DARA Unit 2-3 Lectures
Radio Frequency Interference

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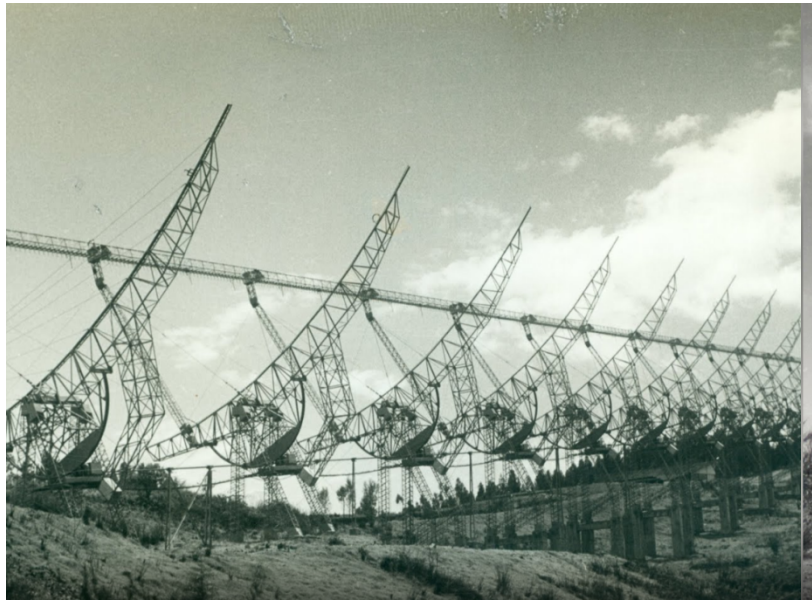
Growing up at ORT and OSRT… 1974-84



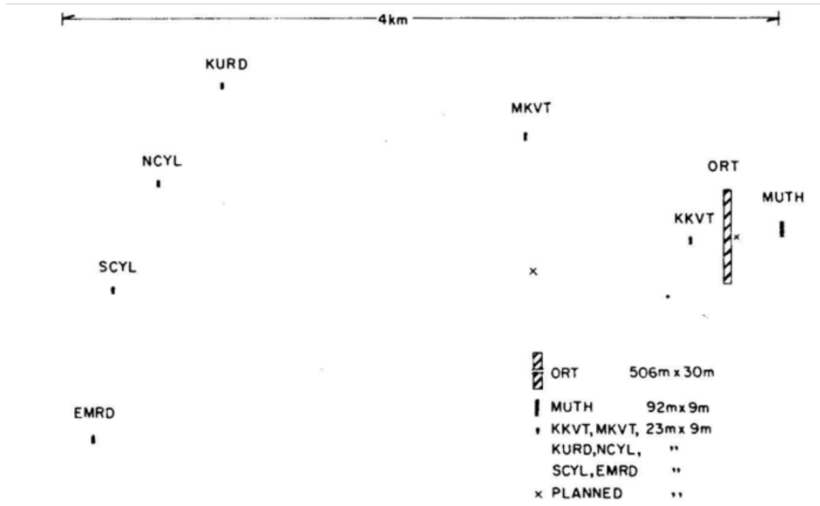
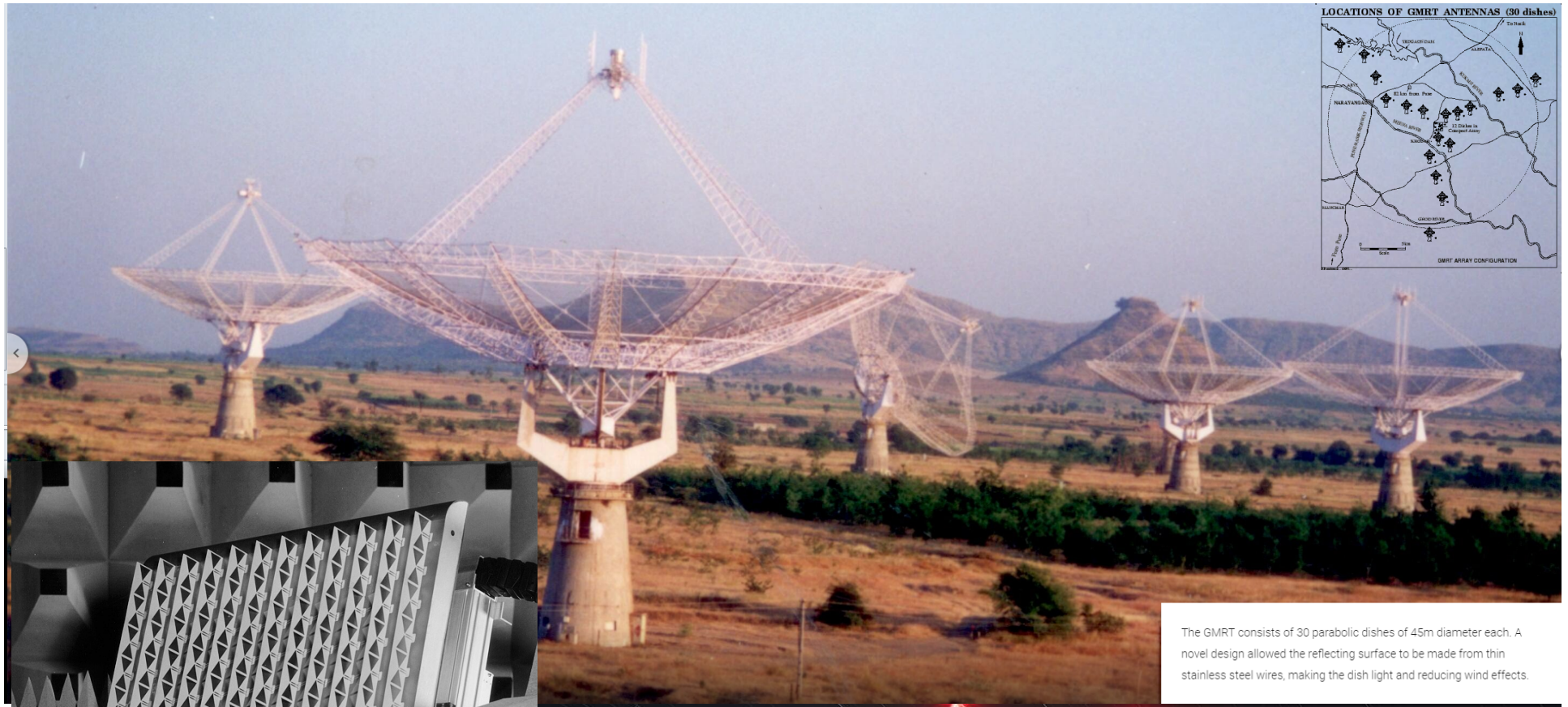
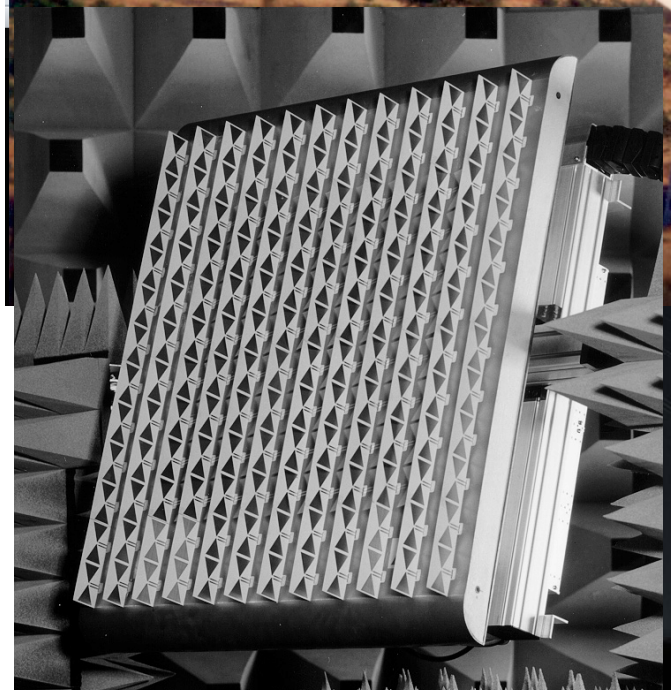


Figure 1. Configuration of the 4-km Ooty Synthesis Radio Telescope (OSRT).

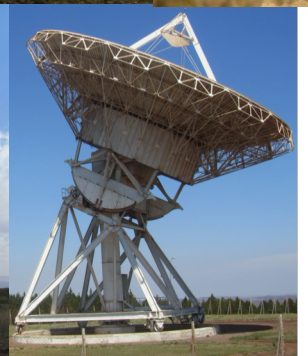
Mid career…. GMRT and OSMA 1985-2007



The GMRT consists of 30 parabolic dishes of 45m diameter each. A novel design allowed the reflecting surface to be made from thin stainless steel wires, making the dish light and reducing wind effects.



The Finale: KAT-7, MeerKAT & AVN 2008-17



Currently, quality time with family in India; Involved in setting up 3 Geodetic VLBI stations in India; DARA support etc.

Plan

- The Electromagnetic Spectrum – A Primary Resource in Communication
- Interference and Types of Interference
- Few anecdotes on RFI in radio astronomy observatories
- Mitigation Measures – in domains other then DSP

- Over to Nadeem, to talk on Mitigation Measures in Data Processing

The Electromagnetic Spectrum and Radio Astronomy

- A Radio Telescope is NO DIFFERENT from any other communication receiver you know of like cellphone, television etc, EXCEPT that the Transmitter here is FAAAAAAR away and radiates electromagnetic waves by NATURAL phenomenon.
- The Radio Telescope System processes and records the VERY SMALL perturbation in the background noise as received from a celestial object in the field of view of the antenna
- The recorded signal with an accurate time stamp is used for studies towards interpretation of the physics of the object and thus lead towards advancement of our knowledge in the fields of astronomy, astrophysics and cosmology through techniques of radiometry, spectroscopy and accurate timing
- The document https://www.itu.int/rec/R-REC-RA.314-10-200306-I/en lists the preferred frequency bands for radio astronomical measurements
- THUS, THERE IS A WIDE RANGE OF FREQUENCIES USED BY RADIO ASTTRONOMY COMMUNITY AROUND THE WORLD. HOWEVER, ONLY A SMALL SUB-SET WILL BE OF RELEVANCE FOR A RADIO TELESCOPE. FOR EXAMPLE, GRAO IN GHANA USES:
  - VLBI at 5 GHz: 4926.49 to 5054.49 MHz
  - Methanol, Single Dish and VLBI: 6650 to 6685 MHz.

The Electromagnetic Spectrum and ITU, NCA, ICASA etc

- The International Telecommunication Union (ITU) is a specialised agency of the United Nations. It recommends and coordinates usage of the electromagnetic spectrum internationally through Radio Regulations.
- ITU has recognised RADIO ASTRONOMY as one of the ~THIRTY services needing spectrum allocation
- The spectrum is regulated, allocated and managed between the services nationally by National Communications Authority (NCA) in Ghana, Independent Communications Authority of South Africa (ICASA) in SA etc. They also coordinate harmonious usage across borders.
- Protected chunks of spectrum from 9kHz to 300 GHz is available with a roughly octave spacing for continuum research in radio astronomy. Protected narrow chunks are also available for spectral line studies (Eg: 1610-1612.6 MHz for OH line studies).
- Allocation varies as PRIMARY (exclusive/ shared), Secondary, Additional, Foot Note mention etc.

Interference to Radio Telescope

- Interference

  ɪntəˈfɪər(ə)ns/

the action of interfering or the process of being interfered with.

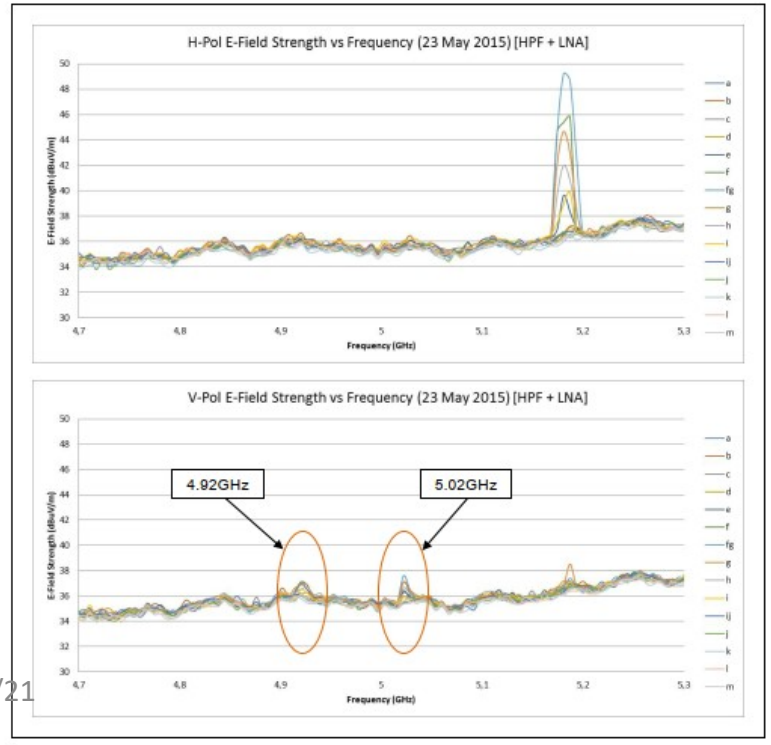
synonyms: intrution, intervention, intercession, involvement, impinging, encroaching, trespass, trespassing, obtrusion; butting in, barging in; meddling, meddlesomeness, tampering, prying, poking around, nosing around;

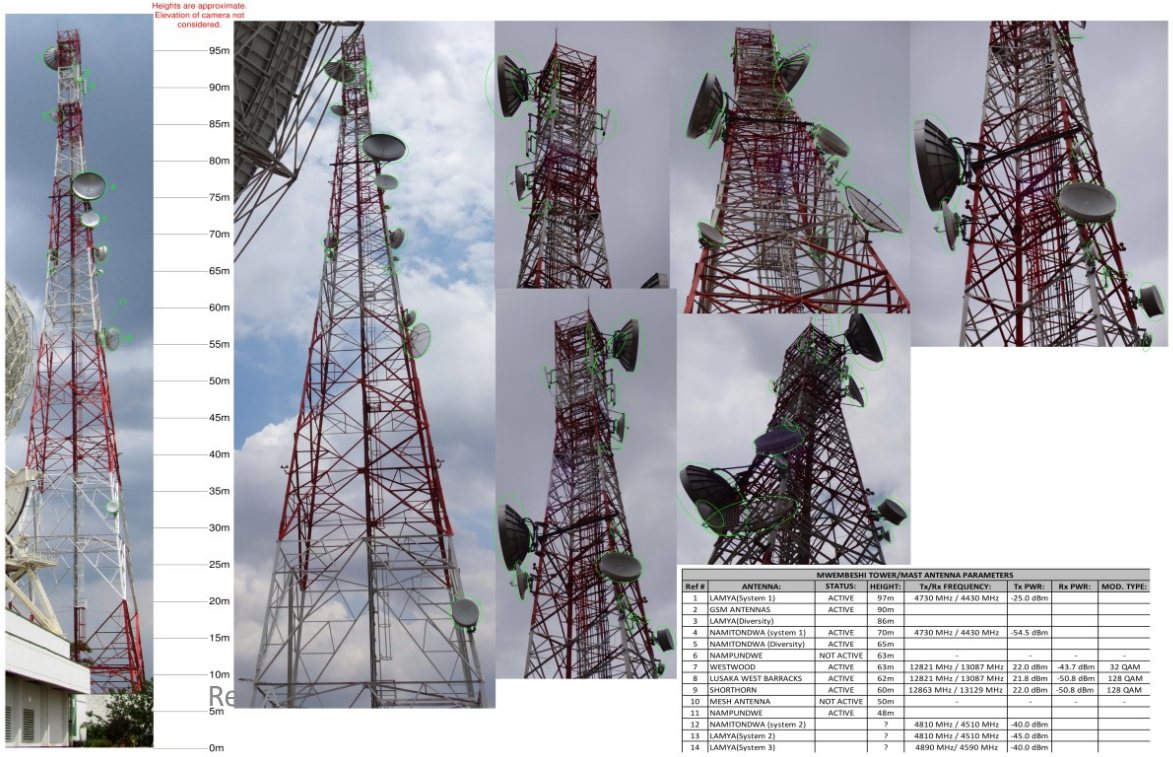
ONE PERSON'S FOOD IS ANOTHER'S POISON

- Radio astronomers have set a limit of 10% loss of data owing to RFI as JUST acceptable and above 10%, unacceptable. This requirement is now incorporated by reference in the ITU Radio Regulations.
- VLBI mitigates against interference because the SAME interference is not present at both sites, and does not therefore correlate. However, t does affect the measurement of system noise and hence the calibration of the system, so it is important to minimise it.
- The Radio Astronomy Receiver operates over a wider range of frequencies to study red-shifted lines and the designer needs to "harden" the design to achieve a linear system in the presence of other signals
- A MAJOR EFFORT OF COORDINATION WITH OTHER USERS, ACTIVELY SUPPORTED BY THE SPECTRUM REGULATOR OF A COUNTRY IS CRITICAL FOR THE SUCCESS OF ENDEAVOURS IN RADIO ASTRONOMY

Types of Interference to Radio Telescope

- Conducted (powerline etc) and Radiated RF (microwave oven etc)
- External (cellphone etc) and Internal (self-generated – harmonics, intermodulation in receivers)
- RF and Non-RF



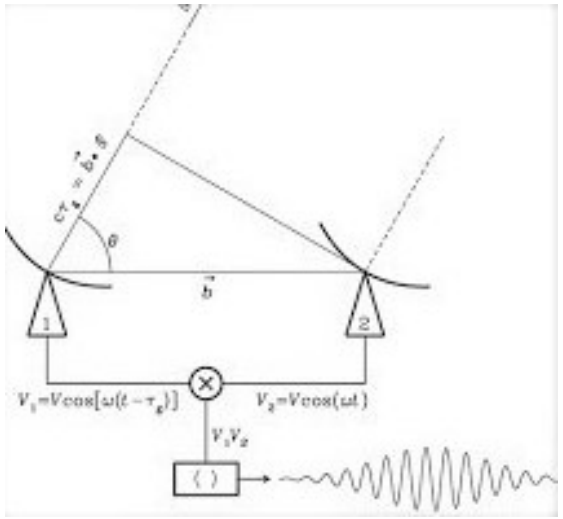


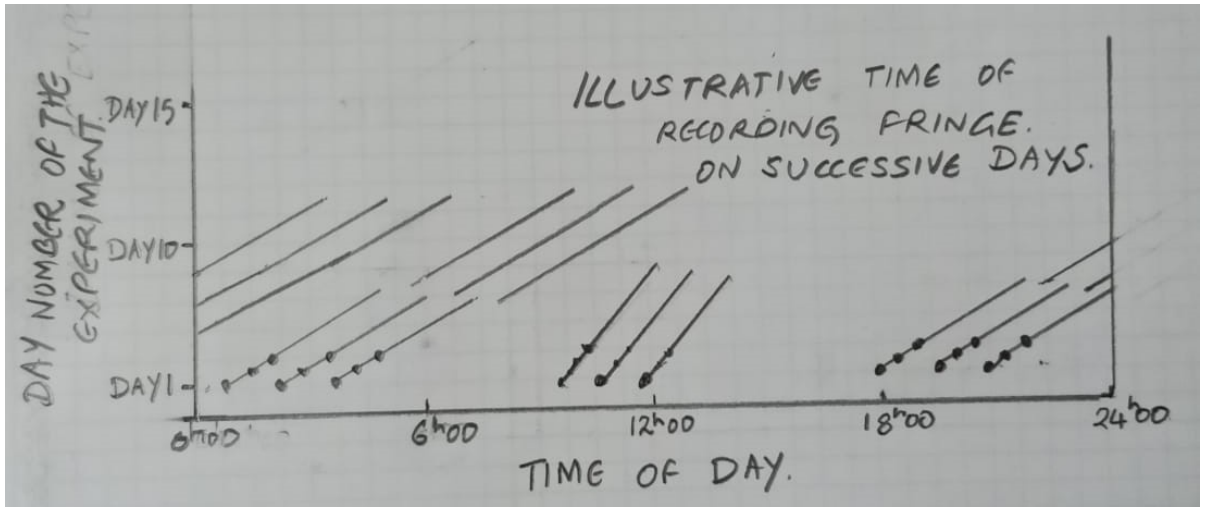
MWEMBESHI TOWER/MAST ANTENNA PARAMETERS

Ref #	ANTENNA:	STATUS:	HEIGHT:	Tx/Rx FREQUENCY:	Tx PWR:	Rx PWR:	MOD. TYPE:
1	LAMYA(System 1)	ACTIVE	97m	4730 MHz / 4430 MHz	-25.0 dBm		
2	GSM ANTENNAS	ACTIVE	90m				
3	LAMYA(Diversity)		86m				
4	NAMITONDWA (system 1)	ACTIVE	70m	4730 MHz / 4430 MHz	-54.5 dBm		
5	NAMITONDWA (Diversity)	ACTIVE	65m				
6	NAMPUNDWE	NOT ACTIVE	63m	-	-	-	-
7	WESTWOOD	ACTIVE	63m	12821 MHz / 13087 MHz	22.0 dBm	-43.7 dBm	32 QAM
8	LUSAKA WEST BARRACKS	ACTIVE	62m	12821 MHz / 13087 MHz	21.8 dBm	-50.8 dBm	128 QAM
9	SHORTHORN	ACTIVE	60m	12863 MHz / 13129 MHz	22.0 dBm	-50.8 dBm	128 QAM
10	MESH ANTENNA	NOT ACTIVE	50m	-	-	-	-
11	NAMPUNDWE	ACTIVE	48m				
12	NAMITONDWA (system 2)		?	4810 MHz / 4510 MHz	-40.0 dBm		
13	LAMYA(System 2)		?	4810 MHz / 4510 MHz	-45.0 dBm		
14	LAMYA(System 3)		?	4890 MHz/ 4590 MHz	-40.0 dBm		

A few Anecdotes on mitigating RFI in Observatories

- The Hunt for "~6 RFI Events/Day" at Ooty, India in 1977





- The Oscillating LNAs at Ooty circa 1980
- The TV Booster LNA improvement at a few thousand private residences around GMRT in India during 2000-2006

A few Anecdotes on mitigating RFI in Observatories

- The Sherlock Holmes of VLA – Identifying source of sporadic night time broad-band interference
- Voluntary RFI prevention measures by residents of Greenbank
- MeerKAT mobile Control in south Africa
- RFI - Perytons

RFI Mitigtion Measures

- Adequate Headroom in receiver design for linearity
- Care in choosing frequency of Local Oscillator signals
- Shielding
- Earthing, Powerline Management
- Filtering
- Observatory RFI discipline
- Active participation National and Internatinal Spectrum management activities
- Outreach to local community
- RFI algorithms in data processing – Over to Nadeem

QUESTIONS

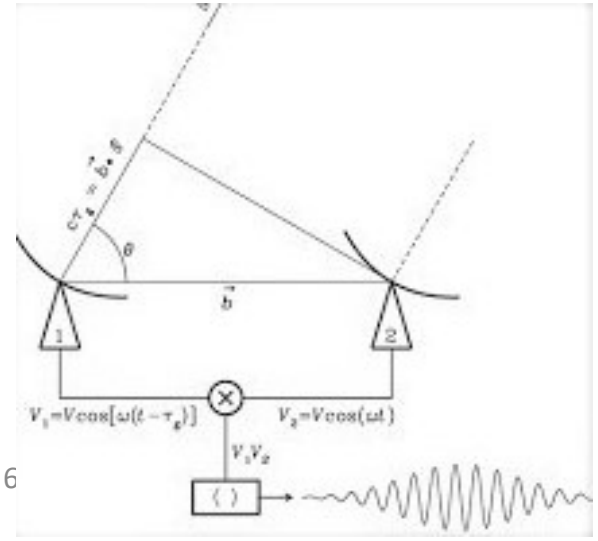
Allocation to services		
Region 1	**Region 2**	**Region 3**
1 300-1 350	RADIOLOCATION AERONAUTICAL RADIONAVIGATION 5.337 RADIONAVIGATION-SATELLITE (Earth-to-space) 5.149 5.337A	
1 350-1 400 FIXED MOBILE RADIOLOCATION 5.149 5.338 5.338A 5.339	**1 350-1 400** RADIOLOCATION 5.338A 5.149 5.334 5.339	
1 400-1 427	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) 5.340 5.341	

5.340 All emissions are prohibited in the following bands:

1 400-1 427 MHz,

An extract from Radio Regulations is shown on the left
The Three REGIONS are explained HERE.

Why has the whole World accepted to PROHIBIT
ALL EMISSIONS in 1400-1427 MHz band and allocate
This band EXCLUSIVELY for passive services similar
To Radio Astronomy?..



This experimental set-up uses 2 dish antennas each of 3m. dia pointed permanently to zenith, separated by a distance of 50 meters. The antenna is equipped with a radio astronomy receiver operating at 322-328.6 MHz Radio Astronomy band.
The signals from the two antennas are multiplied and the DC voltage output is recorded.
A rogue LEO (Low Earth Orbit) satellite with an orbital period of 90 minutes sweeps across the beam of the dishes.

Please find what will be FRINGE FREQUENCY recorded.