SEARFE – Students Exploring Australia’s Radio-frequency Environment

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Introduction

Astronomers use optical telescopes to study the light from objects in space. Radio astronomers use radio telescopes to find objects in space that emit radio waves. Radio waves can tell us about the size, shape, and behaviour of the object, what it is made of and what lies between it and the Earth.

Radio telescopes receive and concentrate radio waves. These waves can then be processed by computers and interpreted by astronomers. Radio telescopes are often dish-like, and the bigger the dish the more sensitive the telescope. Radio astronomy dish antennas, like those at Parkes and Narrabri in NSW, are familiar to us all.

To develop more sensitive dish antennas astronomers from other countries have built bigger dishes. But bigger is both difficult to design and environmentally obtrusive. The new generation of radio telescopes uses many small antennas linked electronically by computers. This system allows a very large antenna array to behave like a huge dish that can probe the universe for very faint radio signals.

As the cost of designing and building such an array is prohibitive for any one country, an international consortium of astronomers is working collaboratively to raise the funds, design the array, and find the most radio-quiet location to build the array. This array is now known as the SKA (Square Kilometre Array) telescope. It will have a collecting area 100 times that of the current largest radio telescope. There are two papers that describe this international project in more detail (Robertson 2001, Irion 2002).

Astronomers from the CSIRO Australia Telescope National Facility (ATNF) are monitoring radio frequency use in Australia to find our radio-quiet areas. Once we have this information, we can bid for Australia to be the site of the SKA. This facility would have many benefits in terms of international recognition, employment opportunities and stimulating Australian science, engineering and high-technology industry.

The SEARFE Project is a collaborative outreach project involving High School teachers and students in the search for the best site for the Square Kilometre Array. The SEARFE Project is being coordinated jointly by CSIRO ATNF, the School of Physics (University of Sydney) and the Faculty of Engineering (University of Technology Sydney).

The aims of the Project include:

- Giving students hands-on experience in using radio-science equipment, making measurements and interpreting data in a real-life research project
- Providing teachers with material and activities relevant to the radio-frequency wave propagation and astronomy units in the Physics, Senior Science and Engineering Studies HSC syllabuses
- Helping students reach a better understanding of the use and value of the radio spectrum for telecommunications
- Enabling communication between city and country school students, giving them valuable experiences in use of the Internet for collaborative research
- Helping students gain an appreciation of radio-quietness as a significant natural resource
- Giving students the satisfaction of contributing to the search for the Square Kilometre Array telescope site.

The Project

At least ten High Schools will be involved in the project in 2002 and 2003 and the research will also run in two university outreach activity centres. There is a waiting list of schools that would like to participate, once we have funds and equipment to
enable them to do so. We hope to continue to run SEARFE over many years and include as many schools in Australia as possible.

Each school involved in SEARFE will be supplied with:
- An AOR AR3000A radio-frequency scanning receiver
- An IBM laptop computer for data acquisition and display
- Software for spectrum acquisition and display
- 25-1300 MHz discone antenna and all necessary cabling
- Resource Kit including operating instructions, experimental notes and background information.

The software is written in the Java programming language. The Java language was chosen for its computer and operating system platform independence, as well as its large public domain software library and development tools. The graphic display routines use the VisAD (Hibbard, 1998) package while Sun Microsystems’ Forte for Java Integrated Development Environment Community Editions was used in developing the software. Spectra of radio frequencies scanned can be displayed as they are acquired. Publicly available packages along with the relevant source code will be made available to the students to allow them to extend or develop the software further.

By working as part of the SEARFE research team students will be able to:
- Discover radio-frequencies used in their area and identify the source of some of the signals
- Monitor variations in signals and learn about radio-frequency propagation
- Learn about the equipment they are using; for example, by exploring differences with different antennas and different antenna positions
- Use an Internet-based database and conferencing system to communicate with students in other areas and learn about the differences in use of the radio-frequency spectrum between city and country areas
- Make a valuable contribution to the knowledge-base upon which Australia’s bid to host the international SKA telescope will depend.

Over time the SEARFE project will build up a database of radio-frequency use around Australia. This will be useful for radio astronomy in general, as well as being specifically useful for the SKA site studies.

The Process

Students and teachers will be involved in setting up their own equipment then using it in a variety of ways.

To become familiar with the equipment and radio frequency use in their area the activities will guide students to:
- Tune directly to a local radio station using the receiver
- Scan for a local radio station using the SEARFE software
- Tune to a local TV channel
- Print the scans they have collected
- Experiment with various antenna positions

Students will then scan the radio spectrum over the whole range being investigated. They will be able to print their results and also send them electronically to the SEARFE website where they will be able to compare them with scans from other areas across Australia. By scanning at different times of the day and days of the week, a better picture should emerge of radio frequency use in each area. Students should also be able to identify radio-quiet frequencies and times for their area. This information will be useful for the SKA site search.

Project Launch and Opportunities for Involvement

The SEARFE Project will be launched on June 21, 2002 and equipment will be in schools involved in July. Educational benefits are being formally assessed by the Education Research and Development unit of Abbotsleigh School, Wahroonga.

The SEARFE website is http://www.searfe.atnf.csiro.au/. Project documentation will be available on this site as it is developed and students will be able to log questions, comments and results via the site. We welcome feedback on the Project, and if you would like your local schools to become involved, please contact Michelle Storey on michelle.storey@csiro.au.

Supporters and Sponsors

People who have helped with the SEARFE Project so far include:
Duncan Campbell-Wilson (Uni Sydney), Anne Green (Uni Sydney), Peter Hall (ATNF), Julienne Harnett (Uni Technology Sydney), Betty Jacobs (Uni Technology Sydney), Paul Krautil (Pymble Ladies College), Oliver Mather (UNSW/Uni
Newcastle), Vince McIntyre (ATNF), Janet Pemberton (Abbotsleigh School), Michelle Storey (CSIRO Publishing/ATNF), George “Nyima” Warr (ATNF), Andrew Wright (ATNF).

Supporters and sponsors of the SEARFE Project include:
- CSIRO ATNF
- School of Physics University of Sydney
- Science Foundation for Physics University of Sydney
- Faculty of Engineering, University of Technology Sydney
- IBM Australia
- BAE Systems Australia
- Perth Observatory
- Australian Geographic

Appendices

The Appendices include samples of the SEARFE documentation from the Resource Kit. The documents included in the Appendices are:
- EasyGuide: Receiver
- EasyGuide: Operating the Receiver from the Computer
- EasyGuide: Installing the Antenna
- Students Activity Guides
- Background Notes: Science with the Square Kilometre Array telescope
- Background Notes: Radio-quiet Reserves and SEARFE Research

References


GUIDE - AR-3000A COMMUNICATION RECEIVER
When in doubt ask your teacher and refer to the Instruction Manual

First, read through the Manual taking particular note of SAFETY CONSIDERATIONS and proper care of the receiver.

Start-up Procedure
- Attach the appropriate aerial to the rear of the AR Receiver – Whip aerial or Discone antenna
- Connect to power by plugging the power supply into the 12V DC plug on the back of the receiver.
- Never use a different power supply. Only use the AC adaptor plug provided with the receiver (not the type shown in the Manual).
- Before turning on the power switch, set the VOLUME to zero and SQUELCH to zero (the fully anti-clockwise position)
- Turn on the power source
- Turn on the POWER button on the front of the receiver.

Direct Tuning Instructions
- On the back of the AR Receiver, turn Remote switch to Off
- Using the buttons on the front of the receiver (see diagram opposite) press [DIAL] to allow you to dial a frequency
- Press [MODE] and use the UP or DOWN buttons to select WFM or AM band for the station you want to find
- Press [ENTER] to select this band
- Press [STEP]. The STEP button allows you to enter the rate at which the tuning knob will move through the frequency band e.g. in steps of 0.05 kHz or 50 kHz
- Enter the step size in units of kHz you would like the dial to move in e.g. kHz for AM band [.] [0] [5] [ENTER] to program the tuning knob to move in steps of 0.05. For WFM band this should be set at 50 kHz
- Press [ENTER] to select this Step.
- Enter a frequency (in units of MHz) below your station number e.g. Press [.] [7] [0] [1] [ENTER] for 702 ABC
- Adjust the tuning knob to find the station you are looking for. The tuning knob will move in units of the step size you have selected.

Reset Instructions
When you get into difficulties or press the wrong button
- Press [ENTER]
- Start the procedure again from the beginning
- Otherwise turn off the Power Button and start again.

If all else fails reset the microprocessor erasing all memory contents
- Turn the power switch off

The receiver will power up with the factory default settings.

Specifications
- Model: AR3000A
- Receiver coverage: 100 kHz ~ 2036 MHz
- Tuning selection: 50 Hz - 999.95 kHz - programmable
- Receiving modes: AM, WFM, NFM, USB, LSB & CW
- Number of memory channels: 400 total (4 x 100)
- Number of search banks: Four
- Aerial connection: 50 OHM BNC
- Audio output: 0.7 WATTS 8 OHM load @ 10% distortion
- Power requirement: External 12V DC @ 0.5A (nominal 13.8V) negative ground approx.
- Size: 138mm (W) x 80mm (H) x 200mm (D) Approx. excluding projections
- Weight: 1.2kgs
GUIDE - OPERATING THE RECEIVER VIA THE COMPUTER

Set-up Procedure
- Connect the receiver to the computer using the 9 pin socket to 25 pin plug serial cable provided. The 25 pin plug connects to the back of the receiver and the 9 pin plug connects to the computer.
- Turn on the computer and the receiver.
- Turn the ‘Remote’ switch on the back of the receiver to ‘On’. This enables the receiver to be remotely operated via computer.
- Double-click the Launch Spectrum Scanner icon on the desktop of the computer.
- Wait while the program loads (roughly 15 seconds). During this time a logging window will appear. When the program loads a Spectrum Scanner window will appear.
- You can either select to view a scan you have previously made, or start a new scan.
- To start a new scan, click the button labelled ‘New Scan’
- Set the scan conditions you require by inputting values in the series of windows.

Window 1 – Spectrum Scan Conditions.
The first window describes conditions external to the receiver. Select the appropriate values for these inputs, either from the list available, or by inputting a new value.

Add any extra relevant notes, which you would like to be recorded with the data file, about the scan you are about to perform. When you have input values for all the variables in this window, press Next to view the next window.

Window 2 – Set up the AR3000A Receiver
This window allows you to enter the details of the scan you want to make. Input appropriate values for all the variables here.

Note the time that each scan will take and the time that the total number of scans will take. If the time is too long shorten the frequency range to be scanned, or shorten the number of scans and/or the delay between individual scans. When you have input appropriate variables here, the Next button takes you to the next window.

Window 3 - Spectrum Scan Status
This window describes progress through the scans you have requested. When you are ready to begin scanning, push the Start button. If you wish to stop the scan before it is completed, push cancel.

If error messages appear, check that all the equipment is correctly connected and that the values you have input are reasonable. If you continue to have problems contact the SEARFE mentors through the SEARFE-chat hypermail site.

When the Scan is completed you will be able to view the data in graphical form. You can also store the graphical output file and analyse it further later or post it to the SEARFE website for discussion.

A SEARFE Software Glossary over gives information on what is meant by the various terms.
Window 1 - Spectrum Scan Conditions

**Location:** This refers to where the scan is being made in Australia, e.g. input your school location here, or wherever the scan is being taken.

**Operator Name:** Input an identifying name for the operator or team here.

**Antenna:** Select whether you are using the receiver’s own antenna, the discone antenna supplied or a different antenna.

**Antenna Transmission Line:** Select whether you are connecting the receiver to the antenna with a cable, and the length of the cable.

**Low Noise Amplifier, Low Noise Amplifier Transmission Line:** These are for a later stage of the experiment. At this stage, these values should be ‘none’.

**Receiver shortwave pre-amp:** An internally switchable shortwave preamplifier (which is active only between 100kHz and 30 MHz) is fitted into the AR3000A and is set to the ‘On’ position. This should be left ‘On’ unless you are advised to turn it off by the SEARFE mentors.

Window 2 - Set up the AR3000A Receiver

**Start Frequency.** The frequency at which you want the receiver to start taking measurements.

**Stop Frequency.** The frequency at which you want the receiver to stop taking measurements.

**Frequency Increment.** The step size in MHz, which the receiver will step through taking an intensity measurement at each frequency step.

**Dwell time.** The time for which the receiver will pause between moving to a new frequency and taking a measurement. This should always be at least 50ms to allow the internal receiver electronics time to stabilise.

**Number of scans:** The number of scans to be recorded one after the other.

**Delay between scans.** The time delay between completing one scan and starting the next in the series requested.

**Receiver Mode.** The receiver can be set to different modes, optimised for particular types of signals received. Page 52 of the receiver manual gives the bandwidth and sensitivity of each mode available. Further information on different modes of transmission of radio signals is contained in the Background Notes.

**Attenuator.** This may need to be on in certain circumstances. Leave in ‘Off’ position unless advised to turn it on by the SEARFE mentors. More information about the attenuator and its purpose is available in the receiver manual.
GUIDE - ASSEMBLING THE DISCONE ANTENNA

Important: don’t panic and don’t rush!

First, read the Instructions that come with the discone antenna, and identify the various labelled components. In particular, READ THE SAFETY INSTRUCTIONS on the reverse side of the Instructions.

Make sure that no components are damaged and all are there. Note: some of the screws are already in place in the apex assembly. We recommend that you work on a large sheet or other area where you can clearly identify screws and washers that fall out of your grip and would otherwise get lost between floorboards etc!

Detach the support pipe from the assembly, taking care to put the three M3 screws in a safe container. Insert the coaxial cable (provided with the SEARFE equipment) into the bottom end of the pipe and push it gently, until the end is above the top of the pipe. You can then attach it to the coaxial receptacle at the bottom of the apex assembly. The SEARFE mentors have already attached the correct adaptor to the apex assembly to enable you to connect the coaxial cable. Remember to replace the M3 screws and washers to reconnect the pipe to the assembly. Be careful not to cross-thread the screws.

Fit the large caps to the unthreaded ends of the radial element rods. Then use the hexagonal wrench (often called an Allen key) to bolt each radial element rod to the apex assembly. Note the instructions on the manufacturer’s sheet about the tightness of the bolts. Be careful not to cross-thread the rods or twist the coax cable excessively.

Remember: don’t rush!

Now screw the M4 nuts onto the threaded ends of the disc element rods. When you have completed this, screw the threaded rods into the holes on the upper side of the apex assembly.

Place spring washer 01011 onto the threaded top of the apex assembly. Screw the loading coil down onto this washer.

Fit the top element into the top of the loading coil and screw the set screw (01010) into the hole on the top side of the loading coil. This stabilizes the top element.

Your antenna should now be ready to go! When you are ready to permanently mount your antenna, you can use the brackets and bolts provided, but first experiment with the antenna not permanently mounted in various locations to find the most suitable at your site. The antenna can sit on its diagonal legs, so long as you are careful.

Diamond Wideband Discone Antenna

Specifications

<table>
<thead>
<tr>
<th>Frequency Range:</th>
<th>25-1300 MHz for receiving (Amateur frequency bands and personal radio frequency band for transmitting)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length:</td>
<td>1.7 m (66.9&quot;)</td>
</tr>
<tr>
<td>Weight:</td>
<td>1 kg (2.2 lbs)</td>
</tr>
<tr>
<td>Max. Diameter:</td>
<td>0.41m (16.1&quot;)</td>
</tr>
<tr>
<td>Mast Diameter:</td>
<td>25 to 52 mm (0.98&quot; to 2.05&quot;)</td>
</tr>
<tr>
<td>Max Power:</td>
<td>200 W at transmittable frequency bands.</td>
</tr>
<tr>
<td>Type:</td>
<td>Wideband omni-directional Discone antennas.</td>
</tr>
</tbody>
</table>
To take part in the SEARFE Project you need to be able to use the equipment:
- The AR-3000A Receiver with its whip antenna
- The SEARFE software on the laptop
- The discone antenna.

The next activities take you through the steps to help you familiarise yourself with the SEARFE equipment.

NOTE: Although it is legal to tune in and listen to broadcast frequencies, for some frequencies it is not legal to act on any information received. Ask your teacher if you are not sure what is meant here.

1. Tuning to a local radio station using the receiver

Find out the frequency at which a local radio station transmits (e.g. 702 kHz is ABC in Sydney)

Follow the Guide - AR-3000A Communication Receiver to tune it to the local station by the
- Direct tuning method
- Dial tuning method.

Practice using the receiver by trying to find a few more stations.

2. Scanning for a local radio station using the SEARFE software

Follow the Guide – Operating the Receiver via the Computer to scan across a range of frequencies (e.g. a 10 MHz range) near the frequency of your local radio station.

Your results will appear as 4 graphs and will also be saved on your computer as a text file to use later.

One peak will represent the local radio station you were scanning for. You may be able to identify what other frequency peaks represent, either by tuning to each frequency with the receiver and listening, or by using resources such as the Australian Communications Authority database.

3. Tuning into a local TV channel

Both the Jaycar website and the Dick Smith Electronics websites have data sheets available listing radio frequencies used by TV stations and other transmitters.

Find the frequency range being used by a local TV channel.

Use the Receiver and Software Guides to set up and scan the bandwidth of the channel you are trying to find.

It is always advisable to check how long the scan you have programmed in will take.

Can you identify the various signals being broadcast?

You can check the sound carrier frequency by tuning to it with the receiver and then also tuning a TV set to the relevant channels. The sound tracks should be the same!

Experiment with using a smaller or larger frequency step to determine which step size gives you maximum useful information in minimum time.

The SEARFE team would appreciate it if you could let us know what seems optimum for you, as this will help us refine the experiments. Ask for advice using the SEARFE-chat hypermail when you need it.

4. Printing your results

Print your results directly from the SEARFE Software or use the Guide – Printing a Scan Using Microsoft Excel to import the text files you have produced in these activities into an Excel Spreadsheet. Print out a graph of the local radio station and TV channel.

The next important step is to understand how to use your antennas most effectively. The AR-3000A Receiver comes with its own Whip Antenna, and you also have a Discone Antenna. Background Notes on Antennas contain basic information on how antennas work and how the discone antenna in particular functions.
The discone antenna comes with its own set-up instructions, there are also some helpful hints in the Guide – Assembling the Discone Antenna.

5. Positioning your antenna

It is important to position the antenna as far away as possible from sources of local interference. You will need to experiment with different positions of the antenna to try and find the best location. Possible initial investigations are suggested below. Please email your findings to the SEARFE team as your results will be important for other team members and future SERFE students, so that we can learn what likely sources of interference are and how to avoid them.

For the radio-quietness scans it will probably be best to locate the discone antenna outside and as high as possible. Perhaps a school maintenance person can mount the discone somewhere high and isolated using the mounting brackets provided. Again please email us with ideas and your findings as to the best mounting locations. Pictures especially welcome!

Possible initial investigations to explore best antenna positioning.

a. Use the whip antenna.
Position the receiver near your computer
Set up a short scan from 50-200MHz at a frequency increment of 0.5 MHz, and extra dwell time of 50 ms and running 2 scans.
Print out the resulting graph
b. Detach the whip antenna
Attach it to the cable supplied.
Attach the other end of the cable to the receiver
Position the antenna near the receiver and laptop but make sure it does not touch either of them
Set up the same scan as in (a)
Print out the resulting graph
c. Position the antenna as far from the receiver and laptop as possible, in various locations.
Set up the same scan as in (a)
Print out the resulting graphs
d. Set up the Discone antenna as far from the receiver as possible using the instructions supplied.
Set up the same scan as in (a)
Print out the resulting graph

Compare the graphs to find any effects you can detect with distance from sources of em radiation (like computers and power cables) and length of aerial cable.

Do you experience significant loss of signal strength when using the long cable?

Experiment with the Discone antenna to find the best location for it to be mounted.
The purpose of SEARFE is to find out how much of the radio-frequency spectrum is being used, and for what fraction of the time, at various locations around Australia. In this activity we would like you to explore the radio frequency spectrum in your local area, take various scans over different frequency ranges at different times of the day and hopefully different times of the year.

Communicate your results on spectrum use to students at other schools and to the SEARFE scientists. We would like you to take some scans spanning the range of frequencies 300 MHz to 1 GHz. However, we suggest that you take some shorter scans first and begin to build up a picture of where the radio quiet regions of spectrum are in your local area, and what time of day they are radio-quiet.

We don’t know what you will find so cannot give specific advice on what you should try. We will all learn as we progress – very much the nature of real research.

1. Quick scan for radio spectrum use in your area
   - Set up the scan
   - Remote
   - WFM
   - 100-300 MHz frequency range
   - 0.2 frequency increment
   - 50 extra dwell time
   - 2 scans

   How long will this scan take? ---
   - Identify your local radio spectrum users and radio quiet bands
   - Create a graph and examine the radio quiet areas on your graph
   - What happens if you look at quiet areas with a more detailed scan?

2. Whole spectrum scan for radio spectrum use in your area
   - Set up the scan
   - Remote
   - WFM
   - 100 kHz, 2000 MHz, 0.2, 50, 2

   How long will this scan take? ---
   - Identify your local radio spectrum users and radio quiet bands
   - Examine the radio quiet areas on your graph.

3. Working with the SEARFE Research Team
   - When you have results that you are happy with, upload your results to the SEARFE website following the instructions you will find there.
   - Look at the results of other areas in Australia
   - What are the similarities and differences

   Email other researchers with your comments and questions about the team results, their similarities and differences.

   You can compare your results with others posted. Please let us know any useful conclusions you can make.
This has begun your research as part of the Australia wide research team to examine radio spectrum use and radio quietness in Australia.

We need to investigate what happens at different times of the day, different days of the week, different times of the year? Remember to be consistent so all the results can be compared.

To be true scientific research your investigation must be standardised across all teams, controlled, reproducible, replicated and well documented. You need to consider the controls that will make data from your team comparable with data from the other teams.

Please send your ideas to SEARFE-chat so that we can ensure that our results are the best they can be. SEARFE Mentors will work actively with you on developing the best experiments for your area.

Keep in touch and have fun!
Science with the Square Kilometre Array telescope

The study of the stars has captured the imagination of humankind for tens of thousands of years. Even in our modern, visually exciting world, most people find the dark night sky an awe-inspiring sight. Astronomy satisfies a deep-seated human wish to understand more about our place in the universe.

To search deeper and deeper into space we need larger and more sophisticated telescopes to measure the light and other radiation from distant objects in the universe. The Square Kilometre Array telescope (SKA) will be one of these telescopes. It will be a radio telescope, detecting and processing radio waves rather than light.

The diagram below highlights science that will be possible with the SKA. The SKA will be able to look simultaneously in more than one direction, indicated by the several beams directed at different cosmic objects. It will also be able to minimise the impact of radiation from man-made sources such as radio communications transmitters and strong nearby satellites.

For further information
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Australian SKA web site: http://www.atnf.csiro.au/ska/

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The following gives an overview of some of the key fields of investigation that work with the SKA will focus on in order to obtain a deeper understanding of the universe.

1. Probing the Early Universe
The SKA will be able to detect very weak radiation. This means that it will be able to study galaxies that are very distant from us. The radio waves emitted from these galaxies have travelled for a long time to get to us, so when we study this radiation we are seeing galaxies as they existed long ago. We think that the universe emerged in a “Big Bang” explosion roughly 14 billion years ago, which created all space, matter and energy. As matter from the Big Bang expanded and cooled it began to form lumps, which then evolved into galaxies and stars. Using the SKA astronomers will be able to see radio-waves that have come from these first structures of the very early universe and will be able to answer fundamental questions about how the universe evolved.

2. Exploring cosmic structures
Because the SKA will see very faint objects in fine detail it will enable major advances to be made in many areas of radio astronomy. Some examples are given below.

**Dark Matter.** Matter can be detected through its gravitational pull, and measurements of gravitational effects on objects in space indicate that there is vastly more matter in space than just the matter that we can “see” from the radiation it emits. This is the so-called Dark Matter. The SKA will give more information on the way galaxies move, and thus on the Dark Matter in these galaxies. This will help us to learn how much matter there is in the universe.

**Gravitational waves.** Pulsars are tiny spinning stars with a very precise spin rate. The spin rate is altered when a gravity wave passes by the pulsar. The SKA will be able to time a number of pulsars to accuracies of better than a microsecond, and so will be able to detect gravity waves, the ripples in the overall geometry of space produced by moving objects. One cause of gravity waves is thought to be pairs of giant black holes orbiting each other. Black holes are the most compact form of matter, and the gravitational pull of a black hole is so great that, on its surface, not even light can escape. Finding gravity waves will help confirm that these black hole pairs exist.

**Search for Extraterrestrial Intelligence (SETI).** The SKA could conduct searches for intelligent life elsewhere in the universe with a sensitivity up to 100 times greater than is now possible, and will be able to detect any Jupiter-size planets orbiting stars near our solar system.

**Space tracking.** The SKA will be able to simultaneously track many satellites and space probes, and detect and track asteroids, including those which may get dangerously close to the earth in the future.

**Gamma-ray burst sources.** Intensely powerful explosions producing bursts of very high-energy radiation called gamma-radiation have been recently observed. The SKA will be able to follow the life of these massive explosions, which are now thought to produce black holes. It will be the only instrument in the world able to see the fine details of what is happening in these explosions.

3. Discovering the Unexpected
Scientists have predicted the experiments they will be able to perform for the first time with the SKA. They believe they will solve many current mysteries with the new telescope. However, history has taught scientists that such innovative new equipment as the SKA makes unexpected new discoveries that radically change our view of nature. We expect the SKA to fundamentally change our understanding of the universe.
Radio-Quiet Reserves and SEARFE Research

An international radio-quiet reserve would be a world-recognised area that could be made available for investigations that required a radio-quiet environment, i.e. one where the levels of radio-frequency radiation were low over a significant portion of the spectrum for a significant proportion of the time. There are no international radio-quiet reserves in the world today, but there is interest in establishing one or more (see Background Notes, Regulations controlling mankind’s use of the radio spectrum). The central site of the Square Kilometre Array radio telescope needs to be located on a radio-quiet reserve.

It would be important to choose an area for a radio-quiet reserve that was already radio-quiet, because it would be politically and economically difficult to request that existing services be stopped. In addition, the reserve would need regulatory or legislative protection controlling activities starting up nearby that would generate unacceptable levels of radio-frequency interference.

It is likely that Australia contains some excellent sites for a radio-quiet reserve. Because the population density is so low inland Australia is still radio-quiet. In many locations there is also good access to the sophisticated infrastructure, like optic-fibre links and power sources, which facilities would need. The needs of a radio-quiet reserve are quite compatible with conservation needs and it is possible that a radio-quiet reserve could happily be located in a conservation reserve. At the moment, CSIRO ATNF and various State Governments are actively working towards establishing a radio-quiet reserve in Australia.

One of the complex issues is to determine how you would define radio-quietness. What is of most interest to radio astronomy (and others who require radio-quietness) are the areas of frequency spectrum in between licensed transmitter frequencies in a particular area. The quality of a radio-quiet reserve (or radio-quietness anywhere) will realistically depend on how much spectrum can be defined as not being used and how radio-quiet these unused areas really are.

One of the important tasks is to identify where the radio-quiet locations are in Australia. This is where the SEARFE Project will make a valuable contribution. The SEARFE Project will assist CSIRO and the State Governments in identifying areas of potentially quiet spectrum; areas where not many transmitters are operating. CSIRO ATNF is developing portable radio-frequency receiving equipment to use to explore the radio-quietness of particular regions to very high sensitivity levels. SEARFE Project data will help to direct the high-sensitivity radio-quietness investigations, both in location and in frequency. The data will also give us valuable information on how accurate theoretical modeling being conducted is of the radio-quietness of various regions.

For more information contact
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