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| **Conference Preparatory Meeting for WRC-15 Geneva, 23 March - 2 April 2015** |  |
| **INTERNATIONAL TELECOMMUNICATION UNION** |  |
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| **PLENARY MEETING** | **Document CPM15-2/XX-E** |
| **09 March 2015** |
| **Original: English** |
| Committee on Radio Astronomy Frequencies (CRAF) | |
| CRAF Position on WRC-15 agenda items relevant to radio astronomy | |
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The Expert Committee on Radio Astronomy Frequencies (CRAF) of the European Science Foundation (ESF) represents European radio astronomers and observatories in matters of spectrum management. It is a sector member of the ITU and active in the study and promotion of the protection of the frequency bands used by the Radio Astronomy Service (RAS). The WRC-15 Agenda Items of interest to CRAF are discussed and CRAF’s position on each is stated, based on the current status of WRC-15 preparations.

The Conference Preparatory Meeting for WRC-15 is invited to consider CRAF’s view during the preparation of its Report for the WRC-15 and implement adequate measures for the protection of radio astronomy from interference emitted by active radio services and applications.

Any comments or concerns may be addressed to

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| AI 1.1 | to consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution 233 [COM6/8] (WRC‑12); |

This AI is one of the most important issues at WRC-15, not only for the RAS but the whole telecommunications sector. Mobile systems do not usually provide viable co-existence environments for the RAS in shared or even some adjacent bands. Therefore an IMT allocation within a shared or nearby RAS band can affect an observatory’s operational capability. The targeted frequency range is ~470 MHz up to ~6 GHz, where the RAS antenna background and receiver noise is at its minimum and therefore the sensitivity and range of radio astronomical measurements at its maximum. This frequency range is therefore extremely important for the RAS, which is reflected in the numerous primary and secondary allocations.

**CRAF Position**

In-band sharing between the RAS and IMT systems will be practically impossible (see Draft new Report ITU-R RA.[RAS-IMT]), as studies show that separation distances from 500 – 1000 km are required. Therefore allocations leading to RAS-IMT in-band sharing should be avoided.

For adjacent band compatibility separation distances range from a few km for user equipment to up to 200 km for base stations, based on a maximum unwanted emission level of -50 dBm/MHz. Such maximum unwanted emission levels should be adopted in the relevant standards (e.g. 3GPP and ETSI) for IMT equipment. Any allocation immediately adjacent to passive service bands protected by RR. 5.340 should be avoided. The filtering needed by the RAS to operate in the presence of strong emissions generated immediately outside the band, would greatly compromise their use of the band.

**CRAF most strongly opposes** the proposed allocations in (parts of) bands used by the RAS, i.e., 608 – 614 MHz, 1 330 – 1 400 MHz, 4 800 – 4 950 MHz and 4 950 – 4 990 MHz, under Methods B and C.

**CRAF opposes** the proposed allocations immediately adjacent to the passive service bands at 1 400 – 1 427 MHz and 2 690 – 2 700 MHz, under Methods B and C. Examples include the allocations at 1 427 – 1 452 MHz and 2 700 – 2 900 MHz.

**CRAF also opposes** proposed allocations that are immediately adjacent to spectrum bands that are passive service bands in various CEPT and ITU-R member administrations; namely, the allocations affecting the bands 608 – 614 MHz and 4 800 – 4 990 MHz.

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| AI 1.2 | to examine the results of ITU‑R studies, in accordance with Resolution 232 [COM5/10] (WRC‑12), on the use of the frequency band 694 – 790 MHz by the mobile, except aeronautical mobile, service in Region 1 and take the appropriate measures; |

A specific band proposed for mobile (including IMT) use in its own right. It is sufficiently far away from RAS allocations such that assuming no degradation of OOB limits in the equipment standards applicable to mobile systems is allowed, it is anticipated that the interference environment for the nearest RAS band (608 – 614 MHz) will not be significantly degraded. It is likely that in the future this band will also be used for PPDR. Frequencies outside this range will be considered under AI 1.1.

**CRAF Position**

No new allocations of spectrum to IMT systems should be made unless acceptable compatibility criteria for the RAS are developed via appropriate studies and included in subsequent regulation. Special attention should be paid to intermodulation products falling in the passive service bands at 1 400 – 1 427 MHz and 2 690 – 2 700 MHz. See also CRAF’s position for AI 1.1. The frequency range considered here should not be significantly extended downwards as that would endanger protection efforts for the localised RAS use of the 608 – 614 MHz band.

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| AI 1.5 | to consider the use of frequency bands allocated to the fixed-satellite service not subject to Appendices 30, 30A and 30B for the control and non-payload communications of unmanned aircraft systems (UAS) in non-segregated airspaces, in accordance with Resolution 153 [COM6/13] (WRC‑12); |

This AI potentially includes allocations near the following RAS/SRS bands:

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| **Frequency Band (GHz)** | **RAS Status** | **RR Footnote** | **RAS Use** |
| 14.47 – 14.50 | sec |  | Spectral line observations, VLBI |
| 14.50 – 14.80 | sec |  | VLBI (when compatible with primary use) |
| 14.80 – 15.35 | sec | 5.339 | VLBI (when compatible with primary use) |
| **15.35 – 15.40** | **PRI** | **5.340** | **Continuum observations, VLBI** |

To ensure adequate protection, all RAS bands that may be affected should not be subjected to interference levels from wanted or unwanted emissions of UAS that exceed those specified in Recommendation ITU-R RA.769-2.

**CRAF Position**

CRAF supports the protection of existing RAS and SRS allocations. No changes should be made to the RR unless acceptable sharing and compatibility criteria are developed with the RAS and SRS.

**CRAF strongly opposes** method A. The proposed application of the FSS for UAS CNPC applications is not in accordance with the definition of the FSS. Appropriate sharing and compatibility studies of this mobile airborne application with the RAS have not been conducted and no regulations have been developed to protect the existing RAS and SRS allocations.

**CRAF supports** method B: no change to the Radio Regulations.

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|  | to consider possible additional primary allocations:  1.6.1 to the fixed-satellite service (Earth-to-space and space-to-Earth) of 250 MHz in the range between 10 GHz and 17 GHz in Region 1; |
| AI 1.6 | 1.6.2 to the fixed-satellite service (Earth-to-space) of 250 MHz in Region 2 and 300 MHz in Region 3 within the range 13 – 17 GHz; |
|  | and review the regulatory provisions on the current allocations to the fixed-satellite service within each range, taking into account the results of ITU‑R studies, in accordance with Resolutions 151 [COM6/4] (WRC‑12) and 152 [COM6/5] (WRC‑12), respectively; |

RAS and SRS bands that may potentially be affected (i.e. by sharing or adjacency) are:

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| **Frequency Band (GHz)** | **RAS Status** | **RR Footnote** | **RAS Use** |
| 10.60 – 10.68 | PRI | 5.149 | Continuum observations, VLBI |
| **10.68** – **10.70** | **PRI** | **5.340** | Continuum observations, VLBI |
| 14.47 – 14.50 | sec | 5.149 | Spectral line observations, VLBI |
| 14.50 – 14.80 | sec |  | VLBI (when compatible with primary use) |
| 14.80 – 15.35 | sec | 5.339 | VLBI (when compatible with primary use) |
| **15.35** – **15.40** | **PRI** | **5.340** | Continuum observations, VLBI |

To ensure adequate protection, all RAS bands that might be affected should not be subjected to interference levels from the emissions of FSS systems that exceed those specified in Recommendation ITU-R RA.769-2.

**CRAF Position**

**AI** **1.6.1**: As noted at 4.1/1.6.1/4.1 - 4.1/1.6.1/4.3 of the CPM text, compatibility with the RAS is not achievable for the 10.6 GHz RAS bands for FSS operating in the space-to-Earth direction, without at least 100 MHz separation between FSS and RAS allocations. No studies were performed regarding unwanted emissions into the 15.35 – 15.4 GHz RAS band.

**CRAF supports** all methods *X*1 and *XX*1 that do not change the Radio Regulations.

Regarding Methods F2 and FF2 that propose allocations in the existing FSS band at 14.5 – 14.8 GHz, no compatibility studies were conducted with regard to the secondary RAS allocation in the adjacent band at 14.47 – 14.50 GHz. It can be assumed that the 100 MHz separation requirement that has been computed for the 10.6 GHz band is also valid for the 14.5 GHz band.

**CRAF strongly opposes** method FF2 allocating the band 14.5 – 14.8 GHz in the space-to-Earth direction, because of the secondary RAS allocation in the adjacent band 14.47 – 14.50 GHz and because of the secondary SRS allocation in this band that is also used for VLBI observations by the RAS.

**CRAF also strongly opposes** method GG2 allocating the band 14.80-15.35 GHz in the space-to-Earth direction, because this band is directly adjacent to the 15.35 – 15.40 GHz primary RAS allocation and because of the secondary SRS allocation in this band that is also used for VLBI.

**AI** **1.6.2: CRAF opposes** additional allocation to the FSS (Earth-to-Space) in the frequency band 15.35 – 15.40 GHz, because of its importance for the passive services, such as radio astronomy, which is reflected in RR FN 5.340.

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| AI 1.8 | to review the provisions relating to earth stations located on board vessels (ESVs), based on studies conducted in accordance with Resolution 909 (WRC-12); |

Resolution 902 (WRC-03) introduced provisions relating to the use of earth stations on board vessels (ESVs) in certain bands allocated to the fixed-satellite service (FSS). Based on agreed technical assumptions, minimum distances from coastlines have been calculated for the bands 5 925 – 6 425 MHz and 14.0 – 14.5 GHz, beyond which an ESV will not have the potential to cause unacceptable interference to other services. This distance for protection of observations in the secondary RAS band 14.47 – 14.50 GHz is 125 km.

Since Resolution 902 was accepted, the technology used by ESVs has advanced, including the use of spread-spectrum modulation and other techniques. It is suggested that these new techniques may improve compatibility with terrestrial co-frequency services and may make it possible to decrease the protection distances from ESVs up to coastlines.

Detailed technical characteristics of new types of ESVs are resulted in Recommendation ITU-R S.1587-2 (2007) “Technical characteristics of earth stations on board vessels communicating with FSS satellites in the frequency bands 5 925 – 6 425 MHz and 14.0 – 14.5 GHz, which are allocated to the fixed-satellite service”.

CRAF Position

Five methods have been developed to satisfy this AI, ranging from Method A: NOC to Method E, which proposes to review the regulatory regime governing the operation of ESVs to conform to the principles and objectives of the Radio Regulations. The intervening methods either lengthen or shorten various offshore protection distances based on different underlying assumptions and variables.

This AI is subject to more than the usual uncertainty in the basic assumptions needed to do definitive studies. Until these uncertainties are relieved, no changes to the RR should be made.

**CRAF** **approves** Methods A or E that would not change the RR.

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|  | to consider, in accordance with Resolution 758 [COM6/15] (WRC‑12): |
| AI 1.9 | 1.9.1 possible new allocations to the fixed-satellite service in the frequency bands 7 150 – 7 250 MHz (space-to-Earth) and 8 400-8 500 MHz (Earth-to-space), subject to appropriate sharing conditions; |
|  | 1.9.2 the possibility of allocating the bands 7 375 – 7 750 MHz and 8 025 – 8 400 MHz to the maritime-mobile satellite and additional regulatory measures, depending on the results of appropriate studies; |

A study presented to ITU-R WP4A on the proposed possible new allocations to the FSS in the frequency bands 8 400 – 8 500 MHz (uplink) concluded that exclusion zones for FSS of more than 700 km were needed for all SRS (deep space) stations considered. The exclusion zones were computed based on the Recommendation ITU-R SA.1157 protection criteria for the SRS deep-space earth stations, which are broadly similar figures to those for the RAS stations in Recommendation ITU-R RA.769-2. New FSS allocations as proposed will potentially providea source of interference for the 8 400 – 8 500 MHz space research band used for geodetic VLBI measurements by radio observatories together with ground stations of the space research service.

**CRAF Position**

CRAF supports the protection of the SRS allocation at 8 400 – 8 500 MHz. No new allocations to the FSS should be made in this frequency band unless acceptable sharing criteria with SRS in 8 400 – 8 500 MHz are developed and included in appropriate regulations.

For AI 1.9.1 three methods have been developed.

**CRAF approves** methods A, B and C.

For AI 1.9.2 two methods have been developed of which the 2nd method has 2 options.

**CRAF supports** method A: no change

**CRAF approves** method B, option B: Adoption of a Resolution, referenced in a footnote that would respect the exclusion zones around SRS (deep space) earth stations.

**CRAF opposes** method B, option A.

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| AI 1.10 | to consider spectrum requirements and possible additional spectrum allocations for the mobile-satellite service in the Earth-to-space and space-to-Earth directions, including the satellite component for broadband applications, including International Mobile Telecommunications (IMT), within the frequency range from 22 GHz to 26 GHz, in accordance with Resolution 234 [COM6/16] (WRC‑12); |

The 23.6 – 24.0 GHz band is protected by RR 5.340 and used by the RAS. It could potentially be affected by unwanted emissions of the proposed use in adjacent bands. Shared RAS bands around 22 GHz may also be affected. The SRS band 22.50 – 23.15 GHz could be affected by sharing or unwanted emissions in adjacent bands.

To ensure adequate protection, all RAS bands that might be affected should not be subjected to interference levels from the emissions of MSS systems that exceed those specified in Recommendation ITU-R RA.769-2.

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| **Frequency Band (GHz)** | **RAS**  **Status** | **RR Footnote** | **RAS Use** |
| 22.01 – 22.21 | 1 | 5.149 | Continuum and spectral line observations (e.g. Water line), VLBI |
| 22.21 – 22.50 | PRI | 5.149 | Continuum and spectral line observations (e.g. Water line), VLBI |
| 22.55 – 23.12 | 1 | 5.149 | Continuum and spectral line observations (e.g. Water and Ammonia line), VLBI |
| **23.60 – 24.00** | **PRI** | **5.340** | Continuum and spectral line observations (e.g. Ammonia line), VLBI |

1 RAS use is supported by the inclusion of footnote RR 5.149

**CRAF Position**

As noted in the CPM text at 4.2/1.10/3.1 studies that to date the MSS spectrum requirements, in either the space-to-Earth or Earth-to space directions, have yet to be identified. In the immediate vicinity to the frequency band 22 – 26 GHz there are already MSS allocations with a significant amount of spectrum for the implementation of new MSS systems that is currently largely unused.

As noted in a liaison statement from WP 4C to WP 7D (Document 7D/127), and in the CPM text at 4.2/1.10/4.6 and 4.2/1.10/4.10, no sharing or compatibility studies were conducted with regard to either of the two bands used by the RAS in the 22 – 26 GHz range, including the RAS bands 23.6 – 24 GHz (subject to RR. 5.340) or 22.21 – 22.5 GHz (RR 5.149). For this reason no allocation to MSS should be made that might affect either of the RAS bands.

**CRAF supports** Method A: no change to the Radio Regulations.

**CRAF strongly opposes** the following methods:

Method B: To allocate the frequency bands 23.15 – 23.55 GHz (space-Earth) and 25.25 – 25.5 GHz (Earth-space) to MSS …

All methods C1: Allocations for MSS in the space-to-Earth direction.

All methods C2: Allocations for MSS in the Earth-to-space direction

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| AI 1.12 | to consider an extension of the current worldwide allocation to the Earth exploration-satellite (active) service in the frequency band 9 300 – 9 900 MHz by up to 600 MHz within the frequency bands 8 700 – 9 300 MHz and/or 9 900 – 10 500 MHz, in accordance with Resolution 651 [COM6/18] (WRC‑12); |

Unless strongly suppressed, the out of band emissions of these EESS systems can be a far-ranging source of RFI for the RAS in the adjacent 10.6 – 10.7 GHz band and in the 8.4 – 8.5 GHz SRS band used for geodetic VLBI measurements by radio observatories (together with ground stations of the SRS). Draft New Report ITU-R RS.[EESS-9GHz\_OOBE] on, e.g. the influence of these on Earth stations operating in the RAS band around 10.65 GHz, conclude that reducing the data loss level to 2% as specified in Recommendation ITU-R RA.1513 would require an attenuation of unwanted emissions of 63 dB with regard to the peak envelope power of the SAR pulse. It would be difficult or impossible to meet such attenuation in practice.

It was also pointed out that accidental damage to RAS receivers could be avoided, if an area of 92 km (vertical) by 28.8 km (horizontal) centered on the RAS station is excluded from illumination, or if the RAS station avoids pointing towards the satellite.

**CRAF Position**

The addition of 600 MHz to the existing allocation can only be supported if the RAS and the SRS (passive) using radio astronomy techniques in nearby bands are adequately protected from unwanted emissions via appropriate regulations. CRAF considers that the burden of any required co-ordination actions should rest with the satellite operator and not individual RAS observatories.

Two methods have been developed to satisfy Agenda Item 1.12:

Method A - Primary EESS (active) allocation in the frequency band 9 900 – 10 500 MHz. Method A has two variants: Method A2 additionally includes specific technical and regulatory constraints in the RR to protect the fixed service.

Method B - Primary EESS (active) allocation in the frequency bands 9 200 – 9 300 MHz and 9 900 – 10 400 MHz.

In both cases protection of the RAS in the nearby bands 10.6 – 10.68 GHz (RR. 5.149) and 10.68 – 10.7 GHz (RR 5.340) is addressed in a new ITU-R Recommendation ITU-R RS.2066 to be incorporated by reference via a footnote in the RR, which includes a list of radio astronomy stations that will not be illuminated by SAR using the new allocation except with advance coordination. Compatibility with RAS operations is not possible for either Method A or B when RAS stations are illuminated at every opportunity.

Illuminations of RAS sites by SAR are of general concern because the power in the radar beam is sufficient to destroy an unfiltered RAS receiver in the unlikely event of strong coupling between the SAR and radio telescope beams. The methods proposed for AI 1.12 have the benefit that illuminations of RAS sites by SAR using the new allocation would largely be avoided. However, the use of existing and new allocations by a variety of SAR systems will make it impossible for RAS site operators to know when their stations were being illuminated.

**CRAF prefers** Method B that places the radar allocation further away from the RAS bands.

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| AI 1.16 | **to consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication in accordance with Resolution 360 (WRC 12);** |

The method C1 for AI 1.16 described in the draft CPM Report ([CPM15-2/1](https://www.itu.int/md/dologin_md.asp?lang=en&id=R12-CPM15.02-C-0001!!MSW-E))proposed the frequency band 161.7875 – 161.9375 MHz for a new MMSS allocation (space-to-Earth). The nearby band 150.05 – 153.00 MHz is allocated to passive services such as the Radio Astronomy Service and systems under this service are highly susceptible to interference from unwanted emissions of active services.

**CRAF Position**

CRAF approves Method C1 as long as an attenuation of 85 dB and the pfd mask described in section 3/1.16/6.1 of [CPM15-2/1](https://www.itu.int/md/dologin_md.asp?lang=en&id=R12-CPM15.02-C-0001!!MSW-E) as proposed by the MMSS are implemented in the nearby radio astronomy band. Under such conditions compatibility between MMSS in the band 161.7875 – 161.9375 MHz and the RAS in the band 150.05 – 153 MHz will be feasible.

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| AI 1.17 | to consider possible spectrum requirements and regulatory actions, including appropriate aeronautical allocations, to support wireless avionics intra-communications (WAIC), in accordance with Resolution 423 [COM6/22] (WRC‑12); |

The RAS bands that may potentially be affected are given in the following table.

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| **Frequency Band (MHz)** | **RAS Status** | **RR Footnote** | **RAS Use** |
| **2 690 – 2 700** | **PRI** | **5.340** | **Continuum observations, VLBI** |
| 4 800 – 4 990 | sec | 5.149 | Continuum observations, VLBI |
| 4 990 – 5 000 | PRI | 5.149 | Continuum observations, VLBI |

Unwanted emissions from WAIC systems may significantly affect RAS use in these bands owing to the acknowledged susceptibility of the RAS to airborne sources of interference. To ensure adequate protection, all RAS bands that might be affected should not be subjected to interference levels from the emissions of WAIC systems that exceed those specified in Recommendation ITU-R RA.769-2.

**CRAF Position**

As noted in the Executive Summary 3/1.17/1 of the CPM text,

“The Report concludes that 145 MHz of radio frequency spectrum is necessary to support the requirements for WAIC systems.”

**CRAF approves** either Method A (any option) or Method B, with a slight preference for Method B, both of which allocate the band 4 200 – 4 400 MHz to WAIC, with variations in the way the allocation is described and footnoted. This band is wider than the stated needs for WAIC of 145 MHz.

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| AI 1.18 | to consider a primary allocation to the radiolocation service for automotive applications in the 77.5 – 78.0 GHz frequency band in accordance with Resolution 654 [COM6/23] (WRC‑12); |

Radio astronomical observations in the band 77.5 – 78.0 GHz are covered by Footnote 5.149 and have a secondary allocation. The mm-wave regime is already strongly affected by quantum noise in the receivers and radio astronomy uses wide bandwidths in order to achieve sufficient sensitivities. Increased interference from the proposed allocation will practically isolate the 76 – 77.5 GHz primary RAS band from the other primary band at 79 – 94 GHz, reducing achievable sensitivity. Studies presented in ITU-R WP7D show that exclusion zones of about 30 km or more would be needed around observatories to ensure protection of the RAS from the automotive application of these radars.

On-going studies also include airborne SRR applications up to heights of several hundred meters in this frequency range, in helicopters, in airplanes to avoid collisions on airports, and in cranes and in road infrastructure to monitor traffic. These applications differ from the automotive application by a (much) higher altitude above the ground, resulting in significantly larger areas that are impacted by the radar. For instance, for the helicopter application exclusion zones around RAS observatories in the order of 100 km are required.

**CRAF Position**

Two methods are proposed to satisfy AI 1.18:

Method A: Adds a primary allocation to the radiolocation service between 77.5 GHz and 78 GHz on a worldwide basis, limited to automotive applications via a footnote. The footnote in Option 1 stipulates that the characteristics of the automotive radars are given in Recommendation ITU-R M.2057, while Option 2 has no such stipulation.

Method B: Adds a primary allocation to the radiolocation service between 77.5 GHz and 78 GHz on a worldwide basis, not limited to automotive applications. Method B is said to “support” use by automotive radar, but this is merely incidental to supporting all uses. In any case, no studies were conducted at the ITU level to support an allocation to radiolocation applications other than vehicular.

As the executive summary of the CPM-15 text makes clear in Section 3/1.18/3, compatibility between vehicular radar and RAS operations will require the creation of local coordination zones whenever a radio telescope is not fully terrain-shielded or otherwise protected by natural circumstances. The coordination radii could range up to 40 km or more. Crafting local solutions that are not supported in hardware by making vehicles position-aware and providing vehicle operators with radar-off switches will be problematical.

**CRAF opposes** allocation to the radiolocation service under Method A.

**CRAF strongly opposes** allocation to the radiolocation service under Method B.