

Exhibit 1

SwRI Proposal 15-30960
January 31, 2001

A Proposal for

THE SWRI HF DOPPLER RADAR

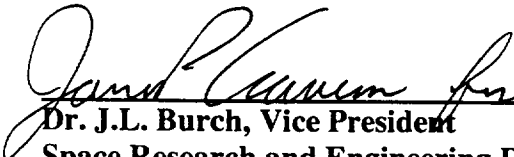
PREPARED FOR:

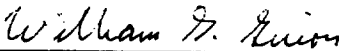
The Advisory Committee for Research

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EXECUTIVE SUMMARY

BACKGROUND

The Nation's reliance on advanced technological systems is growing exponentially. Many of these systems are susceptible to failure or unreliable performance because of adverse conditions in the space environment. Corresponding disruption of communications, navigation, electric power distribution grids, and satellite operations, leads to a broad range of socio-economic losses. Atmospheric gravity waves (AGWs) are generated by atmospheric processes, and the motion of the neutral gas in the AGW sets the ionosphere into motion, resulting in a travelling ionospheric disturbance (TID). TIDs can be thought of as travelling corrugations in the ionosphere, seriously affecting HF radio communications and surveillance systems.

OBJECTIVES

This Developmental IR project focuses on the development of a HF Doppler radar to monitor TID activity over Texas. Our goal is to perform a Development IR investigation that produces new equipment and methodologies that will be useful almost immediately to the Institute's technical program, and which includes a level of risk. The proposed project contains a level of risk because such a system has not previously been built at SwRI, the deployment of equipment at remote sites always involves risk, and the software for analysis and display of the HF Doppler data has not yet been written.

The objectives of this IR project are listed as follows:

- 1) Design and build a HF Doppler system at SwRI.*
- 2) Deploy transmitters to sites around Texas.*
- 3) Collect data continuously for at least 2 months.*
- 4) Develop data analysis capabilities.*
- 5) Operate HF direction finding system and vertical ionospheric sounder for two 1-week campaigns.*
- 6) Analyze the data.*
- 7) Publish papers describing the results from the SwRI Doppler system.*

APPROACH

The final configuration of the system will consist of three transmitter sites (Austin, Bandera and Uvalde) and a single receiver in San Antonio, together with data logging and analysis/display software. It will be deployed for 2 months to demonstrate the ability of the system to measure TID characteristics. The database will be sufficient to demonstrate the capability of the system, but not sufficient to perform extended scientific studies of the type envisaged for future external funding. On a campaign basis, an HF direction finding (HFDF) antenna will be deployed in San Antonio to determine the direction of arrival of the Doppler signals as they are perturbed by the TIDs. A vertical incidence sounder (ionosonde) will also be deployed on a campaign basis to provide background information on the shape of the ionosphere. The project will also benefit from coordinated ionospheric tomography data from UT-Austin. The proposed program is expected to result in the publication of three peer-reviewed manuscripts.

PROGRAM PLAN

This interdivisional project is proposed for a period of 12 months with a total budget of about \$149K (\$89K to Div 15, and \$60K to Div 16). It leverages the ionospheric expertise in Divisions 15 and 16. Dr. Crowley (Div 15) will be responsible for the management and oversight of the project. He has previously worked with HF Doppler systems in Britain and the Antarctic, and with vertical ionospheric sounders in Greenland. Division 16 has conducted research in various related areas of ionospheric propagation for over 20 years. This project was conceived with the help of Bill Sherrill (Div 16), who will act as an informal consultant to the project, and does not request any support.

Division 16 Radiolocation Systems staff will design and build the Doppler instrumentation, using existing Division 16-owned HF propagation equipment, and the 200-acre SwRI HF field site. Brent Fessler (520 hours) will lead the design, building and deployment, with the help of a Div 16 Senior Technician (240 hours) and Division 15 Senior Technician (320 hours). Dr. Crowley will oversee the design, building and deployment, and will lead the data analysis effort (320 hours). A member of the Div 15 software support team (PL2) will spend about 1 month (160 hrs) developing the display and analysis software tools required by the project. The Doppler measurement program will be enhanced, on a campaign basis, with concurrent vertical incidence ionospheric sounding and direction finding data.

BENEFITS

The proposed work:

- i) Permits development of new instrumentation that adds synergistically to the existing capabilities of Divisions 15 and 16, and will be immediately useful in the Division 15 and 16 technical programs.
- ii) Maintains SwRI in a highly visible leadership role in ionospheric physics;
- iii) Results in several technical publications and conference presentations.

1. TECHNICAL BACKGROUND

1.1 INTRODUCTION

The Earth's space environment includes the middle atmosphere at altitudes of about 50 km, through the upper atmosphere and magnetosphere, to the solar wind and ultimately to the Sun itself. Figure 1 illustrates this complex system. The solar wind streams out from the sun at speeds of several hundred kilometers per second, carrying energetic particles and its own magnetic field (the Interplanetary Magnetic Field, IMF). The magnetosphere (the magnetic cavity surrounding the Earth) protects the atmosphere from direct bombardment by most of these particles (Figure 1a). However, the magnetosphere accumulates energy through its interaction with the solar wind, and the energy is released periodically in the form of particle precipitation, strong electric fields and large currents flowing in the ionosphere at high latitudes. The particle precipitation causes bright aurorae in both the Northern and Southern hemispheres (Figure 1b). The large currents produce perturbations in the magnetic field measured at the Earth's surface, resulting in the phenomenon known as a magnetic storm. The large amount of energy and momentum deposited in the thermosphere and ionosphere during magnetic storms changes the global circulation patterns, density, temperature and composition above about 100 km altitude. Some of the most energetic particles penetrate to lower altitudes, where they alter the mesospheric and stratospheric chemistry (Figure 1c).

Space for Figure 1a

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The Nation's reliance on advanced technological systems is growing exponentially, and many of these systems are susceptible to failure or unreliable performance because of extreme space-weather. Space-weather refers to conditions on the sun, in the solar wind, magnetosphere, ionosphere, thermosphere, and mesosphere, that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health. Adverse conditions in the space environment can cause disruption of communications, navigation, electric power distribution grids, and satellite operations, leading to a broad range of socio-economic losses (Crowley et al., 1999; Crowley and Freitas, 2001)

Atmospheric gravity waves (AGWs) play potentially important roles in ionospheric dynamics and on the generation of plasma instabilities in the middle and low latitude ionosphere. AGWs are generated by numerous lower atmospheric processes, such as storms, and can also be generated by auroral processes in the ionosphere (Fesen et al., 1989; Crowley, 1991). The motion of the neutral gas in the AGW sets the ionosphere into motion, resulting in a travelling ionospheric disturbance (TID). TIDs can be thought of as travelling corrugations in the ionosphere, seriously affecting HF radio communications and surveillance systems.

This Developmental IR project focuses on the development of a HF Doppler radar together with associated analysis and display software. The HF Doppler sounding system will be designed and built at SwRI, and then deployed for 2 months in Texas to demonstrate the ability of the system to measure TIDs driven by gravity waves. The final configuration of the system will consist of three transmitters and a receiver, together with data logging and analysis/display software.

The work proposed here leverages the ionospheric expertise in Divisions 15 and 16. Dr. Crowley (Div 15) has published over 50 papers, most of which involve ionospheric data analysis and modeling. He worked with HF Doppler systems in Britain (Crowley and McCrea, 1988) and the Antarctic (Crowley, 1985) for 8 years, and with vertical ionospheric sounders in Greenland for 5 years (Crowley et al., 1992; Cannon et al., 1992; Wang et al., 1993). Division 16 Radiolocation Systems staff will design and build ionospheric Doppler instrumentation, using existing Division-owned HF propagation equipment, antenna arrays, remote sites, and the 200-acre SwRI HF field site. These test bed facilities for the basic ionospheric Doppler measurement program will be enhanced, on a campaign basis, with concurrent vertical incidence ionospheric sounding and parallel channel direction finding interferometer data to provide a uniquely complete characterization of the TID events. Radio direction finding performance is dominated by ionospheric TID occurrence (Sherrill, 1971; Sherrill et al., 1972). Division 16 has conducted research in various related areas of ionospheric propagation for over 20 years, with many refereed publications and DoD reports (e.g. Sherrill, 1977; Black, 1993; Black et al., 1993, 1995; Johnson et al., 1994; Brown et al., 1997).

The proposed project contains a level of risk because such a system has not previously been built at SwRI, the deployment of equipment at remote sites always involves risk, and the software for analysis and display of the HF Doppler data has not yet been written. After deployment the system will be operated continuously for 2 months, generating a uniquely complete database of propagation parameters for observed midlatitude TID events. This database will be sufficient to demonstrate the capability of the system, but not sufficient to perform extended scientific studies. The project will benefit from coordinated measurements with other instruments in the area, including ionospheric tomography data from the UT-Austin chain. The proposed program is expected to result in the publication of three peer-reviewed manuscripts.

The IR project proposed here demonstrates our ability to build and field a HF Doppler radar for ionospheric specification, for validating and developing terrestrial ionosphere models, and for other research purposes.

1.2 MEASUREMENT OF TIDs USING AN HF DOPPLER SYSTEM

If a wave is reflected from a moving surface, a Doppler frequency shift Δf occurs in the reflected wave. The magnitude of the frequency shift is related to the rate of change of phase path, P and the wavelength, λ , according to

$$\Delta f = -1/\lambda (dP/dt) \quad (\text{Equation 1})$$

In the case of radio waves reflected from the ionosphere, both changes in the height of reflection and changes in the electron concentration below the reflection height may cause the variation of P . The corresponding Doppler shifts are then proportional and inversely proportional to the transmitted frequency, respectively. The contribution due to changes in the reflection height always dominates the observed Doppler shifts from HF radio sounders at middle and low latitudes (Crowley, 1985).

A simple Doppler system consists of a CW (continuous wave) transmitter and receiver which are highly frequency-stable (1 part in 10^8), together with some kind of recording device (e.g. Crowley, 1985). The CW signals are typically transmitted on frequencies between 2-10 MHz with a power of about 20 watts. A sensitive communications receiver with a narrow bandwidth (~ 100 Hz) receives the skywave signal at a site about 50-100 km from the transmitter and down-converts the signal to a frequency of several Hertz. The Doppler shift of the received signal is thus measured from variations of the receiver output frequency, which is recorded directly.

HF Doppler sounding provides a convenient means of continuously monitoring vertical movements of ionospheric reflecting layers. Figure 1 illustrates typical Doppler frequency changes detected by the Antarctic Doppler system (Crowley, 1985). Three transmitters at Almirante Brown, Palmer and Adelaide, operated on two frequencies, and several perturbations were well correlated on all six traces. Traveling disturbances perturbed the radio reflection points on the different transmission paths at different times, and the velocity of the disturbance in the plane of the reflection points was determined by triangulation. Time delays between the perturbations on different Doppler paths have traditionally been estimated by the cross-correlation technique, however cross-spectral analysis has the advantage of separately examining the time (i.e. phase) delay for each frequency component of a signal. Thus, using cross-spectral analysis, TID speeds and azimuths were obtained for each wave frequency by triangulation (Crowley et al., 1984).

Doppler systems with three separated transmitters provide three independent phase spectral estimates, any two of which yield a measure of the horizontal phase trace velocity of the disturbance at a given wave frequency. The validity of wave parameters obtained in this way is assessed by means of the coherency calculated during the cross-spectral analysis. The coherency provides a measure of the noise in the two spectra at a given frequency: when the noise is zero the coherence is unity, but when two signals are uncorrelated their coherence is zero. The major source of uncertainty in the velocity calculations is usually the measurement of time delay. The statistical uncertainty in the time delay obtained by cross-spectral analysis is a function of the coherency (Jenkins and Watts, 1968). This dependency enables error bars to be placed on individual velocity calculations.

In order to calculate wave parameters from the time delays between Doppler signatures, knowledge of the geometry of the Doppler array is needed. The Doppler reflection heights on the different paths are generally assumed to be the same. If this is not the case (possibly from large electron density gradients) the vertical velocity contributes to the time delay, and if unnoticed, in a worst-case scenario may introduce significant errors. Crowley (1985) studied the refraction of the Doppler signals under different conditions, and found that the TIDs themselves perturb the reflection point by several kilometers in the horizontal plane. However, this refraction is a minor contribution to the error analysis for TID velocities, because it is similar on each path.

Figure 3 shows the horizontal phase trace speed and wave azimuth as a function of wave period deduced by cross-spectral analysis from the Antarctic data in Figure 2. The speed and directions are substantially in agreement for both Doppler sounding frequencies, and are very similar at all periods whose coherency functions have significant values. Each wave component has a horizontal speed between 100 to 300 m/s, and azimuth 100° to 140° . The smooth variation of the vertical phase velocity with period is shown for Palmer station in Figure 4.

HF Doppler systems have advantages over all other techniques for the measurement of TID characteristics. They are more amenable to analysis than data from ionosonde chains. In addition, they respond to wave activity at particular altitudes rather than integrated effects such as those obtained from total electron content (TEC) methods. (Equation 1 shows the phase measurement is an integrated quantity, but as noted above, the contribution due to changes in the reflection height always dominates the observed Doppler shifts at mid-latitudes). Finally, because the HF Doppler systems have low power consumption, both spatial and temporal resolution can be maintained for many days without the costs that would be associated with an incoherent scatter radar.

The Antarctic HF Doppler system operated continuously for 5 years and revealed new information on the differences between TIDs observed during geomagnetically quiet and active conditions (Crowley et al., 1987). It also detected a new and unexpected type of phenomenon relating to the penetration of high latitude electric fields to low latitudes (Dudeney et al., 1980; Crowley et al., 1984). A Doppler system was deployed for a month in the UK during the Worldwide Atmospheric Gravity-wave Study (WAGS). The data collected during WAGS led to new theories on the generation of gravity waves by the aurora (Crowley and Williams, 1987; Williams et al., 1988; Rice et al., 1988) and on their propagation to mid-latitudes (Crowley and McCrea, 1988).

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Space for Figure 2 --- HF Doppler data

Space for Figure 3 -- Vh

Space for Fig 4 – Vz

1.3 PROBLEM STATEMENT

There are many geophysical problems that require knowledge of gravity wave characteristics and their effect on the ionosphere. There are currently no techniques that routinely monitor the wave background, or that can provide the required wave characteristics on a campaign basis. The HF Doppler technique has been demonstrated in the past to provide detailed and accurate information about the waves. The PI has extensive experience analyzing HF Doppler data from Britain and the Antarctic, and our goal in the proposed work is to build a prototype system here at SwRI.

We propose to build a prototype HF Doppler system at SwRI and to deploy it in Texas. The prototype would demonstrate the capability of such a system, and would briefly collect useful data on TIDs. The prototype system will have three transmitter sites (Austin, Bandera and Uvalde) and a single receiver in San Antonio. It will operate on two sounding frequencies to sample two different heights in the F-region of the ionosphere. On a campaign basis, an HF direction finding (HFDF) antenna will be deployed in San Antonio to determine the direction of arrival of the Doppler signals as they are perturbed by the TIDs. This will permit some initial analysis on the effect of TIDs on the accuracy of HF-DF systems, and will provide some insight into the potential for correcting HF-DF systems for TID effects. In addition to the HF Doppler system, a Vertical Incidence Sounder (ionosonde) will also be deployed on a campaign basis to provide background information on the shape of the ionosphere. The ionosonde will help with the interpretation of the HF Doppler data; in particular it will specify the difference between the reflection heights of the two Doppler frequencies.

2. THE PROPOSED PROJECT

2.1 OBJECTIVES

- 1) Design and build a HF Doppler system at SwRI.*
- 2) Deploy transmitters to sites around Texas.*
- 3) Collect data at SwRI continuously for at least 2 months.*
- 4) Develop data analysis capabilities.*
- 5) Operate HF direction finding system for two 1-week campaigns.*
- 6) Demonstrate effects of TIDs on HF-DF systems.*
- 7) Operate a vertical ionospheric sounder during the campaigns to provide further information on the background ionosphere.*
- 8) Compare the HF-Doppler data on TIDs with ionospheric tomography data from UTAustin.*
- 9) Publish papers describing the results from the SwRI Doppler system.*

2.2 APPROACH

2.2.1 Design and build a HF Doppler system at SwRI.

Division 16 personnel are recognized internationally for their expertise in radio systems. The proposed prototype HF Doppler system will be built in Division 16 using existing hardware. The HF Doppler system consists of a highly frequency stable CW transmitter and corresponding frequency stable receiver to measure the Doppler frequency offset in the received signal induced by TIDs. Figure 5 shows the transmitter, consisting of a stable conventional signal generator with

reference oscillator disciplined by a precise frequency reference derived from a GPS receiver. (Alternatively a laboratory Rubidium standard can be used).

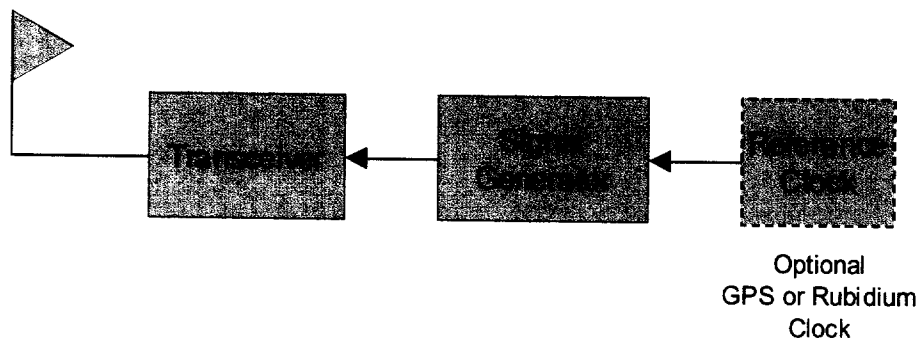


Fig. 5 Transmitter Block Diagram

The corresponding precision receiver set up is shown in Figure 6. In addition to precision frequency standard, the output of the receiver is digitized, decimated to 100 Hz bandwidth, and Fourier analyzed to .03 Hz resolution to record the micro-variations in received frequency introduced by ionospheric propagation. Each FFT spectrum will be time stamped and logged to Disc for off-line analysis.

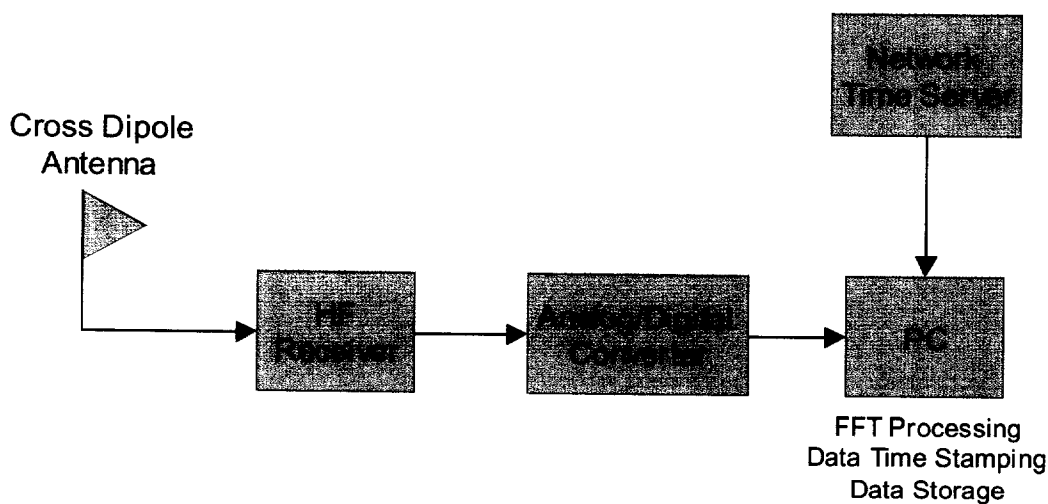
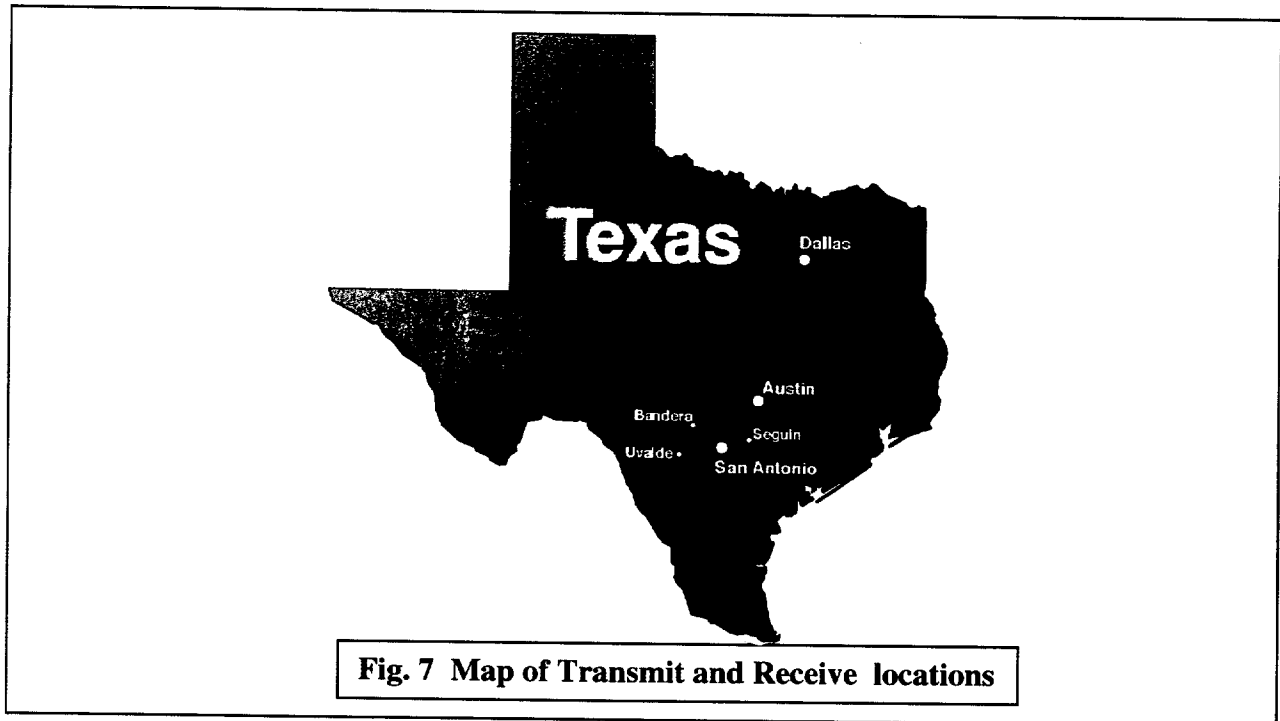


Fig. 6 Receiver Block diagram

2.2.2 Deploy transmitters to sites around Texas.

The measurement of TID characteristics with the HF Doppler system depends on spaced reflection points in the ionosphere. This is achieved by spacing the transmitters, as described above. In the proposed system, transmitters will be deployed in Austin, Bandera, and Uvalde, where we have access to power and sufficient space for the antennas (see letter of support from Dr. Gary Bust, UT-Austin). The spacing of the ionospheric reflection points is about 50 km, as illustrated in Figure 7. This is ideal for medium scale TIDs with horizontal phase trace velocities typically in the 100-300 m/s range. The corresponding time delays of 0 - 500 sec are easily detected in the cross-spectral analysis. Other locations such as Dallas and the McDonald Observatory have also been offered by UT-Dallas as field sites for the transmitters, but they will not be used in the present project because of their relative inaccessibility.



2.2.3 Collect data at SwRI continuously for at least 2 months.

To demonstrate that the system is fully operational and autonomous, data will be collected continuously for at least 2 months. This will be sufficient time to obtain geophysically interesting data, and to obtain joint observations with the HF-DF system and the vertical sounder. It will also be possible to perform some comparisons with the tomography experiments of Dr. Gary Bust from UT-Austin. Because the solar rotation period is 27 days, 2-months of continuous operation will provide data from a variety of solar and geomagnetic conditions.

2.2.4 Develop data analysis capabilities.

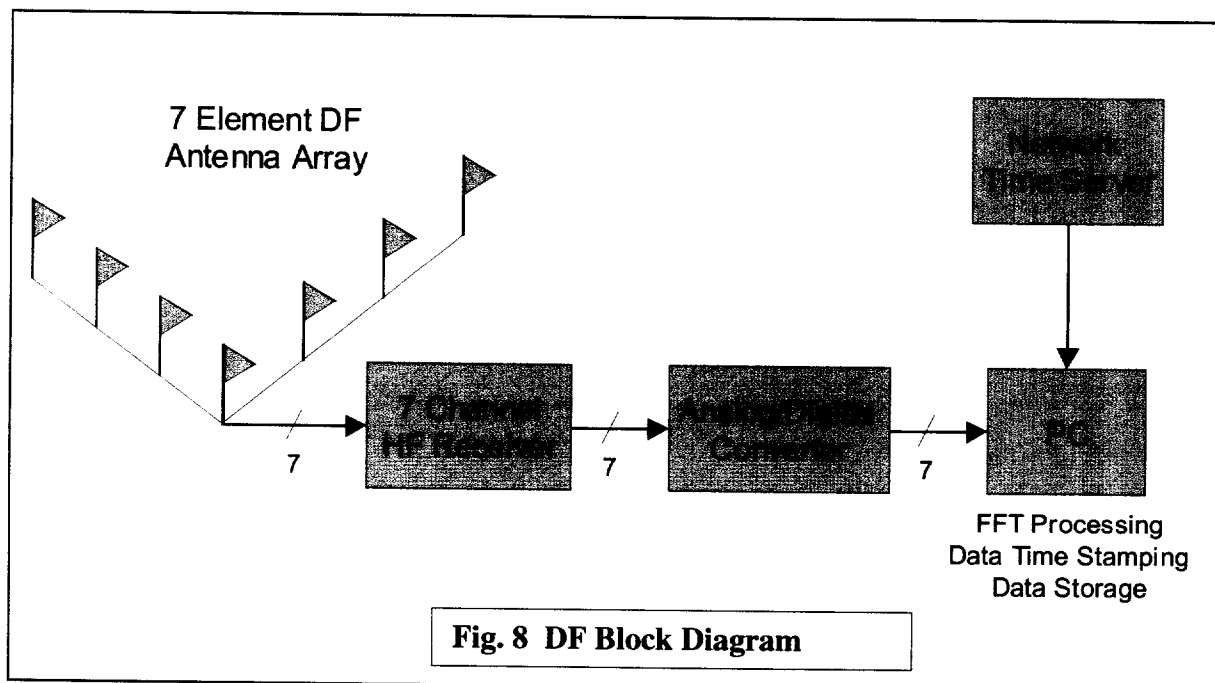
Div 16 will be responsible for developing the software to obtain Doppler spectra from the HF radio signals. Div. 15 will be responsible for software to plot the data, to perform cross-spectral analysis and to plot the results. Dr. Crowley developed FORTRAN spectral analysis software for

use with the Antarctic and UK Doppler systems several years ago, and some of this will be re-used in the present system. The graphics routines will be developed in IDL.

2.2.5 Operate HF direction finding system for two 1-week campaigns.

Div. 16 personnel routinely operate direction-finding systems at SwRI. Division 16 will make available an existing HFDF test bed to obtain DF data on the Doppler system transmissions during specific campaigns. The test bed HFDF system will measure azimuth/ elevation of arrival on each resolution cell of the FFT using a correlation DF algorithm. This provides a unique set of time tagged DF data per Doppler frequency cell to support the TID analysis. Figure 8 shows a block diagram of the DF system.

The TIDs detected by the HF Doppler system will be correlated with variations in the direction of arrival of the radio signals as the 'corrugations' in the ionosphere move overhead. This research is expected to result in a publishable manuscript.



2.2.6 Analyze TID effects on propagation mode angular fine structure

The effects of TIDs on HFDF accuracy impose an irreducible limit to DF system performance. Investigation of ionospheric mode angular fine structure has been a long-standing research area in Division 16. The frequency sliced DF process permits analysis of directional fine structure on those propagation paths that show ionosphere-induced frequency spread. We will analyze the DF data obtained on the measured Doppler spectra to determine Az/ El spread induced by propagation through TIDs.

2.2.7 Operate a vertical ionospheric sounder on a campaign basis to provide further information on the background ionosphere.

The ionosphere is an extremely dynamic region of the earth's atmosphere. The ionospheric electron density profile varies on timescales of minutes (due to waves), hours (due to solar

illumination, and changes in composition, winds and electric fields), and days (due to seasonal effects). It is possible to specify usable radio frequencies based on midlatitude ionospheric climatology, but the exact shape of the ionospheric electron density determines the reflection heights of the different frequencies. A Vertical Incidence Sounder provides measurements of the ionospheric electron density profile, and therefore the Doppler reflection heights can be accurately specified. This in turn allows an accurate specification of the vertical trace speed of the disturbances.

The Div 16 Vertical Incidence Sounder will be run continuously during the campaign periods to monitor ionospheric conditions. Ionogram data will be obtained 4 times per hour and transferred to Division 15 via the Institute LAN for real time information on current ionospheric weather. A more frequent sounding schedule can be maintained if needed during each campaign.

2.2.8 Compare the HF-Doppler data with ionospheric tomography data from UT-Austin.

The Atmospheric Research Laboratory of the University of Texas at Austin routinely operates radio beacon receivers for use in ionospheric tomography. Ionospheric tomography provides accurate cross-sections of the ionospheric electron density as a function of altitude and latitude. The propagation of TIDs over the tomographic array causes perturbations of the electron density contours, which are then detected by the tomographic inversion. We will perform the first independent comparison of TID parameters with the perturbations in the tomographic results.

2.2.9 Publish papers describing the results from the SwRI Doppler system.

The research proposed here is expected to result in two or three publications. These are likely to be the following:

- i) Characteristics of TIDs measured over Texas.
- ii) Interpretation of HFDF results in light of TID characteristics obtained from a HF Doppler system.
- iii) Interpretation of ionospheric tomography data in light of TID characteristics obtained from a HF Doppler system.

2.3 EXPECTED ACCOMPLISHMENTS

The expected accomplishments fall into two classes: Hardware and Scientific Analysis. In the Hardware category, the development of a HF Doppler system at SwRI represents a new area of expertise that synergistically adds to the capabilities of both Divisions 15 and 16. The approach taken in this project is to leverage existing capabilities to demonstrate a prototype system that will make useful measurements locally.

In the category of Scientific Analysis, there have been numerous reports of TID observations in the past, but few that have been as complete as those from HF Doppler systems. Of the HF Doppler observations, few have been systematic or correlated with other instrumentation. The prototype proposed here will make useful measurements of TID over Texas for comparison with previous work. The direct measurement of TIDs in the vicinity of a HF Direction Finding system is completely novel, and will provide new insights into the operation of the HFDF system. It will also provide the first complete TID specification for use with the interpretation of ionospheric tomography observations.

2.4 ANTICIPATED BENEFITS

The proposed work:

- i) Permits development of new instrumentation that adds synergistically to the existing capabilities of Divisions 15 and 16;
- ii) Produces a new tool that will be immediately useful in the Division 15 and 16 technical programs.
- iii) Maintains SwRI in a highly visible leadership role in ionospheric physics;
- iv) Results in several technical publications and conference presentations.
- v) Enhances SwRI relationship with ARL:UT-Austin;

2.5 PROGRAM PLAN AND SCHEDULE

The program plan consists of performing tasks to fulfil the Objectives listed in Section 2.1. Table 1 depicts the schedule for performing these tasks. The HF Doppler system will be designed and built during the first 5 months of the project. The system will be tested at SwRI before deployment at three transmitter sites, which will occur during the September-October time frame. The system will be operated for two months during November and December 2001. During this two-month period, the HFDF and Vertical Incidence Sounder will operate for two 1-week campaigns. These will be in the declining phase of the solar cycle, and can be expected to yield intervals of both geomagnetically active and quiet conditions. At the same time as the design, building and deployment of the HF Doppler system, the data analysis software will be developed. The data analysis task will involve 4 stages: (1) Write software to identify the spectral peaks in the FFTs from the HF Doppler radar, and produce plots of frequency versus time, similar to Figure 2; (2) Write software to perform cross-spectral analysis of Doppler variations on different paths to identify time delays between ionospheric reflection points; (3) Write software to perform triangulation of the time delays for this particular Doppler system and obtain horizontal and vertical phase velocities; (4) Write software to display the velocities as a function of wave period, similar to Figures 3 and 4. The software will be written in IDL for compatibility with other projects in Div 15. Dr. Crowley developed analysis routines in FORTRAN for his Ph.D. thesis, and these will be used as the basis for the current project.

Following the two-month operation of the HF Doppler system and the HFDF campaigns will be a period of data analysis. The goal of the analysis will be to prepare three manuscripts for publication in refereed journals. These will consist of reporting the HF Doppler results, interpretation of the HFDF results, and comparison with the ionospheric tomography data from UT-Austin. Quarterly reports will document the progress of the work. A final report will be written at the conclusion of the project.

Task ID	Task Description	Qtr 2, 2001			Qtr 3, 2001			Qtr 4, 2001			Qtr 1, 2002		
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Design Doppler system												
2	Build Doppler system at SwRI												
3	Deploy transmitters to sites												
4	Collect data for 2 months												
5	Develop data analysis capability												
6	Deploy HFDF at SwRI												
7	Operate SwRI Vertical Sounder												
8	Data Analysis												
9	Manuscript preparation												
10	NSF Proposal preparation												

TABLE 1: Schedule for Completion of Proposed Work

2.6 PERSONNEL AND ORGANIZATION

Dr. Crowley will have overall responsibility for completion of this Development IR project on time and within budget. Dr. Crowley has extensive experience in various fields of upper atmospheric research. He is currently the PI on several NASA, NSF and DoD projects. He also has experience managing large software projects. For example, at the Johns Hopkins University Applied Physics Laboratory, Dr. Crowley managed a \$4 Million Air Force software project. He brought a previous IR project, the development of a Parallelized TIMEGCM, to a successful completion and is managing a second successful modeling and simulation IR project (see below). He will spend approximately 2 Person-months (360 hr.) on this project. He will be involved in all phases of the project, including the implementation and demonstration phases. He will take the lead in writing the first scientific paper expected to result from analysis of the HF Doppler data.

This project was conceived with the help of Bill Sherrill from Div 16, who will act as a consultant to the project. He has many years of experience in the building and deployment of radio systems for ionospheric research. He does not require any support from this proposal. Brent Fessler (Div 16) will be responsible for designing and building the HF Doppler system. Bill Sherrill and a Senior Technician from Div 16 will aid him. Dr. Crowley will be involved in the design to make sure it satisfies the measurement requirements. The same people will be responsible for the testing and deployment of the system when the transmitters are moved to the remote sites. They will be aided by a Senior Technician from Div 15. Typically the two Senior Technicians will deploy the transmitters, but Dr. Crowley will help with deployment of the first transmitter at the UT-Austin site. Brent Fessler and Bill Sherrill will remain at the receiver site in San Antonio.

The output from the HF Doppler radar consists of Doppler spectra in the form of FFTs. A programmer from Div 15, under the supervision of Crowley and Fessler, will have responsibility

for data plotting and analysis codes. All the HF Doppler data analysis and plotting software will be generated by Div. 15 personnel. Software already exists in Div 16 to plot and analyze the data from the HFDF and Vertical Sounder that will contribute to the campaigns.

The HF Doppler analysis will be performed mainly by Dr. Crowley. Comparison with the HFDF and vertical sounder data will involve Bill Sherrill and Brent Fessler. Comparison with the ionospheric tomography data will involve UT-Austin personnel with their own funding.

2.7 EQUIPMENT REQUIRED

All of the radio equipment required for this project is currently available and will be provided by Div 16. The budget includes \$1000 for incidental materials such as cables and connectors. The necessary computing power for plotting and analyzing the data already exists in Div 15, and will not require the purchase of new equipment. Our colleagues at UT-Austin have offered to let us use their field site in Austin along with an antenna already in place, and an additional mobile antenna if needed (see letter of support).

Exhibit 2

Location 1

10000 Burnet
Austin, TX 78758
Travis County
30.38 -97.70

Location 2

Ranch Road 481
Uvalde, TX 78801
Uvalde County
29.181 -99.850

Location 3

13181 Adkins-St. Hedwig
St. Hedwig, TX 78152
Bexar County
29.413 -98.221