receiving system has been fully developed and at present considerable progress has been made toward design specifics. These design specifics include development of flowcharts and algorithms as well as details of such microprocessor specifies a required memory blocks, data rates and I/O capaiblity.

Of major importance in regard to design of the microprocessor-based receiving system is that the design concept is adaptable to either a channelized receiver approach or to a commutated approach. Project emphasis continues toward evaluation of both technical areas.

Considerable effort continues in the area of analysis of commutated or switched channel techniques. The difficulities that can be encountered in the high speed commutation approach (e.g., intermodulation, meeting sampling criterion, and bandwidth effects) have been discussed in previous monthly reports. However, continuing efforts are being directed to realizing or achieving a workable solution. These efforts are being directed along both qualitative and quanitative lines.

During the coming month project efforts will continue toward design of the microprocessor-based portion of the HF receiving system. Particular emphasis will be given to switch channel concepts in order that positive identification can be given to problem areas as well as potential solutions.

Respectfully submitted,

Charles S. Wilson
Project Director

APPROVED:

R. W. Moss, Head
Communications Systems Branch

Level of Effort and Expenditure Data

Report No. 9 for the period: 5 October to 4 November 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hours Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	17	132
SRS	595	0	55
RS	1040	119	604
ARS	875	163	813

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 57%
Projections for effort expenditures are somewhat below original plans; current levels of effort are moving toward original projections.

A-2323

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

December 20, 1979

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/INAA

Subject: Monthly Progress Report No. 9/10
Contract F30602-79-C-0094
Project A-2323

Gentlemen:

During the current reporting period, project efforts continue to be directed principally to (1) design of the microcomputer-based controller for the improved HF receiving system and (2) continued study and analysis of switched channel concepts.

Microcomputer design efforts continue with flow charting and refinement of software support modules for the controller. Work has also been initiated on candidate selection for the specific microcomputer to be incorporated in the controller design.

The main controller routine is fairly straightforward. However, implementation of the main routine will require several driver routines (i.e., subprogram modules) for integrating hardware into software. Examples of main controller routine elements include: scanning memory data blocks of receiver parameters, polling the keypads for user inputs, and formatting the receiver parameters in the form of tuning codes for transmission over the data bus to each receiver in sequence. Flow charting and refinement of software support modules ensures microcomputer control will be implemented in an optimum manner.

To date, two microcomputers appear attractive as controller candidates: the LSI-11 series and the TI 990/xxx series, both single board computers with varying configurations of on-board memory (if any) division between RAM and ROM and input/output ports. Both are 16-bit word machines of contemporary architecture utilizing multiple registers and choice of clock rates. They differ markedly, however, in system design and configuration. The LSI-11 is DEC's current microcomputer architecture which has software compatibility with the PDP-11 family of minicomputers. In fact, when the LSI-11 is configured with interface cards and memory modules, it then becomes a PDP-11/x3. The attractiveness of the LSI-11 for our purpose, lies in utilizing a Georgia Tech-owned PDP-11/34 as an emulator of the entire controller for software development.

Because a full blown minicomputer may be an overkill in this control application, the TI 990 series will be considered in light of its current industrial applications. The TMS 9900 CPU is frequently used to control

industrial processes via a unique feature in its architecture called the communications register unit (CRU). This CRU is a dedicated I/O port separate from the main data bus and can accept, or send, bit/serial information or even single-bit address a device; a feature particularly attractive for our application.

Continuing efforts are being directed to the area of commutated or switched channel techniques. The extent of these efforts includes analytical evaluation, laboratory tests leading to empirical results, and continued literature review. There exist a number of problem areas associated with high speed channel commuation; problem areas which must be identified and for which solutions must be obtained if a feasible and workable system is to eventually be implemented. Certain of the problem areas are quite difficult and as a result primary efforts are being concentrated in these areas.

During the coming period, project efforts will continue along the present general course of microcomputer-based controller design and study and analysis of switched channel concepts. In addition, efforts will also be directed to analysis of operating efficiency and cost factors of the switched channel approach to HF monitoring requirements.

Respectfully submitted,

Charles S. Wilson
Project Director

APPROVED:

R. W. Moss, Head
Communications Systems Branch

Level of Effort and Expenditure Data

Report No. 10 for the period: 5 November to 4 December 1979
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hour Requirements	Hours Expended In This Reporting Period	Cumulative Total of Expended Hours
PRS*	290	0	132
SRS	595	60	115
RS	1040	80	684
ARS	875	170	983

*The term "Scientist is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS-Principal Research Scientist
SRS-Senior Research Scientist
RS -Research Scientist
ARS-Assistant Research Scientist

Estimated percentage of technical completion: 65%

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

January 28, 1980

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, N. Y. 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 11
Contract F30602-79-C-0094

Gentlemen:

Project efforts during the current reporting period have been directed primarily to (1) continued design of the microcomputer for the improved HF receiving system and (2) further investigation and analysis of switched channel concepts.

The microcomputer design efforts continued with efforts directed to achieving an HF receiver system having enhanced capabilities over conventional approaches. Flow charting and further efforts toward refinement of software support modules is receiving considerable attention. Microprocessor control techniques in current use by such receiver manufacturers as E-Systems, Magnavox, Racal, and Watkins-Johnson are also being noted as a part of this task. Although the microprocessors, as used in these receivers, are only for single unit control, general rational and specific techniques used are of interest to our overall design considerations.

The study and analysis of switched channel concepts continues to receive considerable attention. The current efforts are directed not only to problem analysis but to quantification as well to ensure a thorough investigation and subsequent documentation of the subject matter. An integral part of this investigation is, of course, a search for workable switched channel concepts.

Formal request has been made for a 60-day, no-cost extension to the contract. This time extension will be used for all phases of the research effort; particular emphasis will, however, be directed to the switched channel concepts during the extended period.

Project efforts during the coming month will be directed principally to microcomputer design efforts, switched channel analysis, and to cost factors and operating efficiency of the microcomputer-controlled HF monitoring system.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW/pf

APPROVED:

R. W. Moss, Head
Communications Systems Branch

Level of Effort and Expenditure Data

Report No. 11 for the period: 5 December 1979 to 4 January 1980
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hours Requirements	Hours Expended in this Reporting Period	Cumulative total of Expended Hours
PRS*	290	9	140
SRS	595	68	183
RS	1040	83	767
ARS	875	170	1153

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 77%

A-232

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

February 29, 1980

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, N. Y. 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 12
Contract F30602-79-C-0094
Project A-2323

Gentlemen:

During this reporting period, project activities have been directed primarily to (1) further analysis, design and documentation of the microcomputer controller for the improved HF receiver system, (2) continued analysis of switched channel concepts, and (3) further efforts toward defining operating efficiency and cost-effectiveness.

The analysis and design of the microcomputer portion of the HF receiver systems continues. At present, analysis and design are essentially complete and documentation is being given prime consideration. This documentation provides all elements of the microcomputer design including extensive flow charting, development of main controller routine elements, and the numerous driver routines. A major goal of this documentation effort is to provide a firm design in order that eventual translation in to a workable system can be readily achieved.

Efforts are also continuing in the analysis of switched channel concepts, as applicable to rapid commutation of "typical" signals present in the HF portion of the spectrum. Quantification of these concepts continues to receive considerable attention with an overall objective being the development of workable techniques in a "real-world" environment.

Based on concepts developed through use of microcomputer control of an HF spectrum monitoring system, a cost-effectiveness and operating efficiency study continues. The degree-of-advantage of the microcomputer controlled approach (over conventional monitoring processes) will be the major output, or result, from this study and evaluation.

During the coming month, project efforts will continue along the

same general course, as various tasks are further pursued and as firm goals, design approaches, and conclusions are achieved.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW/pf

APPROVED:

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R. W. Moss, Chief
Communications Systems Division

Level of Effort and Expenditure Data

Report No. 12 for the period: 5 January to 4 February 1980
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hours Requirements	Hours Expended in this Reporting Period	Cumulative total of Expended Hours
PRS*	200	2	142
SRS	375	85	268
RS	1100	65	832
ARS	1329	160	1313

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 85%

A-2323

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

March 17, 1980

United States Air Force
AFSC Rome Air Development Center
Griffiss AFB, N. Y. 13441

Attention: Captain T. R. Hunter, RADC/PKRL
Mr. Roger Ringlund, RADC/IRAA

Subject: Monthly Progress Report No. 13
Contract F30602-79-C-0094
Project A-2323

Gentlemen:

During the current reporting period, project activities have been directed primarily to (1) design and documentation of the microcomputer based HF receiver system, (2) continued analysis and documentation of switched channel concepts, and (3) continuing efforts toward evaluation of operating efficiency and cost-effectiveness of the microcomputer based HF receiving system.

Project efforts related to design aspects of the microcomputer portion of the HF receiving system are being directed primarily to documentation of design rational, development of algorithms, and development of controller routines. Documentation will be comprehensive to the point that eventual translation of the design into workable hardware can be readily achieved.

Investigation, analysis, and documentation of switched channel concepts continues. This phase of the program has been to determine if viable techniques either exist, or could be developed, that would permit high speed commutation between multiple signals in the HF portion of the spectrum. A major requirement of any commutation technique would be to ensure no significant degradation of signal intelligibility.

Project efforts are also continuing on analysis of the operating efficiency and cost effectiveness of the microcomputer approach to an improved HF monitoring system. This analysis uses as a baseline measure the current monitoring system consisting primarily of R-390 receivers. The analysis will demonstrate that significant improvements can be achieved with an advanced monitoring system.

During the coming month project efforts will continue in all areas of the program. Major emphasis will be directed to documentation of the results of this study.

Respectfully submitted,

Charles S. Wilson
Project Director

CSW/pf

APPROVED:

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R. W. Moss, Chief
Communications Systems Division

Level of Effort and Expenditure Data

Report No. 13 for the period: 5 February to 4 March 1980
Contract F30602-79-C-0094

Contractor Data

Labor Categories	Contractual Hours Requirements	Hours Expended in this Reporting Period	Cumulative total of Expended Hours
PRS*	200	9	151
SRS	375	27	295
RS	1100	58	890
ARS	1329	150	1463

*The term "Scientist" is used in a general sense for professional personnel and also includes Engineers and Technologists.

PRS - Principal Research Scientist
SRS - Senior Research Scientist
RS - Research Scientist
ARS - Assistant Research Scientist

Estimated percentage of technical completion: 92%

A-232

ANALYSIS AND DESIGN OF INTERCEPT DEVICE

By
C. S. Wilson, Project Director
L. W. Pickering
J. L. Wood

Communications Systems Division
Electronics Technology Laboratory
Georgia Insititute of Technology
Atlanta, Georgia 30332

May 1980

Technical Report Summary for Period 5 February 1979 - 8 May 1980

Prepared for
UNITED STATES AIR FORCE
AFSC Rome Air Development Center
Griffiss AFB, NY 13441

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Georgia Institute of Technology
Atlanta, Ga. 30332

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This report to the Rome Air Development Center deals with the analysis and design of an intercept device for improved HF spectrum monitoring capability. Present Air Force monitoring of the HF spectrum is accomplished through utilization of conventional communications receivers. There exists, however, a need to improve on this fundamental approach to monitoring in order that the necessary monitoring data can be acquired in a more efficient and cost-effective manner.

To determine viable approaches for an enhanced monitoring capability, the major thrust was directed first to an analysis of switched channel concepts whereby a single, special purpose receiver would rapidly commutate between two or more signals of interest. This general concept was pursued by both an investigation into related areas of technology and through a comprehensive mathematical analysis. Then based on this investigation and mathematical analysis a microcomputer-controlled receiver system was designed. Finally, an analysis of operating efficiency and cost-effectiveness of the selected approach was performed.

Principal findings of the report are that: (1) no apparent method which does not introduce serious signal distortion is available for high speed commutation, and (2) a viable alternative has been developed under this program which will significantly enhance Air Force HF monitoring capabilities. The degree of enhancement is quantified through an operating efficiency and cost-effectiveness analysis.

ANALYSIS AND DESIGN OF INTERCEPT DEVICE
(TECHNICAL REPORT SUMMARY)

Introduction

This research program with the Rome Air Development Center was concerned with the analysis and design of an intercept device for improved HF spectrum monitoring capability. Present Air Force monitoring of the HF spectrum is accomplished through utilization of conventional communications receivers. There exists, however, a need to improve on this fundamental approach to monitoring in order that the necessary monitoring data can be acquired in a more efficient and cost-effective manner.

Problem Definition

Conventional HF receivers are essentially one-channel-at-a-time receivers which may be manually tuned in the HF spectrum. In addition, receiver parameters such as IF bandwidth, AGC function, BFO position, etc. must be individually adjusted to optimize reception of a specific signal. When an operator is tasked to monitor several frequencies with conventional receivers, his approach may be (1) to cyclically tune a single receiver to the several frequencies of interest, or (2) to use several receivers each tuned individually to one of the frequencies. The former approach suffers from several disadvantages including readjustment of many of the receiver functions each time the frequency is changed, and the distinct possibility that signal activity will go undetected while a frequency is not being monitored.

Use of several conventional receivers certainly provides a capability for intercept and recording of signals of interest but at a rate and volume less than what could be accomplished with enhanced technology; specifically use of microcomputer control. Microcomputer control of HF receivers in the near future and eventual computer control of entire monitoring sites offers numerous advantages over current operational procedures. Among these advantages are (1) an increased volume of recorded data; (2) improved probability of intercept; (3) reduced

manpower requirements; and (4) eventual real-time processing of at least some portions of the data.

Because of a need to improve the United States Air Force HF monitoring capability, a feasibility design study and analysis of a Switched Intercept Device was undertaken. The basic concept of the Switched Intercept Device is to provide a capability to simultaneously monitor two or more target transmitters. In concept such a receiver would rapidly switch between two or more signals, changing all receiver parameters (e.g., LO frequency, IF bandwidth and AGC parameters) as necessary for each signal and presenting the outputs of each channel to independent terminals. This operation is analogous to a dual trace oscilloscope which uses a high speed switch to commutate between the two input channels and displays the waveforms on a single-gun CRT as two apparently independent waveforms.

To accomplish this commutation task, a Switched Intercept Device must be capable of operating with all types of signals normally contained in the HF portion of the spectrum. In addition, the Switched Intercept Device must meet typical monitoring conditions and operating scenarios.

Method of Approach

The primary objective of this study was a design study and analysis of a Switched Intercept Device which performs the equivalent functions of two or more single channel HF receivers monitoring separate transmitters. To accomplish this objective, the study was divided into five major tasks:

- Investigation of the state-of-the-art in HF receiver technology
- Investigation of the microprocessor control of receiver functions
- Analysis of the switched channel intercept device in terms of channel parameters and response time

- Design of a microprocessor/microcomputer controlled intercept device
- Analysis of the operating efficiency and cost-effectiveness of the intercept device

The first task was to determine the state-of-the-art in HF receiver technology through (1) an investigation of off-the-shelf HF receivers and receiver systems, and (2) a literature search to determine areas of research which may relate to needs and requirements of the intercept device.

The second task was an investigation of microprocessor/microcomputer control of receiver functions to determine what receiver functions should be controlled in light of mission requirements. The practical aspects of control of various receiver functions was also included in this analysis.

The third task consisted of an in-depth analysis of the basic switched channel concept. This analysis was based on an approach where the intercept device was used to commutate between two or more signals at the Nyquist rate and the original signals reconstructed at individual output terminals. A major thrust of the analysis was to determine the degree of signal distortion, aliasing, and spectrum fold-over effects as a result of the commutating process.

The fourth task was the design of a microprocessor controlled intercept device based on the results of the three previous tasks. The design objectives were directed primarily to achieving improved utilization of the monitoring system, and to provide a capability for an operator to be more effective in accomplishing his monitoring objectives.

The fifth task was to perform an operating efficiency and cost-effectiveness analysis of the intercept device designed under the previous task. The baseline measure of this analysis was the currently used, conventional approach with R-390 receivers.

From the beginning of the program it was evident that the most difficult area would be the development of an approach or concept that would permit an intercept device to rapidly commutate between two or more HF signals without introducing serious distortion to the desired signals. This commutation problem is compounded by the signal congestion which exists within the HF portion of the spectrum; a congestion which can lead to serious intermodulation problems by virtue of the commutating process. A comprehensive mathematical analysis clearly demonstrated the difficulty of practical, high speed commutation.

The principal approach leading to the conclusions and recommendations was the development of an alternative to the Switched Intercept Device, but an alternative which provides a considerable improvement in equipment utilization and operator efficiency over conventional techniques. This improved microcomputer controlled monitoring system, which is identified as the Communications Intelligence Data Acquisition System (CIDAS), was shown to provide a capability for significantly enhancing United States Air Force monitoring objectives.

Conclusions

Present Air Force monitoring objectives are being met through use of conventional HF receivers. The receivers in current use are, for the most part, the R-390; an ongoing modernization program will replace many of these outmoded receivers with the Racal RA6790. The Racal will provide some increased capability but not to a level which could be achieved through microcomputer control. This study has been directed to a microcomputer design approach which will significantly enhance the present monitoring capability.

An attempt to provide an optimum monitoring capability was pursued through the five principal tasks. The survey of off-the-shelf HF receivers and receiver systems indicated several strong on-going efforts being directed to design of HF receivers which have considerably improved capabilities over present capabilities such as the R-390. Many of these new generation receivers contain microprocessors for either

stand-alone capability or with I/O capability, a number of receivers can thus be connected to a common data bus for control by a central computer. In spite of this improved capability, none of these receivers have the capability for high speed commutation between two or more signals.

Similar conclusions resulted from the literature search. Although considerable research is being done in such areas as IFM receiver concepts and frequency-agile receiver systems, there appears to be no current or past efforts directly applicable to the switched channel concept.

A mathematical analysis of switched channel concepts conducted as a part of this study clearly indicated the difficulties associated with high speed commutation. The analysis considered several alternative implementations but a workable solution to high speed commutation was not found.

The investigation of microprocessor or microcomputer control of receiver functions clearly indicated advantages which could be achieved over conventional receivers. To this end, a Communications Intelligence Data Acquisition System (CIDAS) was designed. The CIDAS concept has been shown to provide a viable approach for significantly enhancing the Air Force monitoring capability. This enhancement was shown not only through the design features but also through an operating efficiency and cost-effectiveness analysis.

Recommendations

Based on the findings of this study, a specific monitoring receiver concept is recommended for future implementation by the United States Air Force. This recommendation is based on the use of CIDAS as a replacement for the presently used, conventional approach to HF monitoring.

The CIDAS concept is a channelized approach in which a microcomputer serves as the main controller for a number of receivers having

digital I/O capability. The processor provides the operator with a central point from which the several receivers can be controlled. CIDAS also provides to the operator an ability to not only rapidly configure the receivers but also provides real-time information regarding receiver status. The inclusion of interactive monitoring and surveillance capabilities in the CIDAS approach provides an important additional capability to the operator for dealing with search and handoff requirements.