ATNF Interference Mitigation – Operational Plan

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1. Introduction

Operational interference mitigation is concerned with reducing the impact of self-generated and external RFI on astronomy. It includes activities such as:

- compilation and maintenance of observatory RFI databases for both terrestial and satellite interferers;
- identification of external and self-generated RFI sources using physical measurement;
- design and installation of new equipment in ways that maximise its electromagnetic compatibility (EMC) with sensitive astronomy receivers and associated equipment;
- training of engineers in EMC best practice;
- testing of commercial and custom equipment to ensure satisfactory EMC performance;
- promoting the long-term goal of moving observers and non-essential staff (and attendant sources of RFI) from the immediate telescope precinct.

While longer-term strategic interference mitigation programs aim to minimize the effect of external RFI using data processing techniques, this complementary operational plan outlines activities which prevent or reduce self-generated emission, and which characterize and identify external sources of interference, allowing astronomical observations to be planned more effectively.

In general terms, single-dish radio telescopes are affected more by RFI than arrays. Typically though, the array immunity amounts to 30 dB (a factor of 1000) while interferers may easily be 150 dB above (10^{15} times as great as) astronomy signals. RFI is therefore an issue at both Parkes and the ATCA, although operational mitigation strategies pay greater attention to, e.g., weak self-generated interference at Parkes. Parkes is also at more risk owing to its low-frequency observing capability. For example, the bus clock speeds of personal computers now match the input band of the 75 MHz observing system, and CPU clocks may exceed 500 MHz. As computers and networks become faster they generate fundamental and harmonic radiation extending to, and beyond, the 1420 MHz HI rest frequency. While recognizing the need for sound RFI mitigation techniques in essential equipment, the ATNF sees that a sensible longer-term strategy involves separating people and their computers from the immediate area of the telescopes.

Another general observation concerns the difficulty of retro-fitting installed equipment to good EMC standards. In many cases this is difficult or impossible, and retrofits should only be considered in the case of essential, largely self-contained, apparatus. Even in these cases, results can be disappointing. The key to low RFI is to design and install according to good EMC practice. In the case of the ATNF, this presents a challenge – our systems are often high-frequency, high-speed, and physically distributed. Furthermore, we use commercial equipment which is imperfect. Nevertheless, the ATNF

is beginning to recognize that resources contributed at the design and system planning level pay substantial dividends.

2. Resources Summary

The table below sets out capital and manpower needed to implement particular initiatives. Note that the manpower refers to the additional component needed. In some areas it is assumed that all, or most, of the effort would come from normal operational resources.

Site	Item	Priority	Capital Cost ($Ak)	Manpower (m-yr)
Epping	Screened Anechoic Chamber	1	150	1
	Screened Chamber – Test Equipment	1	100	
	EMC Software CAD Tools	1	40	
	EMC Training	1	40	
Parkes	Screened Room - Tower	1	150	1
	New UPS	1	60	
	Focus Cabin RFI Palliatives	1	40	1
	RFI Monitoring Station	1	20	1
	RFI Database, Visualization	1	40	1
	Control Build Relocation Study	1	20	0.5
	EMC Training	1	20	
	EMC Software CAD Tools	2	20	
	TIMS Extensions	2	40	1
Narrabri	Screened Room Upgrades	1	20	0.5
	RFI Monitoring Station	1	20	0.5
	EMC Training	1	20	
	RFI Database, Visualization	1	40	
	EMC Software CAD Tools	2	20	

3. Notes on Individual Items

Epping Screened Chamber and Test Equipment
This item gives ATNF design and development engineers the opportunity to hone EMC design skills and, most importantly, the opportunity to evaluate objectively the EMC compliance of new equipment before it is despatched to observatories. The facility would be an organization-wide one, in that Parkes and Narrabri engineers would be encouraged to become proficient in its use. The benefits of having a screened room facility close to central development laboratories should not be under-estimated; easy, hands-on, access is vital if our engineers are to improve the quality of equipment delivered to observatories. As an aside, it ought to be noted that such a facility is essential in developing antenna elements and RF systems for the square-kilometre array.

EMC Software CAD Tools
With the growing awareness of EMC in industry, most electronics CAD software now has extensions which simulate (with varying levels of realism) the RFI performance of printed circuit boards and sub-systems. As a bonus, these tools often perform signal integrity analyses of high-speed circuits: a significant advantage to designers. Typically, the tools cost of order $20k per licence and the estimates and priorities tabulated reflect the needs of the various sites.

EMC Training
While some ATNF engineering staff are expert in the principles of interference minimization, we need to extend the awareness to the technical officer and computer support ranks. The figures quoted for training assume that staff in these areas receive first-level EMC awareness training by external training organizations.

Parkes Screened Room
With the increase in the speed of digital equipment and the growing reliance on commercial equipment in critical data acquisition and recording roles, the only practical RFI mitigation strategy involves enclosing many items in a screened enclosure. The figure quoted assumes that a modular room, similar in size to the existing computing/correlator area, is installed.

Parkes UPS
The uninterruptible power supply at Parkes is now over 15 years old. The equipment is showing its limitations when loaded with devices requiring large crest factor (peak/average) current waveforms (e.g. switch-mode power supplies). Apart from basic electrical limitations, such loading results in poor voltage waveforms from the UPS, causing harmonic and related low-frequency interference to be induced (or coupled by earth return mechanisms) into sensitive astronomy equipment. It is appropriate to replace the UPS with equipment similar to that at Narrabri and Mopra. These supplies were specified and purchased with crest factor and RFI performance in mind.

RFI Monitoring Stations
These stations would be located at Parkes and Narrabri, following initial development and trials at Parkes. The stations would be located far enough from the telescopes and other structures to avoid reflections and multi-path confusion. Rotatable or switchable antennas would provide directional information, greatly assisting in identifying sources of RFI. Real-time outputs would be available to observers and engineering staff. As an aside, these stations most likely have considerable value in strategic programs requiring reference antennas sensitive to interference alone, and in building up temporal interference statistics.

Parkes Focus Cabin RFI Palliatives
This initiative would substitute RF-tight enclosures and associated filters etc. for the receiving system racks currently in place, bringing this part of the focus cabin upgrade to the EMC standard of the translator drives and control system. In some cases it may be possible to to extend the palliative measures to individual receiver packages.

RFI Database and Visualization
The ATNF is gaining considerable value from a database of terrestial and satellite interferers, and associated manipulation and visualization tools. Much of the material is already available in a first-generation web-based tool (with options for use at all Australian observatories). Extensions to the system are already being evaluated, including options to display (in an easily interpreted way) moving satellite interferers. To maintain the databases, and to continue the development of visualization tools, additional workstation and manpower resources are needed. While the main development work is sensibly done at Parkes, ATCA observers will also benefit by having database interrogation and visualization platforms at Narrabri.

Control Building Re-location Study
The growing use of faster digital (e.g. PC) and communications technology by observatory staff and visitors is a major problem. Even if we could afford the high cost of screening work areas, the resulting enclosed environment is too unpleasant for long-term occupancy. The only practical solution is to move non-essential staff and systems further from the telescopes, gaining roughly 70 dB/km suppression. While Parkes observers would be the main beneficiary of such a move, this first-round study to assess costs and benefits would also examine the ATCA situation.

TIMS Extensions
The Transportable Interference Measurement System will be operational in basic form by early 2000. This item extends the capabilities of the system (and particularly its correlation backend) to locate and display a wider range of interference (such as low-level impulsive signals) at ATNF and other sites, including potential square-kilometre array sites.

Narrabri Screened Room Upgrades
As more digital and communications systems are successfully re-located to the existing large screened room, the requirements for items such as line and power RFI filters is

growing. This item ensures that we approach the ultimate screening integrity of the Narrabri enclosure by replacing many breaches of the screening with EMC compliant paths.

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