Spectrum Management and the Spectrum Landscape: Prospects for Radio Astronomy

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The world's radio telescopes / quiet zones

tinyurl.com/yrvszk

What is spectrum management?

- Regulation of use of the radio spectrum
  - Every nation has a radio spectrum regulator
    - Chile's is SUBTEL
    - The US has two, NTIA for federal use, FCC for private & shared use
  - Radio spectrum defined by UN treaty as 0 – 3 000 GHz
  - Radio spectrum is allocated up to 275 GHz
    - US has no rules for active spectrum use above 95 GHz
  - Preferred bands for science have been identified at 275–1 000 GHz
    - The obvious atmospheric windows

Goals of spectrum management

- Maximal use of spectrum
- RFI-free operation of recognized operations within their bands
  - Safety of life services are especially privileged
  - Radio astronomy has some particular privileges too
    - Every major radio observatory EXCEPT ALMA contributes to the ongoing international effort to maintain and protect these privileges
- Regulatory certainty to protect investment
- Harmonization of band use

Spectrum management works by:

- Classing uses of the radio spectrum into radio services
  - Fixed, fixed-satellite; Mobile, mobile-satellite; Radiolocation; Maritime, maritime-mobile; RNSS; Broadcasting; Aeronautical; Meteorological AIDS, Meteorological satellite; Amateur
  - Radio astronomy (RAS); Earth-exploration satellite service (EESS), Space Research Service (SRS), Time
- Allocating spectrum to services
  - Giving primary, co-primary, secondary status within shared bands
- Writing service rules for using allocations
  - In-band, out of band, spurious emissions all controlled
- Making location/frequency assignments to stations of services

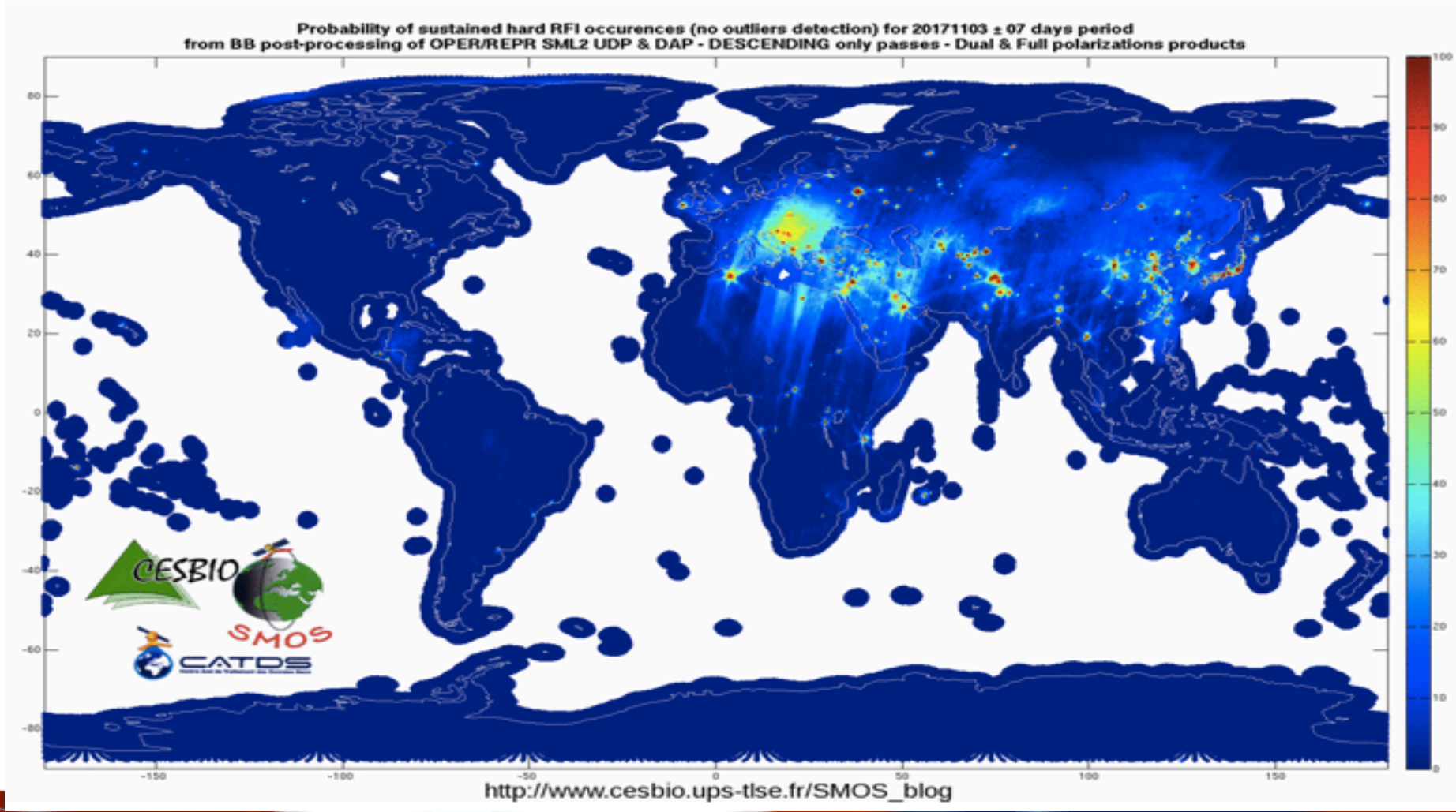
Innovation and accommodation for science

- Passive service bands not shared with active services
  - RR. 5.340 "All emissions are prohibited in the following bands …"
    - Dates to ~1960 when RAS was recognized at ITU-R
      - IUCAF formed for this purpose in1960 at behest of URSI
    - Diverse bands above 1 400 MHz, few % of spectrum
      - Much higher percentage at highest frequencies
      - A source of irritation to some spectrum thought leaders
    - Used importantly by EESS for weather/climate study
    - ALMA built a calibration beacon to broadcast across the 86 – 92 GHz band. I acted to stop that. I got some angry comments from ALMA staff.

1400-1427 MHz,
2690-2700 MHz, e
No. 5.422,
10.68-10.7 GHz, e
No. 5.483,
15.35-15.4 GHz, e
No. 5.511,
23.6-24 GHz,
31.3-31.5 GHz,
31.5-31.8 GHz, in
48.94-49.04 GHz,
50.2-50.4 GHz[2],
52.6-54.25 GHz,
86-92 GHz,
100-102 GHz,
109.5-111.8 GHz,
114.25-116 GHz,
148.5-151.5 GHz,
164-167 GHz,
182-185 GHz,
190-191.8 GHz,
200-209 GHz,
226-231.5 GHz,
250-252 GHz.

How well does regulation actually work?

SMOS regularly maps the globe at 1 400 – 1 427 MHz



Innovation and accommodation for science

- Radio quiet zones (generally for fixed terrestrial transmitters)
  - ALMA: 35 km radius core (no transmitters within bands allocated to RAS on a primary basis) + 120 km coordination zone
    - Spectrum in ALMA band 1 mostly NOT allocated to RAS
  - GBO: NRQZ limits power received at GBT across entire spectrum, including spectrum not allocated to RAS
  - SA RQZ attempts to limit airborne transmissions
  - 15+ RQZ in the world now, all have different rules
- Controlling fixed infrastructure contains the impact of mobile devices like cellular phones, TV Whitespace devices

What are the imminent threats to radio astronomy?

- Terrestrial
  - 5G (AI 1.13 on WRC-19 agenda)
    - Frequencies up to 71 GHz allocated within US, 86+ GHz to follow
      - Bands 57 – 64 & 64 - 71 GHz allocated for 5G in US recently
    - Currently coalescing around 26 – 28 GHz as first step at mm-wave

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    - Geographic remoteness, terrain-shielding and/or a QZ can contain this
- A QZ controlling fixed infrastructure can contain the impact of mobile devices that need access to fixed infrastructure
  - Cell phones, TV Whitespace devices

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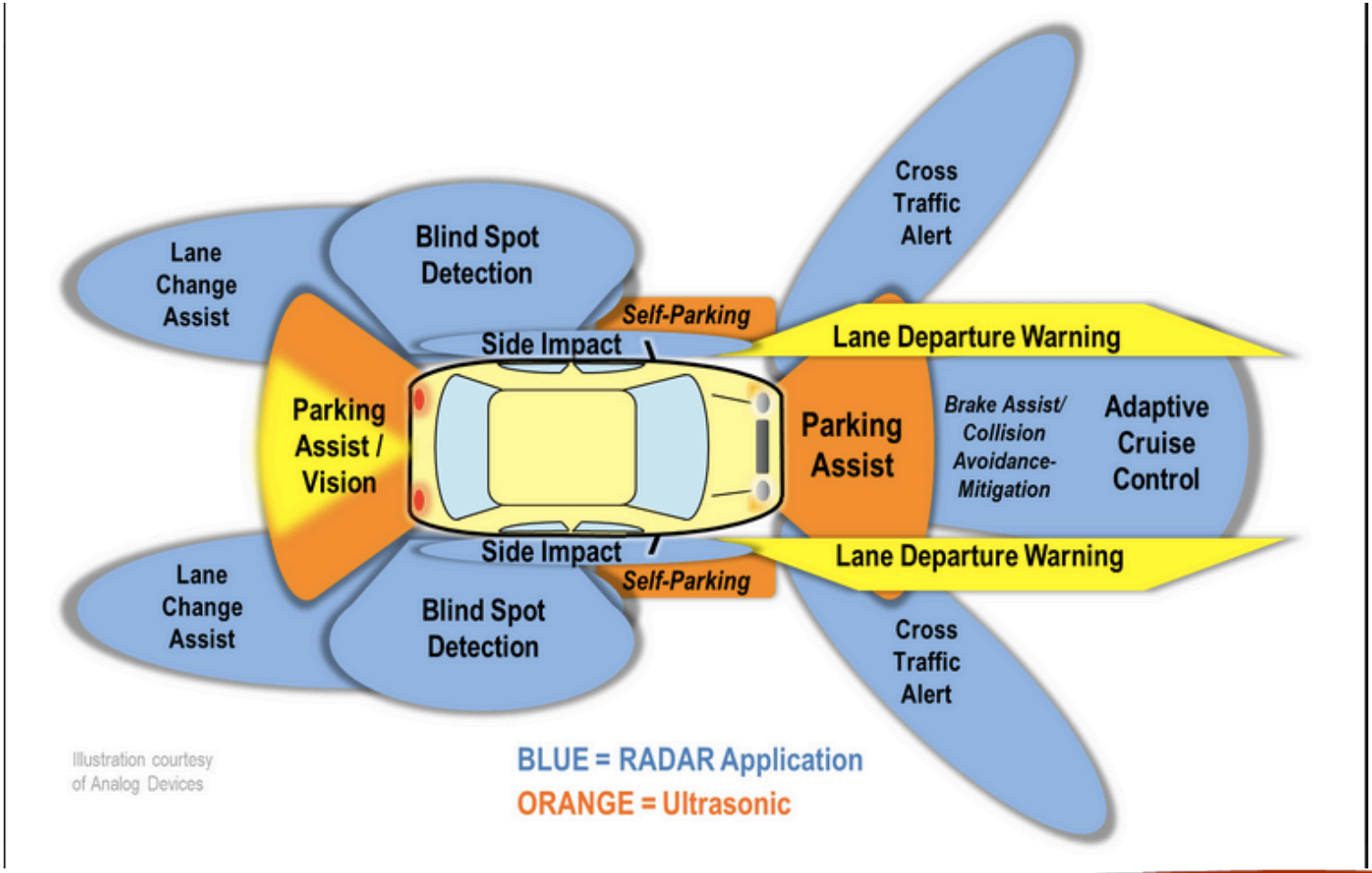
  - Cars
    - Radar, WiFi and ITS apps

Here's one aspect of a new car



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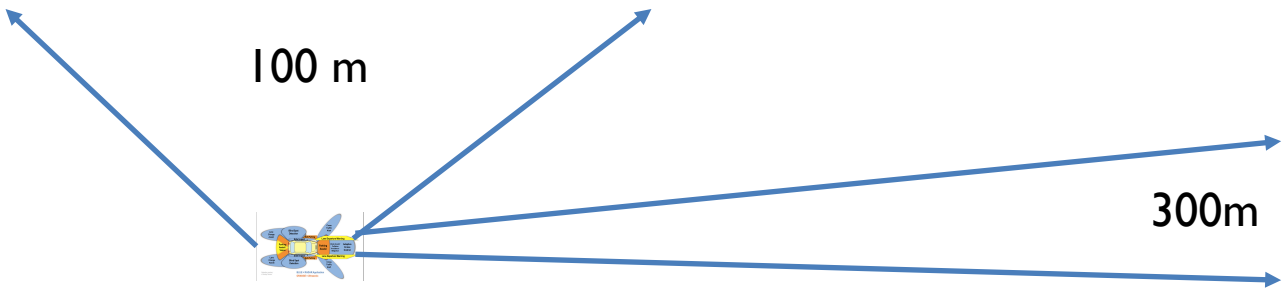

- Radars on a car will interfere above harmful levels at distances 30 – 100 km
  - Max eirp allowed 55 dBm ,76 – 81 GHz in US, Chile

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  - Cars
    - Radar, WiFi and ITS apps
    - Geographical remoteness and terrain shielding are the only controls. Impractical to ring-fence a radio telescope to keep radio waves out
    - FCC and SUBTEL did not require coordination to protect RAS, or that there be an off-switch in cars, that battle is over, lost.
    - The 10 dBm power source in a car radar is a few below the burnout level for a RAS receiver

What are the current threats to radio astronomy?

- Space-based downlinks for global wireless broadband
  - 10.7 – 12.75 GHz Ku band FSS downlinks
    - OneWeb, SpaceX planning 1000-4000 satellite LEO constellations
    - OneWeb will protect RAS 10.6 – 10.7 GHz band. SpaceX ?
  - 37 – 42.5 GHz Ka band FSS downlinks
    - Boeing planning a ~4000 LEO satellite constellation
    - I am trying to dissuade them from working up to 42.5 GHz
- The only defense is SM, coordination
  - Ku band coordination mandated by FCC to protect 10.68-10.7 GHz
  - Ka band coordination forced by existing rules for FSS at ITU-R

“RFI is what happens when spectrum management fails”

"RFI is what happens when spectrum management fails"

- Yeah, but this also happens when spectrum management fails:

"RFI is what happens when spectrum management fails"

- And this *also* happens when spectrum management fails:


"Relax, I've come for your spectrum

Shouldn't the ngVLA be inside a Radio Quiet Zone?

- All recent large instruments are inside QZ
  - SM has been integral to recent international efforts
    - Used as one basis in the SKA site competition
    - ALMA is inside a Quiet Zone, within a larger coordination zone
  - Distributed design a complication
- US SKA planning ca. 2002-3 alienated the FCC
  - Appeared to want much of the US Southwest to go radio quiet
  - US caused radio astronomy much grief at WRC-03 in Geneva, scuttling an effort to give international consideration to radio QZ

Why isn't the VLA already inside a Radio Quiet Zone?

- The present VLA site was opposed by DoD
  - DoD worried that WSMR operations would be compromised
- Dave Heeschen (NRAO Director) wrote a letter stating that NRAO would **never** seek to impose on WSMR operations
- The joke is that NRAO and WSMR have excellent relations, cooperate fully, and benefit from each other's presence
- In any case, a QZ would have to be a joint effort w/ WSMR

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