TAPR Spread Spectrum STA Activity Report, April 27th, 1997.

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As the TAPR position concerning Spread Spectrum communications states (attached), TAPR feels that amateur radio operators have to actively pursue the technology of spread spectrum communications in order to keep pace with technology and maintain amateur radio's place as a viable service for experimentation and technology development. I personally feel, as TAPR President, that the task of education and developing a new operating mode falls on the shoulders of organizations like TAPR and other leaders in the amateur radio community. This is one reason TAPR has attempted to work towards being a leader in the development of such systems and education of its members and the amateur radio community as a whole about the technology. The TAPR Spread Spectrum STA is an important step for TAPR and the amateur radio community as a whole in gaining purposeful activity in this technology area. The amount of activity seen today from a year ago is the difference between night and day. The TAPR Dayton Digital Forum at this year's Hamvention is a good indication to that higher level of activity (attached). Join this activity level to TAPR's ability to get developed technology into the hands of the amateur radio community and I feel very positive that we will see amateur radio designed and built SS equipment in operations in the next 18 months. Maybe even multiple designs. I would hope that the FCC will act positively on our request for an extension of the STA.

Since the STA began, I have been very busy encouraging, promoting, educating, and operating under the STA. I'll give a brief outline of these activities below. As of this date, the STA has 60 amateur radio stations participating (http://www.tapr.org/ss/sta_stations.html). Like any amateur radio activity, some participants were more active than others. Past history within TAPR on volunteer project activity (like this STA) shows that with every project the degree of activity by participants can not be defined in any meaningful manner. There are no fixed patterns with regard to activity levels and interest from project to project. Thus, each TAPR project must be viewed as an individual project with no correlation between past or future projects.

Much of the early interest in the TAPR SS STA was generated when TAPR arranged for a group purchase of technology that could be placed directly in the hands of participating members under the STA at a reasonable cost. As will be discussed later, the failure on the part of the commercial vendor to deliver the agreed upon radios hurt the initial attempts to get people operating and experimenting with off-the-shelf equipment while longer lead time spread spectrum amateur radio design and development projects took place. This two step approach was hoped to build a base of developers and experimenters that could later participate in the testing of amateur radio designed and developed equipment, since an infrastructure to support such communications will be an important first step in any new technology roll out. The focus since January, after the collapse of the purchase, has been on getting the experimental development supported, focused, and moving forward on several fronts.

As with any self-motivated project, TAPR attempts to provide the necessary tools, information, and communications to foster activity and direction. These steps have been accomplished with the TAPR Spread Spectrum Web page (http://www.tapr.org/ss) which has received over 26,000 visits to date. In addition, over 5,700 people have examined current information about the STA activity (http://www.tapr.org/ss/tapr_sta.html). TAPR began actively working on Spread Spectrum rules issues in 1993 at its annual membership meeting at which time the TAPR FCC Regulatory Affairs Committee was established. TAPR worked with the ARRL at meetings in 1994 and 1995 on the issue of spread spectrum rule changes before the release of RM-8737. Once RM-8737 was announced, TAPR began to actively make available comments to the rule making process regarding spread spectrum communications on our Internet site (http://www.tapr.org/ss/rule_changes.html). We believe this is the first time that such detailed information has attempted to be made available directly to the amateur community outside the FCC standard method of receiving such information. The response to these pages have been very positive from those both in favor and opposed to current rule making. Early in 1996, TAPR set up the first of two listservs for discussing Spread Spectrum communications technologies. In November of 1996, a second list was established covering the SS STA itself. Over 1500 messages of dialog on the subject of Spread Spectrum communications have been communicated over both lists. The SS STA list has been very useful in maintaining communication among the people involved in the STA over such a diverse geographic area in the United States. In March, project funding on the first Spread Spectrum radio design project to help with the cost of PCB, parts, and other expenses related to any development project began. TAPR is now considering a second proposal for a SS radio design. In addition, TAPR's work with the National Science Foundation should begin during the summer and that will result in additional cash infusion for project development and support at a significant higher level as compared to previous years of research support. Couple these activities to the raised interest within the community, those that feel the technology is positive or negative, and the numerous amateur radio magazine articles written during the TAPR SS STA (as compared to previous years) and we have seen major educational movement forward on the subject of spread spectrum technology. If SS technology is not widely adopted within the amateur radio community, we have at least had a large segment of the community learn about this technology area than were knowledgeable about it six to twelve months ago.

As you can see in the TAPR SS STA report being submitted, we had activity ranging from none to people actively beginning the design and development of amateur radio-based SS systems. This is to be expected of any volunteer/hobby such as the amateur radio service. As compared to previous amateur radio STA requests, though, the level of interest across geographic coverage, operating interests, and focus has been greater then any previous granted amateur radio Spread Spectrum STA.

November/December Activity

The STA was granted on November 8th, 1996. At that time, Dewayne Hendricks and I began the process of organizing and setting up the processes for managing and administrating the STA. After the initial stations included in the 8th announcement, a second round of participants to the STA were added on December 27th, 1996 with further participants added at intervals thereafter (http://www.tapr.org/ss/sta_stations.html).

I began looking at issues of operation of Spread Spectrum equipment on the 900Mhz amateur radio band since the Freewave radio purchase agreement looked like it would be in place the first of 1997. Some of my work can be viewed at http://www.tapr.org/~wd5ivd/specana900.html The initial investigation looked at the current noise floor and operational limits with other users on the 900Mhz band in the Denton, Texas area. Tests between the Denton station location and the Univ. of North Texas, Gerald Knezek, KB5EWV, lab were conducted between November 20th, 1996 and April 20th, 1997 using a pair of 902-928 MHz Freewave radios, the earlier 400 mW unit, operating into gain antennas. The web page details the difference seen between antenna polarization. In addition, mobile operation around the UNT campus was conducted out to 15 miles to show the feasibility of amateur radio high-speed networks for providing both voice and video transmission from remote locations (such as disaster sites or weather spotting). Issues regarding networking in point-to-point and point-to-multipoint were examined. Limitations of the Freewave radio in point-to-multipoint TCP/IP configurations were easily seen. The solution to some of these issues can be seen on projects under development within TAPR now.

The Texas Packet Radio Society (http://www.tprs.org) held its Fall Digital Symposium December 1996 in Austin, Texas. TPRS was kind enough to allow me to take up a considerable amount of presentation time discussing what TAPR was doing and the future of Spread Spectrum communications in regard to networking and other interests. I was very pleased to see many members of both TPRS and TAPR present at the meeting. My presentation was done by pulling up my overheads over a wireless link at 256Kbps at my laptop from the Linux server sitting on the other side of the room. Very impressive way to demonstrate the potential for future access. A large number of participants left the meeting ready to join the STA and get active with spread spectrum technology.

December 9, 1996, saw a link established between my station location in Austin and that of Bob Morgan, WB5AOH, station which continued for 3 weeks. The link was established to allow Bob to begin the design and testing of a series of antennas for 900Mhz operation as well as looking at local operational issues in Austin in concerning the 900Mhz band. These operations were with the 902-928 MHz Freewave, the earlier 400 mW unit, operating into a gain antenna. See Bob Morgans report for day by day description of this operation. A Linux router was set up at my station location and attached to my ISDN line. The radio link allowed Bob access to my networking connectivity for his testing.

January/February

In January, 1997, I spoke at the University of Texas amateur radio club meeting. The presentation was on Spread Spectrum and the TAPR SS STA. The University of Texas Amateur Radio Club are very excited about having the opportunity to support educational opportunities about the Spread Spectrum mode to its members and the larger ham radio community in Austin and Texas. They subsequently applied for a position in the STA.

In January and February the work towards providing hardware from Freewave into the hands of STA participants failed. Approximately 200 hours of personal time towards closure of this project was lost. After this failure, my time working daily on the STA was cut back to allow more time to be available for working on my dissertation. Operating activity at the Denton location continued on weekends when I was at that location.

March / April

By the March / April time period, it had become obvious that Part 15 manufacturers were seeing amateur radio operations in our bands using their Spread Spectrum technology as a threat and the possibility of getting equipment from these sources in any recognized group purchase seems to be zero. The Part 15 coalition has stated that they plan to fight the rules changes as set forth under RM-8737 and now Docket 97-12. They want Part 97 operations of spread spectrum, which is a recognized service, on bands where they are selling equipment as an unlicensed service to be limited to the same technical requirements they currently operate under. While the engineers and others that we have been discussing group purchases with are enthusiastic about the possibility of getting their technology into the amateur radio community for experimentation, by the time the decision reaches higher levels, resistance begins to build within the company to not provide the technology at an affordable price for the amateur radio service as compared to business sales. After following up on several other potential group purchases, the effort on my part within TAPR was to focus getting amateur spread spectrum projects going and selecting the best for TAPR project development funding.

As a result of this change in focus, TAPR now has one project being fully sponsored to create a FHSS radio system with a data rate planned around 200 kb/s throughput. A second proposal is being reviewed in the next few months and a third proposal should also be available to examine shortly. TAPR is still looking at potential agreements with commercial vendors to make technology development available to the amateur community in some type of formal group purchase in order to broaden the scope of operation of this mode, but the emphasize is now on creating and developing our own technology in the next 18 months instead of spending energy finding a commercial source of equipment to operate.

Conclusion:

Even though the FCC is considering changes to the Amateur Radio Service's rules concerning Spread Spectrum, the current TAPR STA is vital to ensure that further experimentation is moved forward to completion. If the STA is not renewed, much of the energy put forth under the current STA by those participating will be lost before the current rule changes can be enacted. Volunteer motivation could be seriously impacted with the end of the STA before the rules changes opening up spread spectrum communications occur.

I do hope that the Federal Communications Commission will extend the term of the Special Temporary Authorization, as it allows the use and adaptation of existing equipment while the amateur radio service works on its own designs and development in the coming months, and allows the service to use these platforms as learning vehicles with power levels, antennas, and spreading techniques that are not currently authorized for amateur radio service use among recognized participants in the STA.

TAPR's Statement on Spread Spectrum Technology Development

TAPR was founded in 1982 as a membership supported non-profit amateur radio research and development organization with specific interests in the areas of packet and digital communications. In the tradition of TAPR, the Board of Directors at their Fall 1995 meeting voted that the organization would begin to actively pursue the research and development of amateur radio spread spectrum digital communications. At the Spring 1996 board of directors meeting, the following statement of purpose was passed:

"TAPR believes that the technical facts support our conviction that conventional and spread spectrum systems can coexist without detriment to conventional systems on all frequencies from MF to EHF. To this end, TAPR will begin to research spread spectrum systems that will develop technology for future deployment."

As stated above, the TAPR board feels strongly about TAPR's focus on spread spectrum technology and especially how it relates to the potential coexistence on frequencies that will have increased number of users occupying them. The amateur radio bands, like other spectrum, will become more heavily utilized in the future. It is in the interest of amateur radio to develop systems that are interference-resistant while not interfering with other primary or secondary users on those frequencies.

TAPR understands the concerns many have with the new technology, and believes that efforts in both education and research is necessary in order to allay the fears about interference and to demonstrate the benefits of the technology.

TAPR believes that today’s communications technology is moving toward all digital transmitters and receivers. These advances in technology, combined with the swift evolution of cell based transmission and switching protocols, are opening up a new set of possibilities for unique new services utilizing intelligent networks. These will contain smart transmitters, receivers, and switches. Today's Internet is perhaps the best example of a self-regulating structure that embodies these new technological approaches to communications in the networking domain. However, to date, many of these innovations have not moved into the wireless networking arena. TAPR will work on moving these innovations into the amateur radio community.

TAPR feels that the VHF/UHF/SHF radio networks of the future will involve a mixture of links and switches of different ownership, which terminate at the end-user via relatively short-distance links. What will then be required is a built-in, distributed, self-governing set of protocols to cause the network's behavior to make more efficient use of a limited, common shared resource, the radio spectrum. Creating such a self-regulating structure for the optimal sharing of spectrum will require much effort.

One of the major problems which stands in the way of these new approaches today is the current FCC regulatory environment and the manner in which spectrum is managed and allocated under its rules.

Historically, the current regulatory approach to radio has been based upon the technology that was in use at the time that the Communications Act of 1934 was framed, basically what we would call today, 'dumb' transmitters speaking to 'dumb' receivers. The technology of that time required reserved bandwidths to be set aside for each licensed service so that spectrum would be available when needed. Given this regulatory approach, many new applications cannot be accommodated since there is no available unallocated spectrum to 'park' new services. However, given the new set of tools available to the entrepreneur with the advent of digital technology, what once were 'dumb' transmitters and receivers can now be smart devices which are capable of exercising greater judgment in the effective use and sharing of spectrum. The more flexible the tools that we incorporate in these devices, the greater the number of uses that can be accommodated in a fixed, shared spectrum.

Therefore, TAPR will focus its spread spectrum effort in the following areas:

TAPR will work to promote rules and technologies to make the most efficient use of the spectrum through power control, forward error correction, and other means to minimize interference among spread spectrum users and existing communications systems.

TAPR will work on issues and efforts with other national organizations to change the regulatory environment and rules in order to promote the experimentation, development, and later deployment of spread spectrum technology.

TAPR will work to develop information on the topic to help educate members and the amateur community as a whole about spread spectrum technology, and to disseminate this information via printed publications, the World Wide Web, presentations at conferences and meetings, and other means.

TAPR will work to foster experimentation, development, and design of spread spectrum systems, and to facilitate the exchange of information between the researchers and other interested parties.

TAPR will work to develop a national intra-network to foster the deployment of future high-speed spread spectrum systems into regional and local communities, including the development of suitable protocols and guidelines for deployment of these systems.

TAPR will work with commercial companies who manufacture spread spectrum devices which operate in spectrum shared by the amateur radio service (ARS), in order to make them more aware of the nature of ARS operations on those bands with the goal to work towards the deployment of devices which will minimize interference between all spectrum sharing partners.

TAPR will work with commercial companies who manufacture spread spectrum devices in order to identify equipment that can be either used or modified for use for Part 97 operation.

Adopted by the TAPR Board on September 20th, 1996
at Seatac, Washington Board Meeting.

Spread Spectrum Statement Committee:

Greg Jones, WD5IVD
Dewayne Hendricks, WA8DZP
Barry McLarnon, VE3JF
Steve Bible, N7HPR

1997 TAPR Digital Forum Dayton Hamvention (Friday)

1:00 - 1:45pm (45 min)
* Introduction to Spread Spectrum Communications
  Steve Bible, N7HPR

1:45 - 2:00pm (15min)
* Update on TAPR
  Greg Jones, WD5IVD and Steve Stroh, N8GNJ

2:00pm - 2:40pm (40 min)
* Building TCP/IP Networks in the Amateur Radio Community
  John Ackermann, AG9V, Allan Finne, KB5SQK

2:40pm - 3:00pm (20 min)
* Review of current SS developments
  Barry McLarnon, VE3JF, Dewayne Hendricks, WA8DZP

3:00 - 3:20pm (20 min)
* System Design Parameters for Spread Spectrum Systems
  Tom McDermott, N5EG

3:20 - 3:40pm (20 min)
* TBA
  Phil Karn, KA9Q

3:40 - 4:00pm (20 min)
* TAC-2 (Totally Accurate Clock) GPS Project
  Tom Clark, W3IWI

4:00 - 4:20pm (20 min)
* Update on Amateur DSP Activity
  Bob Stricklin, N5BRG, Bill Reed, WD0ETZ

4:20 - 5:00pm+
* APRS Update and TAPR APRS SIG Meeting
  Bob Bruninga, WB4APR and Keith Sproul, WU2Z

Regarding TAPR's intended Group Purchase of 900Mhz Radio from FreeWave

Date: Sun, 19 Jan 1997 12:45:30 -0600 (CST)
From: "Greg Jones, WD5IVD"
To: ss@tapr.org
Subject: [SS:857] Update on Freewave Group Purchase
X-Comment: Tucson Amateur Packet Radio Spread Spectrum

The purpose of this message is to report to you some bad news concerning the special purchase deal that TAPR had arranged with FreeWave Technologies, Inc. (FW) of Boulder, CO.

First, as most of your are aware, TAPR had negotiated a special bulk purchase agreement with FreeWave, which allowed us to offer the FW DGRN-115 Part 15.147 spread spectrum radio to our members who are participating in the TAPR Spread Spectrum (SS) STA project, at a price which was below the normal retail price for the unit of $1250. An initial 'beta' order was placed the first of December with the purpose of getting units so that the radio could be evaluated to determine which options we wanted to request, documentation for common interfaces written, and we could get the purchase process set up with FreeWave. When the order was placed, we were told that we could expect delivery before the end of 1996. However, when we finally received a confirmation of our order from FreeWave, we were informed that we would not receive delivery of the units until January 17, 1997.

The later delivery from FreeWave caused us to revise our plans and we decided to start taking orders for the radio from the SS STA participants. We made this decision due to the fact that our current STA term is only six months and although we expect that it will be renewed, we didn't feel that we could waste any time in getting hardware into the hands of our STA participants.

13 days ago, we were informed that FreeWave has canceled the special purchase agreement with TAPR and that TAPR will receive no other units from FreeWave other than the initial units that we purchased in our first 'beta' order. Since that time, we have been trying to resolve the issue with FW, but have made no progress on the matter to this date. As many of you have noted, there was a special web page discussing the purchase. We removed the links and later the page when the discussions with FreeWave were not going anywhere. TAPR will be notifying everyone that had signed up for the $399 version of the purchase that it has been canceled and no money will be deposited or cashed, since no order can be placed with FreeWave. Any checks for radios will be mailed back.

January 17, 1997 is now past and we still have no word from FreeWave as to when we can expect delivery of the initial units that we have on order. Messages sent over the last seven days have not been responded back to by anyone at FreeWave. If I do not hear back by Monday I will call them. If that does not result in a positive solution the next step will be to involve TAPR's lawyers in the situation. I believe we will get the initial DGR-115 radios without modifications as contracted by FreeWave in December, but the lack of communications on FreeWave part is disheartening to say the least.

I regret this turn of events and you can be assured that everyone involved is attempting to resolve the issues. We are also working on other alternatives which would allow TAPR to offer spread spectrum radios to our STA participants at an 'affordable' price. We will be posting updates on this situation as it develops on our various mailing lists and on the TAPR web site.

Greg Jones, WD5IVD Pres. TAPR

January 23rd, 1997

To: Steve Wulchin
President
FreeWave Technologies, Inc
1880 South Flatiron Court
Boulder, CO 80301
USA

In December of 1996, TAPR ordered 65 FreeWave model DGRN-115 board level radios at a unit cost of $250.00 each, for a total of $16,250.00. Your order acknowledgement, received on December 10th, 1996, indicates that the radios would be shipped on or before January 17th, 1997.

That date has now passed, and the radios have not arrived. Further, and more distressingly, in several email and phone communications you have stated that you do not intend to perform your obligations under the agreement we reached unless TAPR agrees to changes in terms and conditions which were not bargained for.

You are presently in breach of our contract, and under the circumstances TAPR can only conclude that you do not intend to perform your obligations to us.

As you are aware, we have downstream customers who are depending on TAPR to provide them with product. We cannot leave those customers in suspense, so at this time TAPR has no alternative but to inform you that because of your anticipatory repudiation of our agreement, and indeed your actual and material breach, TAPR hereby cancels the referenced order (#961210001213).

This cancellation shall not relieve of any damages to which TAPR is entitled as a result of FreeWave's breach of contract, including but not limited to "cover" and any incidental or consequential damages which TAPR may suffer.

Greg Jones
President

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TAPR Members STA Progress Reports

Name: **Tim Baggett**
Call: **AA5DF**

The project proposed to be implemented under the TAPR STA is a DSSS system with a DSP baseband processor for the transmission of voice or data. The DSP baseband system is currently being designed, while the RF section has been unidentified. It is possible that the RF section of the system will be built as well, as it has proven difficult to locate a commercial DSSS transmitter/receiver without any Medium Access Control (MAC) protocol layer added.

Tim Baggett
AA5DF

Name: **Robert Barron**
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I have been interested in digital communications since first becoming licensed in Amateur Radio in 1985. The inherent limitations of the equipment and techniques used by the Amateur Radio Service, even today, have made it difficult or even impossible to fully realize the potential for advanced networking on the Amateur bands. The TAPR Spread Spectrum STA provided the opportunity to break free of the throughput bottlenecks of the past.

My interests and experience lay more with the software and operational aspects of data communications so I planned on taking part in the bulk purchase of commercial Spread Spectrum radios through TAPR before the manufacturer ended the deal. This development set back the introduction of a high speed network infrastructure here in Austin by several months at least.

Once a Spread Spectrum network is up and running in the Austin area I had planned on augmenting the networking resources to encourage more members of the Amateur community to try out the new technology. Computers to operate as servers are being constructed at my home and at the University of Texas at Austin to provide a number of services to the network users. In addition to those activities now available on the Internet, such as the World Wide Web, email and net news, the servers and gateways they host will provide a way to integrate all Amateur services into the SS network. Radio ports would be provided for many of the existing Packet Radio services that currently exist. Once all of these services are in place SS network users will be able to exchange email with the existing Amateur email system, participate in the DX spotting system and view dynamic maps through the Automatic Position Reporting System, all at the same time. Currently this would be possible only if each user had multiple radios and Terminal Node Controllers (TNC's, or radio modems).

The use of TCP/IP on the SS network and the gateways mentioned in the previous paragraph will help Amateur Radio solve one of the many problems it faces with current Amateur packet technology, Balkanization. Differing packet radio activities in Amateur Radio often take place on separate frequencies and do not intercommunicate with the other activities. This prevents the symbiotic placement of network nodes, regardless of service, to increase the coverage area for all network users. A large number of well placed BBS stations does not help the Packet Cluster users, nor vice versa. By moving to true networking topologies based on TCP/IP Amateur Radio will see the benefits of increased coverage area for all users. A new network node would provide new and better service for all users, not just the users of one particular application.

Even though the FCC is considering changes to the Amateur Radio Service's rules concerning Spread Spectrum, the current TAPR STA is vital to ensure that further experimentation is done, particularly with commercial equipment where possible.

Robert Barron
Austin, Texas

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The reason for participating in this STA is to provide a legal way to experiment with DSSS at freq's below those presently authorized. I want to study effects that the propagation medium has on DSSS signals at frequencies where losses and signal degradation are affected by more than LOS path losses (skip, fading, and the other effects of ionospheric based propagation). This work has already been done by military and others but I want to see what can be done by those who do not require low error rates and rapid data flow.

I feel that it is important to investigate different methods for sending information. It expands ones knowledge in many technical areas and adds to the fun of being an "amateur radio operator". Today, too many hams are nothing more than appliance operators and their technical abilities are rapidly approaching zero! We have to be able to participate in activities like this STA if the excitement of the hobby is to be kept alive. The hobby is being loaded down by too many "Burt Fishers", that is, those who would rather cause problems than experiment!

I joined this STA late in its 'life' and have not yet started tests. I do have an authorized DSSS system running on 3.578MHz at a power level of 0dBm peak at the first combline operating over a 100 mile path that has yet to work! The pathloss, local city noise, and the antenna system efficiencies have resulted in no evidence of any signals even with narrow-band scans with averaging (hp89440A analyzer).

I plan to request authorization from the FCC for power boost increments of 10dB (with 2 week link studies between power increases) until I can synch the systems.

I have started building a DSSS system that will operate at 51.2MHz. It will have the following characteristics:

- Chip clock = 100KHz (derived from 51.2MHz L.O.) and will be increased later to 200KHz and possibly 400KHz
- M=127 PRN sequence (will be expanded once system is working well)
- L.O. phaselocked to hp-10811D timebase (I am developing a VERY stable and inexpensive "oven" that others can reproduce to provide the frequency stability required in most communications systems)

- power 1->10 watts (simple/cheap power control using DAC programmed attn for 0.01dB steps if desired)
- antennae 3 to 5 element beams
- paths of 30 to 50 miles
- most likely voice data

Name: **Joe S. Borovetz**
Call: **WA5VMS**
Address: 2333 Manila
Muskogee, OK 74403

Activity report for Amateur Radio Station WA5VMS, submitted April 20, 1997.

I was in the first group of amateurs that was added to the SS-STA that was granted to TAPR. I was also in the group that was to have made the initial purchase of the Freewave radios. In addition, I was one of those that made the trek to Austin, TX last December for the TPRS Digital Symposium. This gave me the chance to see the excellent SS presentation by Greg WD5IVD. I left the symposium READY to start working with SS technology.

In the time period between the initial grant of the STA and the point that the Freewave sale fell through, I was in the process of installing 900 MHz antennas and setting up a computer running the Linux operating system. This server would be used as an Internet gateway to facilitate linking to other amateur networks.

After the Freewave sale fell through, activity at this station has been on hold as far as RF is concerned. I still continue to work on the computer hardware end of the project until such point and time as a SS radio is available to those of us on the STA.

At the present time, it seems that the amateur community is running in low gear as far as digital modes are concerned. It is hard to excite people about the potential of running digital communications on amateur radio when the average data rate is 1200 baud. The answer that I continue to receive is "Why would I want to spend up to $200 on a packet TNC that runs at 1200 baud when I can spend the same amount of money on a landline modem and have connectivity at rates of 33.6 K or better". I find it hard to argue with their logic.

I realize that there is some packet activity at 9600 and even 56K. The problem with these modes is that they are not easily achieved by the average amateur. I have been involved with 9600 baud data transmission for the last 10 years in connection with the Texnet network. I can speak from experience that there is no easy route to 9600.

One of the reasons that I was excited about the Freewave radios was the fact that here was a unit that the average ham could make use of without the need for access to radio test equipment that is not available to most hams.

I have been disappointed to hear local amateurs telling of the use of various methods of voice communication over the Internet. I wish we had an alternative for them that would let them integrate the use of their computers into ham radio. With high speed SS and existing software that is currently available for Internet use, there is no reason that digital audio between stations should not be a reality. How about digital conversation between two hams as the play a computer game over SS amateur radio. My next
door neighbor (a ham) does exactly this type of operation over the Internet with another ham in Wagoner, Oklahoma, just 12 miles away. I had hoped to have them try SS Amateur radio to accomplish the same thing.

As a communications technician, I was interested in the performance of the off-the-shelf SS radios when they had to compete with existing Part 15 900 MHz activity. Early in the game, we found out via e-mail discussion on the STA reflector, that the Freewave radios experienced interference from existing 900 MHz paging stations.

I expected such problems due to the wide receive bandwidth necessary for SS operation. The interference to the Freewave radios was reduced through the use of horizontal antenna polarization.

This created a whole new set of problems in trying to find the best omni-directional horizontally polarized antenna.

I was excited to see a discussion on the use of the Alford slot antenna for these operations. As a VOR technician, I have experience with the slot antenna and I think it would be a fine choice. I look forward to the point when I am able to install and test one of these antennas on SS.

As I said earlier, I would like to tackle the 900 MHz interference issue. After I had my first Linux server operational, I had plans to install and additional server at a commercial tower site that is in the middle of a "nest" of 900 MHz paging transmitters. By working on the interference issues, I had hoped to pave the way and make it easier for those who wish to operate SS in the future.

I guess that sums up my current activity to present and my goals for the future. I look forward to the extension of the STA.

Joe S. Borovetz WA5VMS

Name: **John Bradley**
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Austin, Texas 78759

I am participating in the TAPR Spread Spectrum STA for several reasons. First of all, it is an opportunity to motivate myself to become familiar with the practical aspects of spread spectrum communication. It is also a potential opportunity to apply some of my professional expertise to a problem domain within my amateur radio hobby. Perhaps most of all, it is a chance to explore a mode of communications that I believe will eventually dominate. I was fascinated by the concept of [frequency hopping] spread spectrum radio years ago. About one year ago, my interest was rekindled as I began to research methods of very high speed wireless digital techniques. The TAPR STA came along just as I was ready to reduce some of my new knowledge to practice.

I had originally planned to join the TAPR group purchase of a commercial FH transceiver, which eventually fell through. Had that option been available, I planned to experiment with propagation and low-level protocols for hand-off, as well as anything else that was interesting. As it is, I wasn't able to obtain this device, so I have not been able to perform any actual experiments as yet.

In the meantime, I have considered to what effective uses the opportunities provided by the STA could be applied. In particular, assessing the impact of sharing bands containing narrow band usage with SS operation seems to be an area of experimentation uniquely suited to this STA and the amateur
radio service in general. This is an area that I would like to investigate as well.

If the current STA is extended, I intend to build or buy a test platform that will permit highly configurable [direct sequence] spread spectrum operation, driven by a PC-based controller-data source/sink. I would like to use this to study the subjective consequences of coincident SS and narrow band operation.

With experimentation enabled by this STA, carried out by the various participants, I believe that invaluable experience will be gained, benefiting both amateur radio and the commercial sector. There is probably no other way to gain extensive experience with the interoperation of SS and the wide variety of wireless modes in use within the amateur bands authorized by this STA.

In summary, I am excited to be a part of the experimental and educational efforts brought about by this STA, and I hope that it can be extended so that I and others will be able to continue to invest time and effort in exploring this elegant mode using affordable equipment adapted from compatible commercial uses.

Sincerely,

John Bradley

Name: **Mike Cheponis**
Call: **K3MC**

I've "paper designed and analyzed" FHSS systems for 50, 144, 902, 2400, and 5800 MHz, all digital transmission of "moderate" data rates - e.g., 64 kb/s.

Surprisingly, systems for 902-928 and 2390-2450 MHz were easier to build than other bands; this is because, I believe, the amount of effort going into commercial SS systems on these bands.

Although it is possible to build Amateur SS systems using FH and to "overlay" existing operation[1], it seems to me that the most interesting application of SS to the Amateur Service will be with dedicated spectrum for SS, and the use of DS and CDMA. For example, two 6 MHz TV channels on 1.2 GHz could be allocated - by the FCC rules! - for ONLY DS SS operation, then we could build an Amateur version of Qualcomm's system, and get an interesting set of services. An SS repeater, with wide coverage, would permit many users to transmit on the "uplink" band at the same time as many users - each "tuned"
to a different code - heard only the station or set of stations it wanted to hear. Since these transmissions will be digital, any digital data (voice, image, TV, etc.) can be carried.

It seems unlikely to me that "virgin spectrum" will be made available exclusively for SS. Because hams can transmit on any frequency allowed by their license class, a DS SS system, operating at or below the noise floor with no significant jamming margin built-in (after all, significant jamming margin costs you in data rate), then a single ham can bring such a DS SS repeater to its knees.

Barring advances in anti-jamming technology, this relegates Amateur SS to FH; it may be possible to put DS under FH, but what are the benefits of doing so to outweigh the cost? Perhaps I am shortsighted, but I cannot see the advantages to such a system except, perhaps, better multipath rejection performance (from DS), and QRM avoidance (from FH).

But, I believe, until and unless we can get virgin spectrum that we can use strictly for DS, we will not begin to realize the benefits of SS to the Amateur Service.

-Mike Cheponis, K3MC

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[1] There is another interesting application of SS: overlay onto the HF bands. But that is another subject entirely.

Name: **Steve Dimse**
Call: **K4HG**
Email: sdimse@bridge.net

What I did:

1. Ordered two of the SS radios from TAPR.
2. Cursed heavily when the deal fell through.
3. Waited patiently for next plans.

While I don't consider myself an "appliance operator", I do not have the skills to go out and design my own spread spectrum system. I am anxious to participate in the testing of and software development for, other people's hardware.

Steve Dimse K4HG
sdimse@bridge.net

Name: **Robert Donnell**
Call: **KD7NM**

TAPR Spread Spectrum Activities Report by Robert Donnell - Amateur Station
KD7NM

Spread Spectrum Communications has been a technology of interest to me since I became aware of its existence, initially trying to understand its benefits at a very low level. Of course, as with many things achieving one level of understanding reveals a whole new level of lack of knowledge and the desire to understand it.

Our initial group (Steve Stroh, Ren Roderick, and myself) were very enthused with the planned offering of radios from Freewave to conduct initial experiments, as we didn't have any extremely good leads on gear that might allow us to communicate together, available off the shelf, or with little modification. As a result of the failure to conclude purchase arrangements for these radios, our initial ability to get equipment on the air was removed.

I have been avidly following discussion on the Internet mailing lists dealing with amateur spread spectrum experiments. Another amateur friend is working for a local entity that is in the network planning and early implementation phases of a PCS CDMA spread spectrum cellular network at 1.9 Ghz, and I've been learning a lot from his explanations of the situations they have encountered, such as the effects of multipath on signals, and how that can be turned from a challenge into a benefit, actually improving the reliability of the radio link by using multiple receivers, spread in time, to individually attempt to copy the signals with different propagation delays from the transmitter.

In the mean time our group has discovered and acquired several data radios which include Proxim spread spectrum transmitter and receiver decks. An engineer working for the company that manufactured the completed assemblies has even designed a small microcontroller that should allow controlling the
Proxim radios for TX/RX operation and frequency control. At this point the microcontroller has not been tested, however the assembly language source code is not so voluminous as to preclude debugging, if any is needed. We have also found a source of PC boards implementing the desired microcontroller, with sufficient breadboard area to construct the additional interface circuitry required. Working on this will be my next effort in the process of getting these radios on the air.

In the future, additional interests are implementing spread spectrum operations on the popular 144 MHz, 222 MHz and 430 MHz amateur bands.

In particular I want to explore the requirements needed to implement an in-band spread spectrum repeater, and to study the effects of narrow band systems on its performance, as well as the effects it has on performance of all existing communications modes on these bands. To allow use of a single antenna, I'm considering a system which uses a time-slotting technique so that the user transmitter and repeater transmitter are not on the air at the same time, to allow the repeater receiver to function without local de-sensitization. With a system like this, it should even be possible for mobile radios with appropriate T/R switching to communicate directly with each other in an apparent full-duplex mode. Less sophisticated user radios would not normally be expected to completely disable the transmitter. Radios capable of rapid T/R switching would be able to participate in automatic power control, and would be an advantage in the case of a potentially high-power mobile radio.

As an employee of a company which manufactures broad band RF amplifiers I will also be interested in the effects of using amplifiers in different operating modes, both on the spectral purity and occupancy, and on the effect on communications efficiency. Specifically I'll be interested in spectral growth characteristics and how the design bandwidth may have to be altered to keep products within the allotted spectrum.

I do hope that the Federal Communications Commission will extend the term of the Special Temporary Authorization, as it allows the use and adaptation of existing equipment while the Amateur Service works on its own designs, and allows us to use these platforms as learning vehicles with power levels, antennas, and spreading techniques that are not currently authorized for Amateur use among non-TAPR members, or those TAPR members who have not become recognized participants in the STA.

Thank you for the opportunity to participate in this technology utilization project to expand the horizons of amateur radio, and to learn about the capabilities I hope become general practice in the Amateur Radio Service in the coming years.

Respectfully Submitted,

Robert B. Donnell, Jr. KD7NM

Name: **John Koster**
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Richardson, Texas 75081

Report:

The reason for participating in this STA is to experiment with SS on various frequencies. Initially the test were to have taken place on 900 Mhz with Freewave FH radios. I was particularly interested in seeing if a 450 Mhz path that had disappeared in recent years due to the construction of high rise buildings in the path could be re-established by using SS. The failure of Freewave to deliver radios as previously
agreed, has delayed any experimentation.

In the meantime, alternate sources of radios have been under consideration. None seem to offer the performance of the Freewave for the cost. It appears that building from scratch will be the only acceptable way to proceed. It is hoped that the STA will be extended to allow this to happen.

Name: **Don Lemke**
Call: **WB9MJN**

Report On Spread Spectrum STA participation - April, 1997
Don Lemke, WB9MJN

The project proposal here is to develop techniques other than CSMA (Carrier Sense Multiple Access) for channel access. I believe future high performance systems will require unidirectional antennas and / or packet times that are small versus propagation delay. Either of these, makes CSMA ineffective.

By participating in the TAPR (Tucson Amateur Packet Radio, Inc) Spread Spectrum - STA (SS-STA), real world experience with low gain 915 Mhz unidirectional antennas, and the benefits of those antennas will be gained. Once this is done, our group will have sufficient basis to move onto channel access techniques problem.

The group of people I am participating in the STA with (Carl Bergstedt and Don Lemley), have been active in Amateur Packet Radio since the late 1980's. We heard of the TAPR SS-STA through participation in the TAPR Spread Spectrum Newsgroup on the Internet. Carl is the president of the Chicago Area Packet Radio Association, the largest amateur packet radio group in the Chicagoland area. Don Lemley is involved with Packet technologies professionally, and was also responsible for the state-of-the-art (in 1988) packet router design known as the "PacketTEN". I have done mods of existing FM Voice radios to ..5GFSK Modulation both as an amateur and for commercial systems as a professional, built 430 Mhz (56 KB) and 1.2 Ghz (19.2 KB) full duplex data radios and 56 KB full duplex data radios. Both Don Lemley and myself have been published in the ARRL (American Radio Relay League) DCC (Digital Communications Conference) notes.

I have developed a low gain (6 dBd) Microstrip Patch antenna for the 915 Mhz Ham Band. This antenna has a high Front / Back Ratio. Permitting reuse of spectrum behind the antenna and rejection of reflections behind the antenna. This is typical of the types of unidirectional antennas that will be needed for high performance goals of future systems.

The SS-STA made the economics of the antenna development doable by myself. Due to present FCC rules, this antenna has little commercial marketplace in the USA. Since aftermarket Part 15 Antennas are forbidden. Within the STA participants, there are sufficient numbers of 915 Mhz antenna purchasers, to allow me to risk my time and capital towards a new antenna development.

The FCC would be wise to permit aftermarket antennas, within the same gain specifications as Part 15 equipment qualifications. By qualifying a Part 15 device with only specific antennas, the FCC is retarding technical development of antennas for no good benefit. Indeed many of the antennas offered by Part 15 radio manufacturers are not of good quality when used in an outdoor environment or are inappropriate for data communications. This lack of quality may cause as many interference situations as the FCC is hoping to avoid with this rule. Such as would be caused by Intermodulation Mixing in the antenna. Poor radio link performance, due to rain susceptible antenna, or delay spread susceptible antenna design, can also result in SS interference. Many retry transmissions are then required to get the data through, and this uses up the spectrum-time-area resource unnecessarily.

Our group has not operated on any frequency band with Spread Spectrum as of yet. We were relying on the TAPR group purchase of 915 Mhz Frequency Hopping Spread Spectrum (FHSS) Data Radios to gain economical access to FHSS technology. TAPR has not been able to acquire radios for this group purchase, as of yet.

We will continue to wait for TAPR to supply economical access to Spread Spectrum radios. We are also investigating the purchase or development of Spread Spectrum radios ourselves.

73, Don.
wb9mjn@wb9mjn.ampr.org

Name: **Bob Lorenzini**
Call: **WD6DOD**
Email: hwm@netcom.com

My interest in SS is mainly in computer networking. In the past I have built > 10 TAPR 9600 baud modems and converted > 30 Motorola mitrek radios. I had hoped to further my knowledge with the TAPR group purchase. I have been the implementor of a ham to Internet gateway in the past and still consult on others.

As of today I have been able to do only limited testing with pair of FreeWave radio/modems for the naval weapons station in Seal Beach Ca. Information I received from the SS list has produced a savings for the USN in setting up a mobile accounting system.

I would like to experiment with one of the bare board projects now being discussed and look forward to actually building something. I hope the STA can be extended into the future so this might be possible.

Bob Lorenzini - wd6dod
hwm@netcom.com

Name: **Anthony W. McConnell**
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STA Report from N3JLI

I started reading about spread spectrum a few years ago when the ARRL published the Spread Spectrum Handbook. I found the idea fascinating. Since then I've read everything I could find on the subject.

Spread spectrum looks to be an opportunity to extend the radio art. Through its use we hope we can operate under conditions of interference without using more power, using process gain rather than more power. SS also holds hope for help on crowded bands, allowing maximum utilization of the amateur spectrum.

I had planned on purchasing a pair of radios from TAPR under a group purchase arrangement. The deal fell through. I am looking into purchasing other radios at this time.

Looking at the available SS products and chipsets left me with a feeling that amateur radio may be better served by experimentation down other lines, not just porting commercial products to amateur use. With this in mind we started examining building a SS radio from scratch.

We (Jake Brodsky AB3A and I) set assumptions for our designs:

- The design should be flexible, to allow experimentation.
- The design should be repeatable, so that the work we do can be used by others.
- The design would use building parts available to anyone, no magic pieces that are unobtainably obsolete or mega-buck space age.
- That the design should further the understanding of spread spectrum communications. Again, no magic, a design that would make this method understandable to many.
- The concepts should not be band specific.

The design that we would like to experiment with is a quadrature amplitude modulation scheme with a spreading direct sequence oscillator, to be received by a receiver steered by a Costas loop. Currently the test units are in the final stages of bread boarding.

The transmitter consists of a reference oscillator which is used to control a phase lock loop (PLL) oscillator that operates at the carrier frequency. A sample of the carrier is sent to a digital divider to provide a clock for the pseudo noise (P/N) generator. The output from the PLL is binary phase shift keyed with the output from the P/N in a double balanced mixer, the output from this mixer is the Noise Local Oscillator (NLO). The NLO is then put into a ninety degree phase shift splitter, the outputs of which go to in phase and quadrature mixers of the quadrature amplitude modulator. The input to the in phase mixer controls the amplitude modulation of the signal. The input to the quadrature mixer controls the phase modulation. The output from the two mixers are input to an in phase combiner, this is the transmitter output. The transmitter output can optionally be amplified.

The receiver is built from many of the same blocks as the transmitter, in a simplex arrangement they may be able to be shared. The Receiver consists of a reference oscillator which is used to control a phase lock loop (PLL) oscillator that operates at the carrier frequency. This reference oscillator can be adjusted in frequency by feedback from later stages. A sample of the carrier is sent to a digital divider to provide a clock for the pseudo noise (P/N) generator. The output from the PLL is binary phase shift keyed with the output from the P/N in a double balanced mixer, the output from this mixer is the Noise Local Oscillator (NLO). The NLO is then put into a ninety degree phase shift splitter, the outputs of which go to in phase and quadrature mixers of the quadrature amplitude demodulator. The outputs from the demodulator are limited then sent to the Costas loop, which will provide recovered data and phase/frequency error that will be fedback to the reference oscillator to control it's frequency and phase. The outputs of the quadrature amplitude modulator are available as data.

Operations will begin soon using this described system. I will make results available to all interested parties.

So far this experiment has been on the 6 meter band. This is a band I enjoy working and thought would be interesting. In many areas it is difficult to uses due to interference. Spread spectrum could help with that, allowing dependable data connections and voice conversations.

In the future I would like an opportunity to experiment further. This technology has great promise for many uses. I'd like to try a direct sequence spread spectrum repeater. Looking at the way this method operates, it should allow excellent coverage control and reuse of system resources. I also see an opportunity to use frequency hopping coordinated by external timing, such as global positioning service, to be used to make contacts over greater distances then would be possible on a single frequency with the use of less transmit power.

Name: **Tom McDermott**
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Spread Spectrum STA Report

1. Why I am a part of the STA.

Purposes for participating in this STA are:
1. To learn about SS technology by engaging in the design, deployment, and operation of a Spread Spectrum system.
2. To learn about the operational aspects of a multi-user point-to-multipoint system.
3. To enhance knowledge and understanding of data networking issues associated with the operations of such a system.

2. Operations since you began operating under the STA.

None. The planned operations were curtailed when the purchase of units from a commercial supplier was canceled.

Motivation (Planned use)

There are a number of ways that radio amateurs can contribute to the effective establishment of communications for the effective provisioning of a public service in times of need and for the learning and enjoyment of individual amateurs.

It is envisioned that an ability to tie a portable laptop computer into the Internet with a high-speed, highly-mobile link is one capability that could prove useful. This capability, if it existed, would allow, for example access to a wide variety of potentially useful information during an emergency event. Such as:

- Display of maps (weather maps, road maps, topographic maps, etc.)
- Access to databases (hazardous material, participants in an event, etc.)
- Access to distant people via Internet telephony or video.

3. Detail what you plan to do in the next 6-12 months.

In order to learn about the design of spread spectrum systems, a paper design has been put together outlining the design parameters for such a radio link, along with the beginnings of a schematic diagram. Currently, I am trying to locate suitable components (such as I.F. filters, R.F. filters, synthesizers, VCO's, etc.) that can be utilized in such a design.

Plan for the next 6-12 months is to complete design of a radio, fabricate prototypes, conduct trials of it's operation, investigate some of the system aspects (see below for details).

4. Experiments or Designs in progress.

Radio Design

The radio design planned is based on frequency-hopping (FHSS). The current plan is to utilize the 900 Mhz amateur band to transmit and receive the FHSS signals. The design is planned to be half-duplex, to dwell on each channel for 10 milliseconds, and to operate quadrature PSK (QPSK). The data rate planned is 200 kb/s throughput. This will be composed by convolutionally encoding the 200 kb/s stream with a rate=1/2, length=7 code to produce a data stream of 400 kb/s. This will then modulate the phase of the carrier at 200 k-symbols/s.

Some of the key design characteristics are to investigate the ability of the channel synthesizer to hop and stabilize sufficiently fast to achieve adequate performance. Possible design alternatives involve having several VCO's that alternately hop and thus have more time to stabilize than a single VCO would. Initial calculations indicate 2 or 4 VCO's should be sufficient, allowing 10 to 30 milliseconds stabilization time for each VCO prior to it's being placed in the active transmit chain. Additionally, the phase noise of each VCO must be sufficiently low to minimize carrier phase modulation. Calculations indicate that commercially available VCO's should provide about 10 dB of phase noise margin.

Initial plans are for a 1 watt transmit power output. Rough performance indications are that the design should perform about 10 dB better than commercially available units based on FHSS with non-coherent FSK modulation. About 5 dB is due to the performance advantage of QPSK as compared to non coherent FSK, and another 5 dB. is due to the use of soft-decision Viterbi decoding of the rate=1/2 code. Our estimates indicate reliable 20+ mile line-of-sight range utilizing horizontal-polarization of such signals to avoid existing 900 Mhz services, and to minimize mutual interference.

The demodulator will consist of I/Q downconverting mixer to baseband, and 10-bit A/D conversion of the I and Q channels. These will be demodulated with a digital Costas-type demodulator. The particular demodulator planned is a VLSI implementation which includes carrier rotation and frequency error estimation to compensate for frequency and phase offset.

Techniques for acquiring hop-epoch synchronization and for acquiring the hopping sequence will be studied as part of the design.

Sufficient hardware support for estimation of received signal strength, frequency offset, and pre-and post-Viterbi decoder error rates is planned to allow the radio to incorporate automatic power control if it is needed, or if the power level is raised above 1 watt.

Individual radios will contain sufficient intelligence to enable them to link to one another automatically (achieve hopping sequence agreement and epoch agreement).

System Aspects

A central node at an advantageous location is envisioned. It would be constructed by connecting several radios together.

From the system perspective, the design envisioned would operate in some ways like a demand-assigned service. A central node consisting of a rack containing several half-duplex radios, with one channel dedicated to requests for channel assignment, and the remainder of the channels being used to provide data bandwidth between individual users and the central node. Several data channel radios could be utilized, perhaps up to 10 or so.

A user radio would consist of a single radio (half-duplex) that initially would attempt to access the node on the demand-assignment channel. Successful access would consist of the user radio being given the proper hopping code and sequence-epoch to enable it to communicate with one of the data channels. The data channels and the assignment channel share the same spectrum at the same time. The sharing is accomplished by using different hopping codes on all the channels. Current idea is to utilize 64 or 128 different frequency channels in the band. The node would keep track of which data channel sequences were in use at any given time.

Errors due to collisions of specific hops (or for other reasons) will be handled by an retransmission (ARQ) method. The hopping sequences will be contained in a one-time-programmable microprocessor, and will not be individually alterable by the user, in order to avoid Department of Commerce export restrictions.

The demand-assignment channel would attempt to estimate the BER performance of the user-node link, and would provide proper hop sequence

information to a user to allow them access to the data channels. If all data channels are busy, then the user would be put 'on-hold' until one freed up. Other
scheduling mechanisms are possible, of course. Information on the received signal strength and error rate would be used to advise a user of significant performance problems, and in order to provide effective
trouble-shooting of the system with minimal additional equipment.

Additionally, the problem of linking nodes together, or of linking nodes to the Internet must be considered. Usually, high-speed Internet connectivity (greater than 128 kb/s) is not available at 'good' node sites, and so one of the data channels at the node could be dedicated to node-to-node communications with another node that may have better data networking arrangements available.

It is envisioned that a node will be composed of a number of radios simply interconnected on the data side, and on the RF side. Power combiners and splitters will be used on the RF side, and an Ethernet
LAN is planned for the data side. Thus, the interface to the user radio will be via a 10 Mb/s Ethernet connection, probably 10-base-2. The radios will acquire the additional intelligence to perform as a node simply by recognizing that they are multiply-connected, or perhaps as a user provisioned option.

Data Networking

In the design of the radio, an Ethernet interface could be used to provide data connection to user computing equipment, between radios at a node site, and interconnection to the Internet. The design of software to provide proper networking of the collection of equipment is necessary. The IP address administration is proposed to be dynamic, with a node assigning IP addresses as users access the node. This is done to maintain the strictly hierarchical addressing of IP, and to prevent any updating of routing tables due to topological rearrangements that happen in a mobile environment. Should a user move out of range of one node, and into range of another node, they will have to disconnect from the former, and reconnect to the latter, thus receiving a new IP address. Sufficient computer processing within the radio is planned to make direct connection at the IP-level possible.

It is envisioned that the nodes will be linked together into a distributed Intranet (via the Internet) forming a closed-group. This will establish the collection of nodes as a closed user group, and should help prevent the use of the system for commercial purposes by the users.

5. Why the STA needs to be extended.

An extension of the STA is needed in order to continue progress in this design. The design was commenced late in the initial STA period after the plan to acquire FHSS units from a commercial manufacturer had to be abandoned. It was felt that since a new design would have to be pursued, we might as well properly accommodate not only the radio design requirements, but the system aspects as well.

Since all of the designers of the radio are non-compensated, and are in fact employed full-time in other pursuits, the time schedule for the project is somewhat difficult to estimate. The availability of funding, time, and volunteers determines the schedule. However, all the participants to date (four) have had a good track record of actually producing working hardware and software in the past. It is hoped that an extension of the STA for 12 months will enable working prototypes of the radio to be constructed, and for some preliminary system aspects to be experimented with.

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Report of activities for Special Temporary Authorization
for
Amateur Radio Spread Spectrum activity

Date of Report: April 19, 1997

Unless otherwise noted, RF activity was conducted from this above location, using indoor antennas. Coordinates of this location: 30-21-31N, 97-45-04W.

Some other operations involving antenna testing were conducted at:

4608 Erath Avenue
Waco Texas 76710
Coordinates (approx.) of this location: 31-32N, 97-11W, using outdoor antennas set up as a test range for antenna measurements.

These are the only two locations which this licensee has used to date to conduct operations. Only fixed operations, not portable or mobile, were conducted from either site, to date. All activities were conducted in the 902-928 MHz band.

I. Overview:

I was invited, even dragged into, this project, but very willingly, by Greg Jones WD5IVD, president of TAPR. Greg happens to live about a block away, and he was very interested in conducting some joint SS tests. I have heard Greg talk of SS for some number of years now, in some very enthusiastic terms, and I was eager to give it a try, and even sink some money into it. The amateur community needs to avail itself of this technology to remain viable as a radio service, and what better way to start, and what better opportunity. I always have considered myself an experimenter and able constructor and problem solver, and always desire to be associated with like individuals who help in the groundbreaking advances of the radio art. I firmly feel that my participation in the SS STA is a very important contribution needed to help amateur radio advance, and without which it's future may be threatened. As will be made clear in the following paragraphs, I believe that there is much unfinished business to be done under the STA, and that it must be extended (or the rules of the STA made a permanent part of the landscape, there is a Report and Order comment period open at the time of this writing).

My activity under this STA started December 9, 1996, and continued roughly for 3 weeks, as shown in the attached logs (Appendix A). I suspended operations at that time, as the activities that I could perform had been completed about as far as I could go with them. Further activities would require a larger pool of local amateurs participating, and our lack of infrastructure, primarily available radio gear, had limited any further variation of activities other than those already attempted. I continued to participate in and otherwise monitor the discussion group we were maintaining via e-mail reflector. Most of that discussion since the collapse of the group radio purchase has been related to various SS radio design proposals that amateurs could design and build ourselves, much as TAPR designed its highly successful TNC2 packet controller. The collapse of the group radio purchase hit us very hard indeed, insofar as meeting some of our immediate operational STA goals was concerned. We are suffering from a severe lack of infrastructure, which we could not overcome in the short term. I was fortunate indeed to have a loaned FHSS dataradio with which to run a few tests.

II. Brief description of operations conducted is as follows:

1. I successfully used a loaned spread spectrum device, a Freewave 400 mW FHSS dataradio, under the terms of the STA and did perform short-range communications with it, at speeds noticeably greater than my landline 14.4Kb/s dialup modem. The nature of these first communications was Internet access, primarily web browsing, as this is a pretty stiff test of information streaming, at least in primarily one direction, although a two way connection is required for it to take place. These tests were repeated several times over several days. All but one of these tests were entirely successful, one day there were unexplained apparent path problems. I also tried some point to multipoint tests, these weren't as well behaved, although there didn't appear to be anything obviously wrong with the path or the hardware that time, rather just difficulties with that mode of operation.

2. I have designed and built a few antennas for the 902-928 MHz band. Amateurs lack some common infrastructure for that band in particular, and in general for all bands above 450 MHz. To that end, I have organized a sole proprietorship to manufacture antennas and related hardware such as RF splitters, bias tees, mast mounted enclosures, amplifiers, and the like. Specific accomplishments so far have been to design and test a 6 and a 12 element yagi design, and to partially tool up for quantity manufacture of them. Under design is a partially constructed prototype of a 4 element cylindrical slot omnidirectional gain antenna. Such a device is apparently unknown in the amateur radio marketplace, and would appear to fill a niche for a horizontally polarized omnidirectional antenna for use at a repeater or common server site. One observation we as a group fairly early on in the

process was that most of the commercial users of this 902-928 MHz band were using vertical polarization, typically for mobile and portable users, and it would be advantageous for amateur operations to use horizontal polarization to minimize mutual interference. That collective decision, which I am in agreement with, necessitates some development of omni-horiz antenna technology.

3. I had to develop some techniques I have not ever used before, in order to allow the available 400 mW FHSS radio to be used as an RF source to perform all manner of antenna testing. Primarily, that method was to couple an oscilloscope to an otherwise conventional inline RF wattmeter. In so doing, it has some inherent advantages, not unlike the use of a sweep generator, for antenna tuning and matching. While this is my first experience involving handling of RF at any frequency above 450 MHz, it was entirely straightforward insofar as the behavior of the antenna matching and adjustments, and due to the lesser physical size, easier in the mechanical respects. I think that any amateur that is capable of tuning standard antenna designs at VHF through 450 MHz has nothing to fear in the way of difficulties in tuning similar equipment through at least 1300 MHz. Also the low power antenna tuning methods greatly simplify the personnel safety and incidental interference problems commonly encountered in antenna testing and tuning.

4. I should note for the record that at no time in the tests I ran did I receive any complaints or comments that the SS operations that I conducted were even noticed, much less generate any noticed interference to any other communications. I was very hard pressed to even notice the effects of the transmitter and antenna operating inside my own room.

III. Some of the unfinished business that I would like to undertake during an extended time interval of the STA would be:

1. To experiment with some direction finding and station locating methods for use with SS. Amateurs have always taken pride in the ability to locate RF sources at large, and the coming of SS will require some changes to equipment and techniques. This is another infrastructure requiring development and experimentation. I have participated in organized locating exercises for conventional NB sources for some time, and recognize it will be important to have useful techniques for SS as well.

2. To complete the prototype omnidirectional antenna discussed above, and install it on a common server site running SS, and test it's behavior.

3. To experiment with some mobile applications, and learn about behavior of SS under mobile conditions.

4. To implement and operate a longer mileage (10 to 30 mile) link, and actually carry some useful amateur packet network circuits with such a link.

5. To experiment with an external transverter to another frequency band, primarily to determine what kinds of problems need to be solved to make the available SS hardware work for amateurs on various bands where use can be made of it.

6. To continue to carry on tests to demonstrate and determine the nature of any interference problems between SS and any narrowband users of the amateur bands, and to be able to present convincing firsthand information about SS/NB interactions to local concerned amateurs and any other interested parties.

7. To continue to build up a very weak infrastructure of the higher UHF amateur bands, and of SS hardware. The difficulties I have discussed in this report highlight the need for amateurs to develop much deeper infrastructure of hardware, sites, servers and networks, and also the intangibles of knowledge and experience.

8. To continue to work with an expanding pool of interested amateurs, who have expressed an interest in joining the STA pool. Since membership is limited to those to join at infrequent regular intervals,
the live of the STA would obviously have to be extended to allow more participants.

9. To participate in the design and construction and testing of various prototype SS radio gear. It should be noted that a supplier of SS radios declined to provide an anticipated group sale for purchase by our STA participants pool, and we were left in the position of having to design and construct our own hardware, and
this will take more elapsed time than was present under the original term of the STA.

IV. My general impressions of SS are as follows:

1. I expected that there would be less than the popularly feared interaction between SS and narrowband conventional operations. This appears to be born out in fact, but I was surprised at how little interaction actually occurred. I was using a narrowband receiver, actually a communications service analyzer, in conjunction with the testing, particularly the antenna testing, and the SS emissions were difficult to hear at all, with the equipment side by side. The SS transmitter had to be placed in an abnormal mode of continuous keydown hopping for it to be measured at all. In its intended intermittent transmit mode, it wasn't measurable and barely detectable at extremely short range. This test dramatically showed that low duty cycle intermittent

transmissions indeed deliver less interference to a narrowband receiver, and that one of the requirements for harmful interference is a higher duty cycle of interference, for interference to exist.

2. It is capable of carrying a very high datarate, in comparison to my extensive experience with 9600b FSK over the last ten or so years, and can do so with minimal amounts of power. The higher datarates
themselves produce much wider signals just by themselves, FH / SS effects not considered, and partially contribute to the lessened impact on adjacent narrowband communications. Of course, the signal spreading is necessary, along with error correcting coding, to further reduce interference, particularly in the opposite direction from the narrowband transmitter to the FH receiver. The best results would appear to be obtained from a combination of high datarate, spreading, and error correcting coding.

3. The conventional narrowband paradigm of FDMA (frequency division multiple access), realized by assignment of separate frequencies either administratively, or dynamically by trunking controllers, may possibly be less efficient of spectrum than the paradigm of spread spectrum, where spectrum is doled out dynamically at a very high spreading rate, and such collisions as do occur are managed by error correction coding and other recovery methods. Also, it appears to me that there may exist the possibility of a simultaneous use of both methods, whereby narrowband FDMA channels could exist side by side with wideband SS communications, with minimal interference in most cases. I think this area may need further study and possible confirmation.

V. Specific logged information and detailed records:

Attached to this document is a zipped archive of the daily progress reports I posted to the e-mail reflector (Appendix A). These daily reports were written at the time to contain specific information for operational logs. These files are excerpted in a minor way to remove off topic comments, but that is all, and there was very little excerpted, and nothing at all removed in the way of loggable data. Due to the length of the logs, the archive contains two text files. Some discussion existed at the start as to whether to log any periods where operations were NOT performed. My own procedure was NOT to do log periods of non-operation, but only to report on days where some loggable activity took place.

Respectfully submitted for the record,

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4 / 19 / 1996
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The primary thrust of my Amateur Radio Service activities is the investigation and usage of new and novel communication methods. I have long been puzzled by the relative lack of higher-speed digital communications in use by the Ham community. I immediately became active at speeds of 9600 bps as soon as I tried digital radio communications. The availability of Spread Spectrum (SS) communication techniques was therefore of great interest to me. However, the license restrictions made the task burdensome until the restrictions were lifted somewhat under the STA. The STA is important to permit meaningful experimentation in high-speed digital communications.

I have had no operating activity so far under the STA due to the failure of the group radio purchase. Significant "paper" investigation has taken place.

I have made arrangement with my son (who lives about 10000 feet from me line-of-sight) to install a two-way link between my station and his ISDN Internet connection to investigate ways of improving such connectivity via radio.

Also initial plans have been discussed for a project to use SS as a means of digital remote-control of an Amateur satellite/EME system.

Availability of equipment is the next step in my plans. Once this has occurred, and initial hands-on experience is available, the projects mentioned above will be promptly activated.

Ron W5RKN
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Name: **Frank Perkins**
Call: **WB5IPM**

STA Member Report
Frank Perkins WB5IPM

My first goal under the SS STA was to provide the "far node" for the local DFW network experiment. This station submitted an order for the commercial unit to be used in the tests, but unfortunately the commercial arrangement did not go forward. I believe that TAPR is now considering a design available through SSS magazine and if this goes forward I will again attempt to be the "far node" for testing.

Meanwhile, please find attached a DSSS simulation that can be ported to a DSP unit to experiment with DS techniques through "voice bandwith" systems (Appendix B). I will try to code this into a DSP-93 if there is a delay in the hardware project mentioned above. The DSSS simulation is written in QBasic 4.5, and will run under DOS or in a DOS window. The speading code is a 31 chip Gold code. As each chip is received, it and the prior 30 chips are correlated against a local copy of the spreading code. If the correlation is greater than +25 a "1" is declared, and if less than -25 a "0" is declared.

The fixed correlator technique is one of the simplest implementations of DSSS and is readily implemented in DSP code. Code sync is immediate and very robust. Hopefully, this code will provide a starting point for TARP members working on both DSP code and under the SS STA ...

Regards,

Frank Perkins WB5IPM
STA Member Report

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Subject: Spread Spectrum STA Progress Report

Status Report - April 1997

I have used commercially available Spread Spectrum (Part 15) devices in a business networking environment for the last 2 - 3 years to link multiple buildings separated by distances between 0.3 and 1.5 miles over non-LOS paths.

I am particularly interested in the results of multiple devices operating in close physical proximity using different spreading sequences but within the same frequency range. Initial investigation using 900 MHz commercial devices has not yet been completed.

The availability of additional Spread Spectrum devices will allow further investigation along these lines. These devices may come either of from commercial sources (Metricom, Freewave, etc.), surplus (see KD7NM's report), or amateur developed resources.

Respectfully submitted,
Ren Roderick WA7QFR

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Moore, OK 73160

1 April 1997

To Whom it may concern:

Having an interest in Spread Spectrum communications, I joined this STA to participate with a group, that I thought of as having a true vision of where the Amateur Radio Service (ARS) needs to be headed. I find this activity to be intellectually challenging, and the electronics and computer networking involved, to be an exciting area of electronics. Not since experimenting with microwave circuits, and Digital Signal Processors (DSP) have I had such a strong desire to understand the technology.

I was quite interested in joining the group purchase of commercial equipment to use in the ARS.
My interest was in a proof of concept, where a system designed for low power shared use, could be used with directed beams for longer range communications with much higher effective power. The purpose of this concept was to expand the emergency data network in data bandwidth capacity. Also of interest, was sharing data and voice at the 115 kbps bandwidth. This interest is on hold, as no commercial spread spectrum manufacturer is willing to sell their product for use in the ARS.

My second interest was that of a Spread Spectrum beacon. My intent is to transmit a moderate power using a frequency hopping scheme. This beacon is designed to be computer controlled in both frequency and power. The frequency generation uses a Direct Digital Synthesizer (DDS) with 24 bits. This generator outputs a frequency of approximately 5 MHz which will then be mixed or multiplied to the final range of 146.000 MHz to 147.995 MHz. My area of expertise is in computer networking, and I thought a great application here, was online reporting and control of the beacon. Using a standard Web browser, anyone in the local area (or world) could connect to the server and report hearing the beacon, or command the beacon into a set of modes. To this end I spent most of this year building the network. As of 1 April 1997 I am now beginning work on the actual Web pages and microprocessor code for the DDS. The Web page can be reached via http://www.oklahoma.net/~ssampson/steve/project/tapr.html and I can be reached by electronic mail at ssampson@oklahoma.net. The actual beacon is connected to a serial port on a personal computer which is tied to my private network. This network can be reached 24 hours a day via the Web page. The personal computer is tied to the DDS through a microcontroller. This is the area I will be concentrating on over the next month. After this phase is complete, I plan to finish with the actual beacon transmitter. I have been experimenting with some tripler circuits, where I triple the 5 MHz DDS frequency to 15 MHz and then to 45 MHz. This technique is proving to be quite hard to filter, and I will probably drop this method and redesign a mixing circuit, where the final output is derived from mixing a frequency in the 150 MHz range.

The main purpose of the beacon is to run 24 hours a day, and provide data into the public domain,
where it can be factually stated, one way or the other, that spread spectrum equipment can co-exist with narrowband legacy equipment. To facilitate the reporting, the Web page will allow entries to the database on a real time basis. Other uses are querying the database for past entries or summaries. A secondary purpose, is for the user to select a mode of operation. This mode will take effect during the next 5 minute interval. I hope this Web page and beacon control will be a popular site to visit for local and worldwide radio enthusiasts. My personal feeling, is that no one will really hear the beacon, so that a defective mode or single frequency mode will also be programmable. Here the object is for the user to set a frequency, and listen for it at various power levels. I intend to offer several protective features. That is, that repeater inputs and simplex channels favored in the area, will not be available for narrowband test mode. I intend to participate in this STA as long as it exists, and develop my interest and experience levels in this mode of operation. It is my hope, that the FCC will convert the complete ARS spectrum to spread spectrum use only. Within the next 10 years, I would hope the FCC will completely phase out narrowband communications in all of the services (HF to Microwave). To do otherwise would be folly.

/signed/

Steve Sampson
Moore, Oklahoma

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My reason for wanting to participate in the Spread Spectrum STA is for the learning experience. I have been an amateur radio operator for 3 years and got into the hobby to learn and feel that that is not occurring in the hobby like it use to. Additionally I wish to be a part of the effort to help make amateur bands more efficient and help promote the usage of new modes of operation.

I have not been able to operate under the current STA due to an equipment purchase that did not occur. I have performed some research into what antenna(s) I would use when I obtain the equipment needed for SS. In the process I have learned about slot antenna theory and continue to read more about it.

In researching SS I have learned more about the theory of operation and feel that it has a promising future in amateur radio. The current state of digital modes needs a boost and I feel that SS can and does provide the incentive to pursue this.

Since I do not have the technical back ground I am limited to the bands of operation that the equipment that can be obtained operate on. As efforts within TAPR materialize I will participate in the group operations.

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Background

I joined the SS-STA because I wanted to evaluate the performance of SS in an amateur radio context. In particular I wanted to know if SS would cause interference to other co-located packet and voice repeaters and I wanted to find out how much speed and range I could get in point-to-point service.

I use packet radio to control a telescope located about 25 miles from Silver City. Bill Neely, KC5ZG, and I built our first 9600 bps systems about 10 years ago with modified TEXNET TNCs and MOCOM 70 radios. Since Silver City and the telescope are not line-of-sight to each other the link employs a mountain top repeater. We now use the telescope for basic research and as a teaching tool both at the University level and in the K-12 public school system. Under the SS-STA we have upgraded the old 9600 bps links to work at 2 Mbps on the short path and 115200 bps on the longer path. The higher speeds have contributed significantly to the usefulness of the system in furthering our educational goals.

Tests with WaveLAN 915 MHz equipment

I made quite a few performance tests using WaveLAN 915 MHz equipment and a variety of antennas. All of the tests were conducted using point-to-point line-of-sight paths. The reference node was a 915 MHz WaveLAN card feeding a WaveAMP amplifier that boosted the signal to 1 watt. This was fed to 20 feet of 9913 into a 6db Antennex Vertical Antenna. This configuration is a maximum power part 15 setup.

I had three test sites at distances of .75, 4 and 5 miles from the reference node. The .75 mile site could run under part 15 rules with no problems. The 4 and 5 mile paths were more of a challenge. These sites are on a couple of mountain tops. The 4 mile path is about 1300 feet higher than reference node (which is 6000 feet AMSL). I could get 100% copy at this site with the following setup: WaveLAN feeding WaveAMP to 25 feet 9913 to 13 element (advertised 12db) beam.

I tried more antennas at the 5 mile path. This site is at 8000 feet AMSL. A part 15 configuration won't work at this distance. I could get intermittent packets with the 13 element beam but this was not really a usable configuration (the rest of the system was the WaveLAN, WaveAMP and 25 feet of 9913.) I tried using 60 feet of half-inch hardline to a higher location on the tower to the same 13 element beam. This didn't work at all. I next built a 25 element beam (probably about 15 db gain) and at times this would give 100% copy. The problem was with propagation effects. I suspect that the antenna was seeing some boundary-layer effects from looking down from the mountain into a warm bubble of air surrounding the town where the reference node is located. The propagation varied from no packets to 100% copy depending on time-of-day, weather, etc. I talked to the local microwave telephone company guys and they confirmed that they have seen this type of problem with some of their sites. They said the location of the antenna was often critical, i.e. a few feet can make the difference between no path and a good one. While I was visiting the phone guys I borrowed a 6 foot parabolic dish. I built an appropriate feed assembly and found that while the dish has superior gain it was affected even more by propagation effects. As a final experiment I set up the test using a loose coil of about 200 feet of 9913. I tested the path quality every few feet on the tower using the 13 element beam. The signal quality reached a peak at about 40 feet up the tower and got worse above that level. For long term testing I installed the home-made 25 element beam at the 40 foot level. For the most part this has worked very well. Once in a while, usually when the weather is changing rapidly, the link looses packets. This doesn't happen often enough for it to be a major inconvenience.

Tests with FreeWave 915 Mhz equipment

I purchased two FreeWave 915 MHz SS transceivers to evaluate under the STA. The transceivers have a number of useful link diagnostics built into them, including:

1. Noise level measurement.
2. Signal level measurement.
3. Percentage of packets received.
4. Number of disconnects.

The units can also operate in a continuous 'ping' mode. This allowed me to set up one end of the link as a reference node. I could then drive around with the other transceiver plugged into the cigar lighter. The unit shows via the front panel LEDs when the link is connected and by the brightness of one of the LEDs the link quality. No computer or any other test equipment is required. This feature made path testing a pleasure.

As a real-world test I replaced the existing 25 mile 9600 bps 440 Mhz link with the FreeWaves. The path is difficult because it does not have a line-of-sight path. The 9600 link was marginal. The FreeWaves running at 115,200 bps work fine. This is excellent performance. The reference configuration is the FreeWave running one watt into 60 feet of hardline to a

13 element beam. The configuration at the telescope end is the FreeWave running one watt into 125 feet of 9913 feeding an eleven foot dish.

Interference test results

The WaveLAN and FreeWave SS radios produced no interference with the existing voice repeater operating at 448.8 MHz. This repeater is part of a linked system with the links operating at the low end of the 440 band. The SS radios produced no interference on the link frequencies.

Likewise the SS radios created no problems with our 439.35 MHz and 145.01 Mhz packet gear or with each other. The SS radios were not affected by the 10 kilowatt commercial FM station on the same tower.

Plans for the future

During the course of the current test series nearly every amateur radio operator in the area who is involved in voice repeaters or packet radio contributed time, expertise and a good deal of effort to conducting these tests. If the STA is extended we intend to evaluate the performance of the FreeWave radios over a 75 mile line-of-sight path which is part of the New Mexico to Arizona packet backbone. We will also test these units as components of a mobile packet system.

We would like to work some more with the 915 MHz WaveLAN radios and to expand our research to include the 2.4 GHz WaveLAN radios for use in a high speed packet network to replace our existing 9600 bps network.

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The University of Texas Amateur Radio Club officially became a participant in the TAPR Spread Spectrum STA only about a month ago, but our club interest in Spread Spectrum has been steadily growing for the past six months.

Past Activities:

The University of Texas was the site of the December 1996 annual meeting of the Texas Packet Radio Society. Among the notable speakers at this meeting was Greg Jones WD5IVD, President of TAPR and STA holder. Greg spoke at length at this meeting on the topic of Spread Spectrum, including a live demonstration of the Spread Spectrum mode operating under the STA. The presentation and subsequent discussion was highly educational and extremely well-received, both by the TPRS membership and the University of Texas Amateur Radio Club members present at the meeting. In January, 1997, Greg Jones again spoke at the University of Texas, this time at our monthly club meeting. His presentation of Spread Spectrum and the STA was made to the largest meeting of the year. The University of Texas Amateur Radio Club is very excited about having had the opportunity to support educational presentations about the Spread Spectrum mode to its members and the larger ham radio community in Austin and Texas.

Present Activities:

The University of Texas Amateur Radio Club joined the STA with the initial intent of joining in a TAPR group purchase of Spread Spectrum radio modems. With several other STA stations in the Austin area, we believed we could help participate in building a prototype high-speed wireless data network. Our
club station is ideally suited for this, located with a kilometer or two of the geographical center of the city. As the group purchase has apparently fallen through, the club has not yet had an opportunity to become active with the Spread Spectrum mode. Instead, club members have been building the underlying support for the project by building and upgrading new computer systems for the club station, and testing networking software under more traditional digital modes. The club's goal is to maintain a powerful digital

platform in the club station capable of supporting our Spread Spectrum experiments under the STA, as well other digital networking modes, available to all club members.

Future Activities:

Club membership has voted to appropriate sufficient funds to acquire Spread Spectrum equipment for participation under the STA. The University of Texas Amateur Radio Club very much looks forward to participating in prototype wireless network experimentation in the Austin, Texas area, should the STA
be renewed. We feel that by pursuing this experimentation as a club effort, we can expose Spread Spectrum to club members, mostly students, at minimal individual cost and maximal educational benefit.

Appendix A

Dec 9 1996:

Greg brought over one of his units last night, and I got it going without too much trouble. I was working about a block long path to Greg's place. For some reason, it wanted an antenna, a dummy load just didn't hack it. I connected it to the one antenna I built that has a matching network on it, and (having previously been through the slave setup to make it recognize the one at Greg's place) it was already connected to Greg's unit by the time I looked down at the radio LED's. While I haven't checked stats yet, it appeared to be a solid connect.

As for the log, operation took place in the wee hours of the morning of Monday, December 9, between WB5AOH and WD5IVD, under the provisions of the SS STA. This was with the 902-928 MHz Freewave, the earlier 400 mW unit, operating into a gain antenna, which hasn't been measured yet for gain or impedance.

I reconfigured the Winsock here to talk to it instead of the ISP over the landline modem, and after a little consultation over the phone with Greg to get the SLIP setup in order, I was able to grab some web
pages off of Greg's server he has attached at his end. The speed of the transfer looked like I was on a fairly fast internet site, and I normally run a 14.4 kb/s landline modem.

As for the antenna: This is the 6 el yagi I have been talking about, and the only one I have equipped so far with a matching network. I had a Bird wattmeter in series, with a 5W slug in it. First observation is that of course the transmitter doesn't key up long enough to do anything but occasionally jiggle the meter needle, and then only during a long file transfer. (The caching mechanism of Netscape got in the way of repetitive file transfers). I did as I had anticipated, I hooked up the scope across the wattmeter meter lugs, and was able to roughly estimate that the SWR was less than 3:1, probably in the vicinity of 2:1. Because the meter movement is a very low impedance device, the voltage drop across it is very low, I had the scope gain turned up all the way, and had some background noise almost equivalent to the signal pulses. Anyhow, the SWR I just quoted was that observed on an antenna which has not been adjusted yet, it is as it was assembled. I just set the T-match about midrange of the driven element and locked it down. Tuning will come later on today, I presume I will try out the continuous test feature of the menu, and see how that works out. First readings appear that the antenna will be practical. The antenna was just lying on top of the couch, and have has some nearby metallic structure of unknown character, pointed in Greg's general direction. I also have a sliding line stretcher (trombone) in series with the antenna, to guarantee that I can positively observe any standing waves, as I have a phobia of having a wattmeter accidentally located at a resistive node in a standing wave, which sure makes all the testing invalid if you don't know it is happening. It also makes a convenient rotating coupling and will support the small antenna.

The Freewave manual has a precaution discouraging operation without a load on the antenna terminals, and I took that to mean that it doesn't have any SWR or open circuit protection, as might be assumed for a miniature device anyway. When I operated it into an unknown antenna load, I took the precaution of putting an attenuator pad (marked 7 db in this case, but 6db is more common) in series with the coax between the radio and the wattmeter. After I determined that the antenna would accept power and in fact was better than 3:1 SWR, I powered it down, removed the pad, and repowered it. I was connected to Greg's server at the time, and although there weren't any web pages in transit at the time it recovered transparently.

73 de Bob

>Bob: regarding the yagi antenna - a question as to it's bandwidth
>arises. Yagi's are normally somewhat narrowband, and the SS systems
>are possibly fairly wideband. Will you be looking at the gain and the
>SWR over the entire band that the FW radios use?
- Tom
>
>Tom McDermott
>mcdermot@aud.alcatel.com

Yes, that has been a concern I pointed out also from the beginning, and I read that it is more of a problem for FH than DS operation. I am hoping that the 28 meg width at 915 will behave. I can recall some 430-440 MHz antennas I have used that rolled off noticeably about 10-15 MHz off of their design freq, but they were much longer antennas. Hopefully, with the scope on some sort of an AGC point, the FH will enable observing such effects, but that is still in the future. If I see a problem, I guess I hope that some width change, like maybe a bow-tie, might help out the driven element. That also might be an advantage of the corner reflector, since it readily permits those mods. Apparently there are some similar sized yagis, like the one that Greg was using last Saturday, and they at least give the impression that they work. Optimized? I don't know.

(Using the scope on the wattmeter observing hopping ought to be fairly straightforward for looking at SWR bandwidth).

From what we understand, the FreeWave is spread all over 902-928. The problem is also a concern for amplifier and preamp designs.

73 de Bob WB5AOH

Dec 10 1996:

I have started tuning and testing the 6el antenna today. I thought I would share a little bit of the Bird wattmeter techniques with the group as I go along. Here's what I have discovered so far.

I am using a 5W slug for 400-1000 MHz, the range 5E slug. I selected it besides as being a little less expensive than the others, would also cover 450 as well, and sometimes I am given to testing 2-port
UHF splitters. Since I have 2 wattmeters (one without the case, just the pieces), this is feasible.

First thing, using a 5W slug with a 400 mW radio, it of course doesn't deflect too much. That I expected. What was the somewhat surprise is how low the duty cycle of the radio TX would be. While I haven't
forced any big outbound file transfers through it, it looks like it is around 5%, and that just barely wiggles the meter needle at best.

(Measurements of duty cycle were around 1.5 mS TX time, at about 22 mS slightly random intervals, test mode selection explained below).

As previously noted, I am using a sliding line stretcher between the antenna and the wattmeter element, so I can slide it back and forth looking for nulls and peaks, and assure myself that the line is truly flat when I finally get it tuned.

I had earlier anticipated using the scope on it, and that certainly came to pass pretty quick. The next discovery was that the meter movement has to go. Besides absorbing all of the signal across a very
low impedance, it also GENERATES noise that I can barely live with. It is a magnetic coil, and it does pick up extraneous noise. In addition, it will generate quite a bit of voltage by itself if the meter is moved or jiggled, since it is a mobile coil of wire of many turns inside a strong DC field, and just a little jar will drive the trace off the scope face. Since it also has appreciable inductance, it leaves some strong transients on the leading and trailing edge of a keyed RF value, and wiggles the DC reference around too, which throws off the baseline. So disconnect the hot lead from the meter, and hook it to the scope. There will now be some more signal available to read, and it will look MUCH cleaner as it keys and unkeys. You will still have to use a fairly high gain vertical sensitivity. I used the 50 mV/div scale without the meter in parallel (had to use the 5mV/div range with the meter in parallel). All of that with the 1X probe setting.

As for calibration, so far all I have done is relative forward / reverse observations, but there will come a time fairly soon when I will need some actual readings of power, using the scope instead of the meter. Here is how I propose this: use some repeatable (meaning predictable from one time to the next) source of RF CW power, and feed it to the wattmeter, and observe the meter reading with the meter connected, maybe at more than one power level if possible, and record that data. Then disconnect the meter, and observe the voltage developed on the scope for the repeated measurements, and relate the unloaded, rectified voltage to that amount of power. Remember things are nonlinear for two reasons, first power is a function of the square of the RF voltage, and second, there is a nonlinear diode in the circuit, somewhere inside that slug. Also at some point that diode will cease to conduct at all. Furthermore, we drastically changed the impedance of the load on the diode. There is a third complication, but it also exists if one uses the meter, and that has to do with the frequency response of the slug from one end of the band to the other. While you could do the above CW test at 450 using the UHF SSB rig, the exact amount of power at 900 might result in a slightly different meter reading, however the above test is primarily aimed at transferring a panel meter face reading to the substitute scope display. Stay tuned.

As for what I have seen coming out of the Freewave, and going into the antenna under test:

The Freewave is in the "test" mode, selected by changing main menu 3 (xmsn charst) parameter 3 (xmsn rate) from 1 (normal) to 0 (test), also I changed it from Slave to Master, as a convenient way of making
it not connect to Greg's unit a block away, as it would otherwise connect, and cease to trnsmit "continuously". Easier than having Greg take his unit down, or dummy out his "phone" number here, etc.
I couldn't hack my way into anything that keyed TX continuously with the letter "t" typed at the keyboard.

First, I had assumed that the radio would be hopping from freq to freq while the key was down. It doesn't, at least it doesn't appear that way to me. Right now, the antenna is of course not properly tuned, so there is some SWR, and as could be expected, it is frequency selective. So I am seeing pulses of power in either direction that are of different amplitudes, however the amplitude is constant over any individual pulse. So that tells me that it is moving freq in its randomized manner while it is unkeyed. I do get pretty square looking keying, so presumably there isn't too much delay through the slug diode and whatever filtering may be inside it.

Second, the antenna, in whatever state it is tuned now, it fairly frequency selective. I have some hops that have less than 10% reflected scope deflection (not power, remember), and some that might approach 30 or maybe even 50 % deflection, meaning it is approaching 3:1. (Starting to think about Corner Reflectors again).

Third, I have no way of knowing what frequency any particular hop is, at least not yet. I wonder if there is any known way to cause the Freewave to transmit on just one freq (so I could measure it), or if there is some table which relates each freq number to its actual freq, etc? Can individual hops be disabled one at a time, ultimately leaving one or just a few running? Can we turn off one end of the band at a time, to use the time honored test of changing freq from one end of the band to the other to tell if it is too short or too long? (I am trying to avoid buying another independent CW type 900 MHz radio).

Another observation, that applies to anyone well heeled enough to afford one of the 2-element Bird line sections, in other words, they make a line section with space for two slugs side by side in adjacent wells, and it has two output connections to attach two meters or external circuits. The idea is to make it possible to make forward and reverse simultaneous readings. Of course, that also doubles the investment in elements. The point of this is that such a wattmeter could be used to feed a dual trace scope, and one could see the forward and reflected readings side by side on the two scope traces. I have the dual trace scope, but not the dual wattmeter, and I imagine that is the general case. (To anticipate a question, my other wattmeter would possibly be too far away even if adjacently coupled, besides it happens to have SO239 "UHF" fittings, and anyhow I only bought one 5E element, so it won't pair up too nicely).

73 de Bob WB5AOH

Dec 11 1996

Now, connected to a dummy load (in fact I tried 2 different types of them to see that they ran OK at that new frequency for me; they did) I read exactly 0.4 W and that is spec from what I understand.

For one point on the curve of the wattmeter-scope scale, the slug delivered 145 mV average unloaded (meter out of circuit) for 0.4 W.

While I was set up, I put a 7 dB pad in the line from the radio, and saw 100 mW on the meter, and 55 mV on the unloaded output, so now there are 2 points on the curve. So the voltage readings yield -8.4 dB
and the power readings yield -6 dB effect. OH WELL... (I know that there are bound to be some ill effects operating at near bottom scale, and unloading the diode bridge, etc).

(Again, this is the Bird 5E 5 watt 400-1000 MHz slug under test here).

Another effect I just noticed is that apparently the radio is transmitting different amounts of power on different hops. I saw this on the antenna I was tuning, and didn't think too much about it, but I just now saw the effect on the dummy load, and it is flat. So it must have some tilt or broad resonance somewhere across the band. Since it is randomized, I can't tell where. I suppose that slightly complicates the antenna adjustments, although I am making most of the adjustments looking at reflected power, and I guess that's pretty standard of most folks tuning antennas. I have heard the tilt is fairly typical anyway, and as good as the radios have performed under some of Greg's torture tests, apparently it is OK. The actual amount of spread I saw was a developed voltage of from 125 mV to 170 mV, centered on about 145. The distribution looked to be fairly uniform to the eye, when slowed down to about 10 mS/div, and I could see definite pseudorandom patterns in the distribution, with a period I would roughly guess was around 30 or 40 mS (it slowly drifted across the screen to the left).

If I square those two numbers, and take the ratio, I get an apparent power ratio of about 1.8 or about 2.7 dB, from lowest to highest. Compared against the apparent center, I get -1.3 dB and +1.4 dB.

The mention of a choice of hopping patterns leads me to ask another "what-if" type of question: What if they had a hopping pattern that instead of pseudorandom, would sweep linearly up the band, so it would behave as a sweep generator for tuning purposes. Obviously the regs want pseudorandom for efficient communications, but we are talking about test and tuning functions here. Next logical question: I wonder if it is another hidden menu choice already, seems like they have some things like that already.

73 de Bob WB5AOH

Last night and this morning's (Dec 11, 96) antenna tuning progress was:

Got the SWR down to about 1.5:1 over the hopping range this morning, progress report going out sometime today. Looks like T-match will work fine, but had to trim the DE back, and I sure need to find out if any of the other elements need trimming back. This is the 6el yagi.

I was able to get some of the hop frequency SWR's down to almost flat, of course others walked out. By adjusting the length of the DE I was able to determine that the best ones were probably on the upper end of the range, but of course being pseudorandom, I couldn't identify them any further than that. So I trimmed a little bit from the DE and things improved somewhat. The sliding straps of the T-match behave about like a variable transformer tap (variac) to adjust the impedance ratio to the feedpoint, and thank goodness they work at around midrange, and I started trimming some off the excess of the matching stubs, and that changed things a little bit too.

Still to do is testing of the 12 el yagi, and it doesn't yet have a matching network, pending successful performance of the first one. Greg mentioned something about maybe trying it out at Ron W5RKN's place sometime soon. He is reasonably close by, maybe a mile or two west (Could scale that one off APRS screen).

Running Guido's wavetek about 3' from the antenna, it will sort of pick up some rather minor interference from the Freewave, but it isn't ever going to be objectionable to narrowband stuff as far as I can see.
That Freewave is pretty unobtrusive, I am impressed. That is, unless one enables the CW transmit mode, and then it covers things over pretty thick. I think that low duty cycle along with some fairly wideband
digital modulation wherever it does transmit make it pretty unobtrusive. Of course, with all the STUFF on that band, anyone interested in narrowband work would have to be nuts to use it there. There's all kinds
of strange digital QRM up there.

73 de Bob WB5AOH

Today (or yesterday evening if you prefer) Dec 12 1996, from about 2030 to about 0230 the next morning, I surfed the web at high speed over the ham radio. (I am sending this to both SS reflectors, this is for operations under the STA).

Greg set his system up on his ISDN line, and had his freewave radio on the other end (of course), and after a little bit of server configuration, and a tweak or two on this end, I was surfing the web, at speeds I wasn't accustomed to on my 14.4 kb landline modem.

One of the first things I happen to find on TAPR's server was the text of Lyle Johnson's speech at the recent DCC, and scanning through it, one paragraph in particular jumped out at me. Lyle was referring
to the SS beta test, and thought something ought to take place in early 1997. That is apparently on track, with the radio order looking like that will be the delivery date (from what I hear anyhow), but here it is the middle of Dec 96, and I am up and running. And Lyle said something about why we have Pentiums and hotshot landline modems, but still run 1200b packet on the air (well I run 9600 most of the time myself but that's another story). Well I smashed that barrier all to smithereens today at high speed, and it was fun. And VERY satisfying.

Greg said to turn the usual landline SLIP/PPP compression off before going on the air, apparently he isn't set up for that as yet. So I am running 38400b to a radio modem with an on-the-air modem speed of some 173Kb, to a server/router on an ISDN line with only him and me for users, and I am seeing average file transfer rates as displayed by Netscape of from 1800 to over 2400 bytes/sec (not bits/sec mind you). When I am on my 14400b landline modem, I guess running compressed, to my ISP down the road, I almost never see anything over 1300 bytes/sec average rate, and of course some of the slow sites back down to half that.

Then I would stop and think about what I was doing here for the first time. Look at the ll modem, it is off line. The file transfers are humming right along. For the first time, I can talk on the telephone while I am surfing the net. Never could do that before. Then I look over my shoulder at the serial cable running over to the SS radio, and the other end of that is a cable that goes to the antenna, and then it just disappears into space. At least for a block away to Greg's place, where his unit is doing the same. I look down at the oscilloscope that I have connected to the feedline wattmeter, and during the thick of the file transfer, there are some intermittent TX pulses about every 20 or so milliseconds (I am only seeing my acks, I wonder what Greg's radio dutycycle is). There is still a lot of empty time on that channel, at least what I can judge from this end. I guess this qualifies as real QRP operation too, just 400 mW, and a low duty cycle at that.
This little unit might make a dandy unit on a solar powered remote site too.

After I got tired of playing with TAPR's site, I turned to chasing some things on the web. I actually had a useful and productive session. I had been looking for some solar flare data, and I found it for the first time and downloaded about a megabyte of that, and all together, I probably pulled down somewhere I would estimate around 3 to 4 megabytes of all sorts of stuff, and may have set some sort of a personal ftp transfer record. As far as I could tell, things were working without a hitch, very smooth, no surprises.

That 1200b radio barrier we have let hang around all too long is just about to get swept away I think. While it has its uses, this has a lot of potential. And it is for real, right now today.

As far as the antenna project is concerned, I didn't get too terribly much more done on it today, but it is tuned reasonably close as far as the feedpoint is concerned, and around 1.5:1 SWR. But now that little 6 element beam has transferred several megabytes of data.

73 de Bob WB5AOH

Dec 15 1996

Greg said-
>Bob and myself started to play with pt-to-multipoint tonight.
>
>Didn't have much luck.
>
>Let me overview what we did and maybe get some suggestions on how to
>improve performance.

SNIP

So for the log here, I played with this with Greg from roughly 2100 or so in the evening of Sat Dec 14 through Sun Dec 15 at approx 0200 local, about 1100 or midnight we reverted to the original point-to-
point mode of the freewave as before, except that I think we have the master and slave roles reversed. I went back to surfing the net, and ftp'd another 2-3 mB of my NOAA solar data that I have been playing with. Got the same transfer rate during those ftp sessions as the other day, about 1800 bytes/sec average according to Netscape.

During the time we were tinkering with multipoint mode, the transfer rates slowed down like molasses in North Dakota during winter, saw some numbers mostly less than 100 bytes/sec and there were long delays of little or no data, and no activity on the scope I have hooked to the RF wattmeter.

(I spent 4 winters in North Dakota. I fought in the cold war in more ways than one.)

73 de Bob WB5AOH

Greg said-

>Dewayne just called and we discussed the posting I made this morning.
>
>Looks like the problem is going to be that Bob's system doesn't have a
>16550A in it.
>
>I guess we will have to get Bob a 16550A installed.
>
>Greg

Yeah, I know. Will start looking around. There weren't any stores open at 3AM this morning. Also I am wondering about the recent 16650 (32 byte buffer) chip. Will it help even more, or will existing 16550A compliant s/w notice the difference? If they are hardcoded to just empty up to 16 bytes from the buffer per interrupt, it would be superfluous, since they would only half-empty it out. If they removed bytes in a loop until it was empty, then it should help more. Who knows what they did? Also I wonder if this is going on in Windows itself, or in the WinSock?

Joe had a question if Win 3.1 itself might be too slow, having just been down that road just recently with a new Pentium board, and having comm troubles, and just upgraded to the 95 version of the windoze viruses. (A W95 upgrade probably/definitely won't happen on this hardware here). For my money, I would rather have Linux anyhow.

Todays log so far includes some more net surfing, mostly FTP activity that went just fine, still at 38.4kb and point-to-point mode, on Sunday Dec 15, from about 1130-1330, and again from 1530-1615 or thereabouts.

73 de Bob WB5AOH

dec 16 1996

>Todays log so far includes some more net surfing, mostly FTP activity
>that went just fine, still at 38.4kb and point-to-point mode,
>on Sunday Dec 15, from about 1130-1330, and again from 1530-1615
>or thereabouts.

Then I got on here about 2235 and messed around on the web until about 2320. Browsed around TPRS, TAPR, F6FBB and other places, and pretty sure I was into some european servers. It worked fine, and this is getting to be pretty commonplace, as long as Greg has his end up, in between his experiments.

Had a note from Wade, N5IST, who lives a whole block away also, and he is interested in the STA, having seen my report the other day. I referred him to Greg and TAPR SS pages. I think this high speed radio is starting to get some notice.

<SNIP>

73 de Bob WB5AOH

Dec 18 1996

>I just picked up a 2 port 'turbo serial I/O' card that had ST16C550C
>chips on on it.   Does up to 460kbps and can use 'AT' IRQs. There is
>supposed to be a 16650 version according to the box and 'manual', but of
>course they did have that one in stock. Its a no name Taiwan TC200 and
>Altex was selling it for $20.00. Linux did recognize it as having
>16550As, but until I have a radio, or figure out some other test, I won't

>be able to provide performance data.
>
>John, w9ddd

John, I went by Altex this afternoon and picked up a TC-200. It had a pair of ST16550CP (and not sure if this means it is a later or earlier than the "A" version, or if it is just packaging info). They didn't have the 650 either that I could tell, although I didn't get a chance to unpack all the boxes on the shelf and they had one clerk and more customers than they could handle. Anyhow, only blew $20, and it does have all the other IRQ's on it, so at least I don't have to scramblewire IRQ's to other cards. Have been there and done that before, and it does work. Thanks (I hope) for the tip. I had subconsciously ruled them out. Now, it is a mess to root around in that thing, but maybe will get a chance soon. But rest of this week i need to go finish antenna pruning, and run some pattern tests, etc., before going into production.

73 de Bob WB5AOH

Log for Monday Dec 16 and Tues Dec 17 1996 for WB5AOH:

Monday: played around a little bit, but minimally.

Tuesday: 2000-2200: Had apparent path problems, and couldn't determine why. No changes that I could tell, except that we had a big bad cold front come through town. But all the gear is indoors, antennas included. Just couldn't get any data through. Checked the usual stuff visually, and Greg and I reset the radios, etc. Nothing helped. This path has been ROCK SOLID up until now, although we hadn't downloaded any stats yet. Of course, in hindsight, we would have !! Oh well.

Greg observed that the local TV station had an ENG truck parked almost outside his door from around 2100-2200, so they could do a weather background shot for the 10PM WX report, and the cold weather etc
(The apt mgr had their usual "don't let your pipes freeze" sign out for all to see), and it made to TV on ch 24. So presumably they were running microwave in our very near vicinity. But it didn't improve when they left, and I GUESS we didn't bother them either.

Got a 16550 2-port card today, not installed yet. I think same as W9DDD got, anyhow his suggestion.

Planning to run antenna pattern / gain tests, perfect the match h / w, etc, and otherwise preparing to launch yagi construction in Jan.

73 de Bob WB5AOH

Dec 19 1996

I have completed 5 alpha-test yagi's and have tested them, specs are below. I plan to make up a "beta-batch" of approx 12 of the 12-el yagis and offer them to the amateur community through TAPR. These will be fully assembled, ready to mount, not kits.

No word on price yet, but I anticipate being competitive with the antennas that Down East Microwave markets, or it won't make sense to sell them.

I will continue to do some research and design of an omni-slot for horizontal polarization, and a corner reflector directional antenna. Possibly a "patch" antenna might be considered. Also, I will make some two way, and maybe also 4-way splitters available.

Another useful accessory that I had recently thought of would be a variable ratio coupler. This device would be applicable towards nulling out a point source of QRM, such as a paging transmitter. This device would be used with an omni type antenna as a main antenna, and an auxiliary yagi pointed at the point source to be eliminated, and would feed an attenuated copy of the undesired signal into the main line from the omni, to completely null it out. I have had some prior experience with a device of this type on a 2M repeater RX back in the 1970's, and measurements at that time yielded about a 5 deg notch at least 50 db deep in the pattern. If one runs polarization opposite to the undesired point source, then the pattern effect on the desired coverage would be about insignificant. The device is a three port coupler, probably the main in-out ports are a simple tee, and contains a variable attenuator and a phasing adjustment, and one tunes the adjustments alternately until the point source QRM disappears. Probably it would take the form of two variable length sliding transmission sections, one acting simply as a variable length line (for phasing) and the other may be a waveguide-below-cutoff attenuating section, which adjusts both amplitude and phase. Of course, two antennas would be necessary for such a system. Any interest out there?

The 6 element antennas were a little disappointing. I don't plan to make up any of them for awhile unless specifically requested to do so. They didn't have a real consistent and repeatable set of data, besides being of fairly low gain. They would be useful as an "almost-omni". In times past, I have used 4 el beams for PBBS service to reach slightly favored populations, but not for real point-to-point work. However the 12 el yagis produced fairly acceptable results, although the efficiency and pattern measurements indicated there was some further optimization possible. That's why I am calling this a "beta", and offering them. I will try to get this batch of about a dozen made up over the holidays, depending on how quick I can get some aluminum bought. Gets a little tricky doing business this time of year.

SPECIFICATIONS FOR 33 cm ANTENNAS

YAGI Model No.	Y33-6	Y33-12
Elements	6	12
Frequency	915 Mhz	915 MHz
Boom length overall	20"	35"
Boom Dia / material	< 1" Al 6061T6, wt .065" or .058" >	
Element dia / material	< 3/16" Al 6061T6 >	
Impedance	50 ohms	50 ohms
Matching network	T-match + Balun	T-match + Balun
DC Continuity	All DC grounded	All DC grounded
Mounting / polarization	Horiz / Vert	Horiz / Vert
Forward Gain	5 dbd	10 dbd
F/B ratio	5 db	10 db
Beamwidth E-plane	40 deg	51 deg
Beamwidth H-plane	52 deg	45 deg
Test VSWR *	1.5:1	<1.5:1
Connector	N female	N female
Test date	12/22/96	12/22/96
Effective boom length	1.22 wl.	2.26 wl.
Power rating	<100 W.	<100 W.

*note: Range over 902/928 MHz of FH Freewave radio.

Robert Morgan WB5AOH

Dec 29 1996

>Intereting comment Don.
>
>I look forward to what Bob Morgan's reply will be to your message. From
>what I have read thus far on Bob's work, I think he has a design that will
>both work and can be fabricated using equipment he has access to.
> <<snip>>
>Cheers - Greg
>
>> Hi,
>>
>> Some years ago, I looked into the Alford slot. The mode on the slot is
>>similar to the mode on a patch antenna. I didn t pursue the Alford slot due
>>to mechanical dificulties. I could not see a way to make a long slot, in
<<snip>>
>> The basic problem with the slot array on 915, is the cost of an aluminum
>>tube to do the job. Something could be fabricated from sheet, and heliarc'd

>>along a seam for a circular waveguide, or along 4 edges for a retangular
>>waveguide. I have a welder in the neighborhood here, and he charges $50/hour
>>shop costs. There are aluminum waveguide manufacturers, one of the biggest
>>is down there in Texas. But, at 900 Mhz, we are talking custom stuff, for
>>sure. Even using the stressed skin construction technigues I use for my
>>antennas, would be expensive for such a large tube. It would be no problem
>>for me to fabricate such a thing tho.

<<snip of patch antennas>>

>>73, Don.

OK, here's the reply. I have been out of town too long, got stuck in Waco where I was fabricating antennas, and ended up watching the ice storm which kept me from doing much antenna work. I got tired real quick of machining Al pipe at freezing temperatures, talk about aluminum chill factor.

ANYHOW, here is where we stand.

I have made up the basics of 15 each 12el yagis for 915 MHz. Only had connector hardware to finish one of them, but will be on the horn tomorrow to order the rest of the stuff pronto. But the one looked pretty good at first SWR test (it is a slight redesign beta) but owing to the icing conditions on the "test range" I didn't get the gain/pattern retest done. (I swear if I ever finally move far enough south to avoid winter, I
will probably wind up in Cancun). While I haven't yet got the manhours per antenna where I want it yet, given some time and a few more jigs and tools, I think I can be competitive. Anyhow I will be able at least to ship a few antennas fairly quick I think. If I can't make the price competitive to Down East Microwave, then we ought to buy from them if their stuff is decent, I haven't seen it yet though.

As for the omni slot design, I have partially fabricated a prototype but am a week or maybe two away from testing it. I did get the slots cut in a piece of pipe, and the hand cutting process will have to get revised into a decent milling process or it won't be practical. But it is ready to finish fabrication of the feed assembly taps.

This omni slot antenna for 915 MHz, unlike some other designs, is a narrow piece of pipe, 1.25" Al sched 40 pipe to be precise, and has a length (height if you prefer) of 5'. It is an array of 4 slots, all above one other on the same side of the pipe, and since the pipe is fairly small diameter, the wave "wraps around" the whole pipe, and approximately becomes omnidirectional. Not perfectly, but fairly decent. In the case of most installations it will probably end up sidemounted to any worthwhile tower anyhow, so I wouldn't think that 2db or so of ripple in the pattern would be a serious problem. Or so it looks on paper. My guess is that the behavior probably starts to approach that of a set of stacked halo rings, just extended into the active portions of the cylinder in the vicinity of the slots.

Since this antenna pipe is way too small in diameter to act as a waveguide (it is a long way beyond cutoff) it can't be fed waveguide style, but must be internally connected with some kind of a harness. I have fabricated a parallel conductor open line feeder that fits inside the pipe, and have only to devise suitable means to tap it into each slot's feedpoint, and then ONLY to manage to make it match and tune. It most likely will have a tuning stub in both top and bottom (but then some waveguides do too), and at least on the prototype will probably have an impedance ratio adjustment too. This stuff still has to be tinkered around with, so far it is only on paper, and even only just the concept not the details. Talk about vaporware!

At first I thought I would be crazy to seriously think about suspending open parallel lines inside the pipe, but after playing around with the impedance numbers a little bit, I discovered that there is a fairly broad region where the impedance of the line doesn't change too far with spacing (as it gets farther apart, it also gets closer to the tubing ID), so I am not as concerned as I originally was about detuning due to mechanical tolerances and wander. Electrically it didn't look like any other feed method could be feasibly manufactured into the innards of the pipe. Time will tell.

This antenna design isn't new, but maybe to most US hams it may as well be. I found it written up in a '61 translation of a 1950 Russian microwave textbook that I just blundered onto browsing around in the attic of the local engineering library. It was pretty well tested and written up, but the skimpy part was the feed method, it just mentioned that it was necessary to feed them in phase and match to the impedances of the slot. At least they had some claimed test data of slot impedances to make use of. In a week or two, I will find out if it is in the ballpark. Also there could be a question of bandwidth to be answered. Another question to be answered has to do with wall thickness, and this pipe is pretty thick indeed. Tubing is also a possibility, but cutting away slot material could leave thinwall tubing pretty weakened.

As for the price of the omni antenna, it is a lot more work, and also a lot more material than a Yagi. I am going to make an offhand stab at maybe double. I would roughly compare it in both gain and complexity to the old DB224 or something like that, but if I can't keep it at somewhere around the $100-$150 range there is something wrong. But the slot milling procedure will certainly have to improve or they will become one of a kind handmade wonders. It took the better part of the afternoon to cut 4 slots with what I had available, and a trip back to the store for more bits. (I have enough pipe for 4 antennas at present).

I do intend to make some money on the antennas, and Greg and I plan to see TAPR get some markup also. But I still want them to be affordable. The reason I opened my mouth in the first place was I was hearing that some of the antenna sources weren't affordable and I intended to make my own. That expanded into a sideline startup. Those who know me know that I have never believed in ripping folks off to construct networking. Joe and I built a network in eastern Okla that ran 9600b trunk performance for below 1200b prices, and it has been running reliably for years. I do think that the omni slot is an unfilled niche, and I would like to fill it, if this design really works. I used to know a line foreman that said if only engineering drawings would catch fire at the spot where there was a short circuit on the paper drawing. Right now I don't know. The mathematics looks pretty good, it just remains to see if it can be made to work, and manufactured affordably.

If this stuff works out, it can be scaled to other frequencies for other purposes, and anyhow there are other uses of the 915 MHz band that this stuff can be used for.

By the way, I might as well introduce the name these things will be manufactured under. It is called "Aus-Tex Data-Wave". The names of the antennas will be just old generic model numbers like Y33-12 or similar, there aren't any trademarks or anything. The yagi's are the NBS design anyhow, and this omni slot was published over 40 years ago. The name is only a company DBA name in Austin (where else - kinda like old Aus-Tex Chili), not the name of any particular product, antenna or otherwise. There's nothing proprietary here that I can tell, and it isn't exactly rocket science as the saying goes. If it does work, I will
probably publish a DCC article on it.

I am still planning to make some 2-port splitters, and have acquired some of the extrusion already to start a few. I think I can beat the competitive prices quite a ways in this area. I haven't made up a 915 MHz prototype yet, but have been making 445 MHz jobs for years. The only tricky part is keeping, or letting, the water out.

I hope to have a few pictures on a webpage, and some better handle on pricing and specs in about a week or so. I'll go surf the web in a day or two and look at the Alford job, etc. to see what they are talking about, but from what I just skimmed of the thread of the last weeks QSO, it probably was a wide diameter waveguide design. I think that my design would be more desireable from a size and bulk standpoint, and part of its marketing advantage is that it could appear inconspicuous.

73 de Bob WB5AOH

Appendix B

```
'  SS22.BAS
'  96.11.27
'  Copyright Frank H. Perkins, Jr., 1996

SCREEN 12

PreTrig = 0       ' scope arm
Trig = 1          ' scope trigger
K = 0             ' TX code index
Bit = 1           ' Tx bit seed
DBt = 0           ' RX bit init

DIM H(30)         ' matched filter correlator coeffs
DIM D(31)         ' SS chip data

DIM Tx(30)        ' TX PN code

DATA 1,1,-1,-1,1,1,-1,1,-1,-1,1,-1,-1,-1,-1,1,-1,1,-1,1,1,1,-1,1,1,-1,-1,-1,1,1,1

FOR P = 0 TO 31

  D(P) = 0        ' clean out matched filter

NEXT P

FOR P = 0 TO 30

  READ AA
  Tx(P) = AA
  H(30 - P) = AA   ' fill correlator coeffs from top down

NEXT P

DO

  GOSUB TxSig
  GOSUB Corr
  GOSUB DataBit
  GOSUB Scope

  C$ = INKEY$

   IF C$ = CHR$(13) THEN EXIT DO
   IF C$ = "q" THEN EXIT DO
```

```
LOOP

END

TxSig:

 K = K + 1

  IF (K >= 31) THEN K = (K - 31)

  IF K = 0 THEN Bit = -Bit

 T = Bit * Tx(K)

RETURN

Corr:  ' correlator

 A = 0
 D(0) = T

 FOR P = 0 TO 30

  M = H(30 - P) * D(30 - P)
  A = A + M
  D(31 - P) = D(30 - P)

 NEXT P

 O = A

RETURN

DataBit:

 IF O > 25 THEN DBt = 1
 IF O < -25 THEN DBt = 0

RETURN

Scope:

IF (Trig = 0) THEN

 IF (T <= 0) THEN
```

```
    PreTrig = 1
  END IF

  IF (T > 0) AND (PreTrig = 1) THEN
    Trig = 1
    PreTrig = 0
  END IF

END IF

IF Trig = 1 THEN

  PSET (Y, 400), 12

  Z1 = T * 50                    ' SS Tx signal
  IF (Z1 > 50) THEN Z1 = 50
  IF (Z1 < -50) THEN Z1 = -50

  D = 80 - Z1
  LINE (Y, 80)-(Y, D), 10

  Z2 = 2 * O                     ' corr Rx signal
  IF (Z2 > 100) THEN Z2 = 100
  IF (Z2 < -100) THEN Z2 = -100

  E = 240 - Z2
  LINE (Y, 240)-(Y, E), 10

  Z3 = 50 * DBt                  ' received data
  IF (Z3 > 80) THEN Z3 = 80
  IF (Z3 < -50) THEN Z3 = -50

  B = 400 - Z3
  LINE (Y, 400)-(Y, B), 12

  Y = Y + 2

END IF

IF (Y > 639) THEN

  Y = 0
  Trig = 0
  CLS

END IF
```

RETURN