World Broadcasting Unions

Report on Intentional Interference to Satellite Services

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Executive Summary

Intentional interference to satellite services is often motivated by political or economic factors. For many years occurrences were not widely known about. During 2009, the levels of interference were such that a wider dialogue started across the broadcasting and satellite industry. It was clear that the issue was more widespread than the experience of a few broadcasters, but it took several years before traction could be achieved and a constructive dialogue commenced. Discussions at an Arab States Broadcasting Union Forum in October 2013 led to an action plan of initiatives to counter the problem and, in turn, a call on the World Broadcasting Unions (WBU) to take similar action. The WBU International Media Connectivity Group (WBU-IMCG) sought assistance of industry experts to identify actions to address the problem. It is that work that is presented in this document. The authors are very grateful for the support of these experts in contributing to this document and working on actions that help to counter and mitigate the effects of the interference.

The work documented progressed across three areas: operational, regulatory and technical. The operational can be larger and more powerful specialist uplink systems, or guidelines to be included in broadcaster/satellite service provider contracts. Regulatory work is around monitoring and reporting of incidents and the classification of them. It is the area of technology that provides both short term and long term opportunities for considerably reducing the consequences of intentional interference as it is currently understood.

The report makes a number of recommendations.

Broadcasters are encouraged to have procedures in place to deal with issues of interference, and to have the best possible contract terms with their satellite service providers. They should also work with the WBU and consider working with other UN bodies to share relevant information.

We recommend that satellite operators and service providers continue to develop a working definition of intentional interference to satellite services and assist with the collection and collation of data on interference. They should maintain a focus on providing technology-based solutions for mitigating interference and, in the longer term with new technologies, ideally eliminating the potential for intentional interference to cause any disruption.

The WBU-IMCG can continue to play an active role to support measures to automate the filing and processing of data recording incidents of interference. It can also support initiatives within the ITU, building upon work already instigated within ITU Study Groups and discussion with ITU-BR on interference monitoring, monitoring facilities and how data is recorded, stored and analysed.

Introduction

Satellite services support the broadcasting of television programmes to nearly all of the world's TV households. A large proportion of these watch direct-to-home satellite services and for others, satellite distributions feed their local terrestrial transmitters. Though fibre and IP networks take some traffic, increasing demands for bandwidth and the efficiency of satellite services keep it relevant and very much a platform for the 21st century. As a radio system, it is reliant on manual processes and disciplines for operation. Consequently, the increasing proliferation of services creates many incidents of service-affecting interference.

Broadcasters share these challenges with other services and applications, such as scientific satellite monitoring of the earth surface, and at a time of proliferation of Low Earth Orbit (LEO) and Mid Earth Orbit (MEO) constellations. The ITU has established co-operation with a network of monitoring stations of satellite services, enabling verification of received signal issues at a number of different locations. The increasing use of mobile uplinks, a very vital business sector for the future for the satellite industry, also drives the need for improvements in uplink identification and geolocation, and in turn will benefit the broadcast services sector.

The problem of interference to satellite services has spurred improved industry training and vigilance, and prompted technical advances in satellite and antenna design and geolocation technology. The high volume (perhaps a billion or more DTH receivers) forms a substantial legacy that is not easily replaced and, whereas point to point satellite links can benefit from sophisticated modem technology to reject interference, it will take many years before this is widely deployed on the uplink path of DTH services.

Access to international media has, through the history of broadcasting, been subject to interference. Whilst the vast majority of interference to satellite services used by broadcasters is accidental, a small percentage shows very different characteristics, and can be considered as intentional. Intentional interference to satellite services and the threats to cyber security provide a real and developing challenge to broadcasters and the industry within which they operate. Historically, much of the work to address the problem centred on terrestrial interference. However with the widespread use of satellite for broadcasting and data transmission, the problem has taken on greater significance and urgency, especially in light of growing cyber threats.

A significant amount of intentional interference affected a number of services during 2009 and in the following years. During 2009, a number of international TV services were subject to deliberate uplink interference. These incidents spurred a dialogue across the broadcasting and satellite industry. It was clear that the issue is more widespread than the experience of a few broadcasters. The dialogue led to the Arab States Broadcasting Union (ASBU) drafting an action plan of initiatives to counter the interference and in turn a call on the World Broadcasting Unions (WBU) to take similar action. Although cases have been reported that are driven by economic or commercial motives, intentional interference is often politically motivated and therefore likely to remain an issue for as long as there are major political and ethical differences between regimes.

The WBU Technical Committee (WBU-TC) resolved to take a number of actions to assist broadcasters and service providers. To progress these actions, the WBU-TC sought assistance of industry colleagues via its International Media Connectivity Group (previously International Satellite Operations Group). The WBU-IMCG Working Group on Intentional Interference to Satellite Services comprised representatives from across the industry contributing their respective knowledge in a collaborative manner. The group produced an internal report for the WBU in November 2016 and since that time has been working on its recommendations for further activity. One of these recommendations was to produce and publish this Report on Intentional Interference to Satellite Services. (Further information on the WBU, WBU-IMCG and its Working Group on Intentional Interference to Satellite Services can be found in Appendix 4.)

Focus of much activity has been the International Telecommunications Union (ITU). The ITU is a UN body that provides a valuable forum for debate and scope for updating regulations and procedures, shaped primarily to deal with matters of terrestrial interference. The issue has been previously discussed at two Plenipotentiary conferences (2010 and 2014), two World Radiocommunication Conferences (2012 and 2015), at the Radio Regulations Board and at ITU symposiums. This report acknowledges that dialogue and proposes further additional steps.

We are grateful to the satellite operators, satellite services providers, equipment manufacturers and broadcasters who have contributed to this work and those whose developments and changes are helping to mitigate the effects of intentional interference.

Background

Satellite interference affects only a relatively small number of services globally, but when it does occur the effect is dramatic and harmful to services. Consumers, commerce, and even governments can be affected – no user of satellite communications is immune. In addition, interference costs the satellite community as a whole, since considerable resources (both human and technical) have to be committed to discovering its causes and resolving the issues found.

Interference is caused by a number of factors and may, occasionally, be malicious. Although this is relatively rare in comparison to other causes, its impact is significant and damaging. It is useful, however, to understand intentional interference within the more general context of interference and as one of a number of types of harmful interference.

Spectrum is a finite resource and spectrum used for satellite communications requires careful management. Satellites in the geostationary arc are being located with ever closer spacing due to a need to provide more capacity (with a spacing of less than 2° in some portions of the arc), and the number of users is continuously increasing. As a consequence, interference has become more likely.

Types of interference

The majority of geostationary commercial satellites use “bent-pipe” analogue transponders. Often many unrelated customers are using bandwidth in the same transponder. A transponder has a finite bandwidth (often 36 or 72 MHz) and aggregated power capacity, meaning that if the power levels of all the signals are not managed correctly, the resulting distortion creates interference across the transponder. Geostationary satellites are also closely spaced, and often share a common frequency spectrum. If a ground station is radiating some unwanted energy towards a neighboring satellite, interference can result.

There are a whole range of different causes of interference (see Appendix 1), and the laws of physics make it impossible to eliminate interference totally. Satellite links are planned to account for an expected and reasonable amount of residual interference, mainly due to practical limitations in uplink antenna beam patterns. If calculated residual interference rises above this level sufficiently to cause disruption or degradation of planned links, it is defined and recorded as interference.

Many satellite operators believe that the main cause of interference is a mix of the use of sub-standard equipment, lack of trained technicians leading to human error, poor operational and installation practices, and poor maintenance procedures (often leading to equipment failure that creates interference). Furthermore, there is insufficient identification and incident coordination between the various satellite and earth station operators which indirectly sustain a high number of unidentified carriers on satellites.

The satellite industry, through advances in innovation, technology and operational practices, is implementing new techniques to try to recognize the risk of interference occurring and make it easier to resolve. Industry has developed technical capabilities to identify and remove harmful interference sources from satellite networks. With more recent VSAT network terminals each already having a unique ID, the development of recognized tools has proven to be beneficial in resolving this long-term problem. Carrier Identification (also known as “Carrier ID” or “CID” is an example of a new and recognized technology which is being used to manage SCPC and MCPC transmission interference, in the same way as with VSAT networks, and thus further reduce the impact of interference to satellite operations and services as the satellite eco-system expands.

The Role of the International Telecommunications Union (ITU)

The International Telecommunications Union (ITU) is the leading United Nations agency for the management of radio-frequency spectrum and satellite orbits. A primary objective of the Radiocommunication Sector of the ITU (ITU-R) is to ensure interference-free operations of all radiocommunication systems. This is done through the implementation of the Radio Regulations and Regional Agreements, and through Recommendations which assure the necessary performance and quality in the operation of these systems. Work done by administrations and industry sector members in ITU Study Groups 1 and 4 (ITU-R Study Groups for spectrum management and satellite services respectively) is important in addressing interference to satellite services.

Both the ASBU Action Plan and the WBU-IMCG Action Plan identified the value of active participation at the ITU. One of the recommendations made by the WBU working group was to initiate WBU-IMCG liaison with ITU-R Working Party 4A (dealing with orbit/spectrum efficiency and interference and coordination aspects of FSS and BSS). WBU-IMCG has also opened discussions with ITU-R Study Group 1 and with Working Party 1C, responsible (among other things) for the identification of emissions and location of interference sources.

A WBU-IMCG liaison role is now established and provides a regular link between the WBU and ITU-R Study Group 4. Discussions at ITU-R Working Party 4A have helped to identify ITU-R contributions reflecting the work of the WBU on interference to satellite services which are of wider value to administrations and sector members.

The Impact of Intentional Interference to Satellite Services

Subjecting broadcasting services to jamming is nothing new, and the techniques employed to interfere with services carried by satellites employ broadly the same aim – to prevent the reception of the targeted service. This can be done in two ways – either by targeting the uplink or the downlink of the satellite broadcast service.

Uplink or orbital interference targets the service on the transponder of the satellite by transmitting an interfering signal or carrier "on top" of the original one. This makes it impossible for the satellite receivers on the ground to recover the wanted signal because it is being swamped by the unwanted "jamming" signal. Uplink jamming also removes the service across the whole satellite footprint, not just over one country, and as such can constitute what is classified by the ITU as "harmful interference." The jamming carrier blocks all channels in the same transponder causing collateral damage to these other businesses, and resulting in considerable commercial pressure on the service being jammed. Equipment used to uplink normal TV signals to a satellite can also be used for jamming purposes, and so most teleports and mobile news trucks are capable of being used for either purpose.

Downlink or terrestrial interference is more localised but just as damaging for audiences, taking place in a particular urban or rural area. This employs lower powered signals on the downlink frequencies being used by the broadcast service and targets ground terminal receivers.

The impact on audiences of interference to broadcasting services is degradation or loss of reception of the desired channel. Where the interference is intentional and aiming to prevent any reception at all, the wanted signal is likely to be completely unintelligible for the audience (some examples of jammed satellite broadcasts at Ku can be found in Appendix 2).

There are many examples of the jamming of satellite broadcasts, but perhaps the most widely publicised was the targeting of the World Cup in 2010. Across the Middle East and North Africa, during the opening game between South Africa and Mexico, subscribers to Al-Jazeera Sports experienced blank screens, pixelated images and commentary in the wrong languages, and this interference was repeated a further number of times during the tournament's biggest games. This is generally believed to have been a commercially-motivated example of intentional interference, Al-Jazeera having had the exclusive pay-TV rights to broadcast World Cup matches to all Arab and North African countries. Services provided by international broadcasters like the BBC and Voice of America have also often been targeted, as have services provided by commercial broadcasters like MBC and Al-Jazeera. After locating the source of the interference, many of these cases have been formally submitted to the ITU by operators like Eutelsat and Arabsat.

Although there has been a reduction in intentional uplink interference in recent years, (the last major incident affecting multiple broadcasters being in Africa in 2014) due to the nature of geopolitics and commercial interests, it is unlikely to go away. Whilst it may be more prevalent in certain regions at certain times and affect some broadcasters more than others, due to the relative ease with which intentional interference can be employed, and the fact that interference can impact services other than those targeted, continued efforts are required by all interested parties to address the impact of intentional interference.

Satellite Communications - Governance and Regulation

Efforts from broadcasters, regulators and the satellite industry are vital in resolving cases of intentional interference. However, for the issue to be effectively addressed, it must also be considered in the context of international space and telecommunications law and regulation.

As the leading United Nations agency for the management of radio-frequency spectrum and satellite orbits, the ITU is responsible for resolving instances of intentional or unintentional harmful interference to satellite services. The ITU's responsibilities for orbital and spectrum resources can also be considered in the wider context of the legal principles governing the use of outer space.

Five UN outer space treaties were adopted between 1967 and 1979 and issues relating to the use of outer space are now dealt with through the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). In 2010, the United Nations General Assembly (UNGA) adopted Resolution 65/68 on Transparency and Confidence Building Measures in outer space activities, which called for a Governmental Group of Experts (GGE) to be set up to conduct a study.

In the GGE's report to the UNGA at the end of 2013 (section VI Consultative mechanisms) it recommends that:

"States are encouraged to consider using consultative mechanisms, for example provided for in Article IX of the Outer Space Treaty of 1967 and the relevant provisions of the ITU Constitution and the Radio Regulations", saying that "timely and routine consultations through bilateral and multilateral diplomatic exchanges and other government-to-government mechanisms...can contribute to preventing mishaps, misperceptions and mistrust" and "may also be useful in...preventing or minimizing potential risks of physical damage or harmful interference".

Although the notion of "intent" can be problematic, especially in a technical context, there is historical precedent in international law for the protection of international communications infrastructures. The United Nations Convention on the Law of the Sea (UNCLOS) affords protection to the submarine telecommunication cables which provide international connectivity. As far back as 1884, recognizing that these cables were a public good requiring protection and regulation, the international community adopted an international convention to safeguard them[1].

[1] Convention for the Protection of Submarine Telegraph Cables, March 14, 1884

Towards an Agreed Definition of Intentional Interference

Attempts to address the issue of intentional interference to satellite services, both within the satellite industry and at the ITU, have highlighted the fact that a number of different terms are used, some of which are more controversial than others, and that there is currently no internationally-agreed definition. Although the terms "intentional interference", "deliberate interference" and "jamming" are in common use, there is no recognised, internationally-agreed definition.

In ITU terms, intentional interference is considered to be "harmful interference". However, this definition also covers unintentional interference and it is not possible currently to consider separately, interference which is a result of intent rather than accident. In addition, it is difficult to argue for an internationally-agreed definition which only relates to satellite, since intentional interference also targets terrestrial communications.

The ITU definition of harmful interference used in the international treaty texts is found in the Constitution of the ITU:

"Interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operation in accordance with the Radio Regulations" (paragraph 1003).

Article 45 of the ITU Constitution and Article 15 of the ITU Radio Regulations cover the obligations of Administrations and provide guidance in dealing with harmful interference.

The ITU Plenipotentiary Conference in 2010 (PP-10) considered proposals[2] to improve the protection of satellites. These included the suggestion that the Legal Sub-Committee of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPOUS) considered establishing international treaty obligations similar to those for submarine telecommunication cables [3]. However, this proposal proved controversial and was not accepted. Nevertheless, PP-10 did consider that harmful interference to satellite services was an issue of serious concern and that the ITU World Radiocommunication Conference (WRC) was the correct forum for such a discussion.

When the term "jamming" was used by the ITU Radio Regulations Board (RRB) in its report to WRC-12 on Resolution 80[4], there were objections from some administrations because this was not a term recognised by the ITU. There were useful discussions at WRC-12 in an Ad-hoc group dealing with a multi-country contribution on preventing

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[2] CEPT's Protection of Satellite Communications and Assets ECP (European Common Proposal).

[3] United Nations Convention on the Law of the Sea (UNCLOS).

[4] Under "Considerations regarding jamming of satellite transmissions" the ITU Radio Regulations Board Report to WRC-12 on Resolution 80 (Rev.WRC-07), makes the following statement:
"Harmful interference reports of this type of interference, commonly known as "jamming," have increased. Despite the application of the administrative procedures in the Radio Regulations, the harmful interference sometimes continues and this has given rise to the idea that something more is needed to quickly identify and eliminate the source of interference."

cases of “deliberate interference”. This contribution proposed to insert a new provision in Article 15 of the Radio Regulations "explicitly stating that transmitting signals that are intended or designed to disturb or prevent the transmission of other signals is prohibited." This was rejected by a number of administrations, but WRC-12 recognised the issue itself as a serious one and worthy of attention. After much debate, agreement was reached on an amendment to Article 15 of the Radio Regulations which strengthened the existing text in terms of the notion of responsibility.

In February 2013, France submitted a useful contribution to the RRB which compiled all complaints and associated data on the cases of deliberate interference affecting Eutelsat satellites in 2011 and 2012. It provided technical, operational and regulatory detail and also suggested that:

“Deliberate or intentional interference...can be distinguished by three specific features:

- *The interfering carrier does not come from a station that is planned to operate with the affected Eutelsat satellite: this carrier is therefore unnecessary*
- *The interfering carrier specifically targets the affected satellite (in a way to avoid harmfully interfering with other, adjacent satellites) and, more precisely, some selected transponders*
- *The interfering carrier is almost always continuous-wave and not modulated by any information signal: this carrier does not therefore carry any identification”*

In June later that year, at the ITU-BR Workshop on Preventing Harmful Interference to Satellites Systems held in Geneva, a number of broadcasters and operators highlighted concerns about intentional interference and referenced experience of it. Eutelsat’s presentation “Satellite Interference: An Operator's Perspective” built on the features of intentional interference outlined in the French RRB contribution. These features can be used to provide a working definition of intentional interference to satellite services for use by the industry and broadcasters in discussion, reporting and analysis.

A working definition of intentional interference

Harmful interference exhibiting some or all of these characteristics can be considered to be generated with the intention of disrupting satellite telecommunications:

- Originates from a station which is not planned to operate with the affected satellite
- Targets specific transponders, sometimes at specific times related to specific content

- Presents as unmodulated carrier, carrying no identification, transmitting no information[5]
- Re-transmission of the intended target signal to interfere with the original service
- Tracks the target channel using frequency-hopping if satellite operator has re-transmitted the affected channel on another frequency
- Disappears if channel targeted by intentional interference is closed
- Transmit parameters are modified in real time to avoid any interference mitigation employed

The value of having an agreed working definition for intentional interference is that it can then be used by operators, broadcasters and regulators to assist in the gathering and analysis of data and in the reporting of cases. This will introduce a more consistent approach and, if an agreed definition becomes widely used, the definition may become more widely acceptable and the case for an internationally-agreed ITU definition becomes more plausible.

Achieving an internationally-agreed definition is a significant challenge, however, given how the issue of intentional interference has been dealt with previously at the ITU. Any ITU definition could also not be exclusive to satellite and would need to apply equally to terrestrial and satellite services. The concept of "wilful or culpably negligent actions" can be found in the 1982 United Nations Law of the Sea Convention (UNCLOS). This provides an internationally-agreed legal regime in respect of service interruptions or damage to submarine telegraph cables and the concept could be used to enable similar protection to terrestrial and satellite telecommunications.

A possible ITU definition for "wilful[6]" (i.e. intentional) interference

In Article 1 of the ITU Radio Regulations (Terms and definitions) under Section VII, an additional definition of "wilful interference" could be proposed as a subset of the definition of harmful interference in paragraph 1.169.

Section VII – Frequency sharing

1.166 interference: *The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.*

1.167 permissible interference: *Observed or predicted interference which complies with quantitative interference and sharing criteria contained in these Regulations or in ITU-R Recommendations or in special agreements as*

[5] After the targeted signal is taken down, other content can also be added to the interfering signal for transmission in place of the original content

[6] The spelling of "wilful" is as used in the 1982 United Nations Law of the Sea Convention (UNCLOS)

provided for in these Regulations.

1.168 accepted interference: *Interference at a higher level than that defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations.*

1.169 harmful interference*: Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations (CS).*

Proposal for additional 1.169A

1.169A wilful interference*: Interference which has come about through design or negligence at a higher level than an agreed level of accepted interference or that, in the absence of any agreement to the contrary, is at a higher level than harmful interference.*

For this ITU definition to be internationally agreed, however, it would need to be proposed by an administration or regional group and agreed by consensus at a future ITU World Radio Conference.

Since there is currently no internationally-agreed definition of intentional interference, all cases of intentional interference submitted to the ITU are reported under the classification of 1.169 as harmful interference.

Guidelines for Reporting Harmful Interference

These guidelines aim at introducing procedures for reporting cases of harmful interference related to GSO satellite services and give advice on preparing a report on cases of harmful interference to national administrations and the ITU, as appropriate. These guidelines are developed based on the procedures for resolving harmful interference as contained in Section VI of Article **15** of the Radio Regulations (RR).

Procedures in case of harmful interference[7]

Section VI of RR Article **15** provides procedures to be followed by administrations in the case of harmful interference. The following provides the key points of these procedures.

1. The administration responsible for the affected service or satellite carrier (Administration A) shall send to the administration responsible for the station suspected of causing the harmful interference (Administration B) full particulars relating to the harmful interference in the form indicated in RR Appendix **10** (RR No. **15.27**).

2. When informed that a station under its jurisdiction is suspected of causing harmful interference, Administration B shall acknowledge receipt of that information as soon as possible (RR No. **15.35**).

3. Administration B shall investigate the matter and take action in order to eliminate the harmful interference if it is confirmed that the interfering station is located on its territory.

4. If the cooperation between Administrations A and B has not produced satisfactory results, Administration A may forward details of the case to the Radiocommunication Bureau (BR) for its information (RR No. **15.41**).

5. In such a case, a request of assistance may also be sent to the BR with all the technical and operational details and copies of the correspondence (RR No. **15.42**)

[7] Although these guidelines are aiming at reporting cases of intentional interference (which normally would be expected to be harmful interference), the term "harmful interference" should be used in reporting as the term "intentional interference" is not defined in the Radio Regulations.

Use of RR Appendix 10 to report harmful interference for the cases related to satellite services

RR Appendix **10** was designed with terrestrial services in mind. Therefore its applicability related to emissions from space stations is limited. This is even more problematic when graphical geolocation information has to be conveyed. Report ITU-R SM.2181 (http://www.itu.int/pub/R-REP-SM.2181) was developed to address these shortcomings and suggests a list of additional information (e.g., geolocation information) to be attached together with RR Appendix **10** when reporting cases of harmful interference related to satellite services. The list of items as suggested is however very detailed and many items may not be necessary or related to the particular case of interference. Many items were left vacant even in the two example reports in the Report ITU-R SM.2181.

To better convey some of the necessary additional information recommended in Report ITU-R SM.2181 and to avoid filling in the detailed list as described in the Report ITU-R SM.2181, these guidelines suggest a way (see Part 1 of Appendix 3) to report harmful interference using RR Appendix **10** (where the suggested information to be filled in is more designed for satellite interference and might give more information than what was originally asked in RR Appendix **10**) and a simple list of additional geolocation information. Part 2 of Appendix 3 shows an example report of harmful interference as per the way suggested in Part 1 of Appendix 3.

Getting geolocation results for the source of harmful interference

In case of harmful interference, the responsible satellite operator would investigate the issue to check if it is due to a known source and coordinate with relevant parties to see if the harmful interference can be eliminated. If the harmful interference persists and cannot be eliminated at the level of satellite operators, the satellite operator can prepare a report to its national administration about the case and request its administration to communicate with the administration responsible for the station suspected of causing the harmful interference as per the procedure in case of harmful interference.

The coverage of a satellite depends on its design and its operating frequencies and would normally cover multiple countries. Taking AsiaSat-5 C-band as an example, its footprint covers more than 53 countries spanning from Russia to New Zealand, and from Japan to the Middle East and parts of Africa. An uplink from any location within the footprint of this satellite could potentially create harmful interference to the receivers within the entire footprint. Without knowing the location of the interfering source, it would be difficult, if not impossible, to identify the responsible administration to communicate with and request for elimination of the harmful interference.

To obtain geolocation results, satellite operators and their responsible administrations may already have facilities or sources for performing the geolocation. Telecommunications regulatory authorities of some countries like China, Germany, USA, Korea, Japan, Ukraine and Kazakhstan have their own space radio monitoring facilities and some of these stations may be able to assist other administrations to perform geolocation in cases involving satellite interference. Information of these facilities can be found in Report ITU-R SM.2182 (http://www.itu.int/pub/R-REP-SM.2182) or http://www.itu.int/online/mms/mars/monitoring/l8_station_search.sh. In addition to monitoring/geolocation facilities of administrations, there are private companies which provide geolocation services for customers.

Steps in reporting harmful interference

Competition for spectrum, as well as an increased growth of VSAT terminals is highly likely to increase incidents of interference unless suitable control measures are put in place. Furthermore, as advancements in technology create new standards of complex waveforms that are more susceptible to interference and in cases of harmful interference that cannot be resolved at satellite operator level, the affected satellite operators/satellite users can take the following steps:

Step 1:

Send a letter to its national administration (Administration A) together with the information to be provided when reporting harmful interference (see Appendix 3 Part 1 for a description on the information to be provided and Appendix 3 Part 2 for an example) to request its help to communicate with the Administration responsible for the station suspected of causing the harmful interference (Administration B) to eliminate the interfering signal.

Step 2:

If there is no response from Administration B, or if satisfactory results cannot be reached, invite your national Administration to send a letter to the ITU. In accordance with RR No. **15.41** and RR No. **15.42**, the letter to the ITU should:

- Request the ITU-R Radiocommunication Bureau to act in accordance with the provisions of Section I of RR Article **13** to help resolving the case of harmful interference

- Provide evidence of the cases, including all the technical and operational details and copies of correspondence between Administration A and Administration B (i.e. the correspondence associated with Step 1 above)

Technology to Counter Interference

Technology is advancing, so it is feasible to imagine a world where interference is highly infrequent and out-of-the-ordinary. Although there may never be one silver bullet to fix all, the satellite industry and in turn, the broadcasters, are now given more choice as a result of these technological advancements. It may be the case that a combination of these will be the key to forming a workable solution for all.

Intentional interference is generally politically or economically motivated and symptomatic of issues beyond the broadcasting and satellite industries. Unintentional interference is by and large the major source of the issues faced by satellite operators. Both sources require effort to identify the source and in the case of the latter to then establish communications leading to a cessation. Satellite operators have thus been incentivised to adopt technology that will allow the effects of interference to be mitigated and ideally eliminated. The activity of the Satellite Interference Reduction Group (SiRG), the promotion of Carrier ID (ETSI TS 103 129 v1.1.1 (2013-05) and the Global VSAT Forum's (GVF) training initiatives are all helping reduce incidents of accidental interference or speed resolution of the source.

Evidently there are initiatives and technologies available to assist broadcasters as they continue to deal with the issue of interference.

Satellites have a designed operating life of 15 years and major platforms can take up to 5 years from concept to service. The introduction of any new technology, such as that to counter intentional interference, thus takes a significant period of time. It is fortunate that in some cases the technologies desired by the satellite operators to increase the efficiency and data throughput of their platforms can also be used to mitigate interference. The WBU-IMCG forums are regularly briefed on relevant initiatives and some of the latest are recorded below.

The European Space Agency (ESA) ARTES Competiveness and Growth programme of research funding has a number of initiatives underway, some of which are already being adopted for satellites under construction.

Source nulling – geographic by designed footprint

The use of regionally specific Ku-band or Ka-band uplinks permits smaller areas to be defined in which the uplinks can operate. In this way the footprint can be set to exclude contentious regions. There are a couple of disadvantages – firstly, services must all be passed to the 'out of region' uplink site, increasing costs incurred. Also, Ka-band is more susceptible to rain fade than Ku-band, potentially reducing service availability.

Source nulling – geographic by dynamic control

The next generation of high throughput satellites from SES, Intelsat and Eutelsat are all to use more sophisticated uplink receive aerial arrays. A paper from the European Conference on Antennas & Propagation (2016) indicates how Eutelsat intend to use a flat panel array that can be configured to have minimum gain, a null (maximum attenuation), at any point within the uplink footprint. This should have the advantage of maintaining a wide area Ku-band uplink footprint but with the selectivity to discriminate against defined areas within it.

Frequency notching for single links

Several manufacturers have a technology for deployment on the ground or in space that allows for the removal of an unwanted signal from the wanted signal. Unless deployed on the satellite, where the satellite can process a signal before re-transmission to earth, the technology is suitable only for point-to-point use (i.e. contribution or primary distribution). However, this does provide a solution for those broadcasters and service providers that experience this type of intentional interference.

Frequency notching for DTH

With their Epic^{NG} satellites, Intelsat have deployed on-board technology capable of processing the turnaround service. This includes the ability to notch the service to reduce an unwanted carrier. Alternatively, Epic^{NG} satellites have the capability to frequency shift the wanted service to move it away from the interferer.

Uplink modem technologies

We are aware that development work is in progress to develop processes/technologies that increase the robustness of the uplink modem. In broad terms, this involves combining more sophisticated error detection and recovery mechanisms with spread spectrum techniques and in so doing considerably reduce the destructive effect of the interference.

It will be a number of years before such technology can be deployed on DTH satellites, but nevertheless it provides a further tool that can in future be considered.

Single satellite geolocation

Though not a technology for countering interference, the location of the source is an important factor in countering interference. Geolocation of most sources of interference relies on the platform operator having access to radio frequency (RF) and positional data from two satellites. This is not always possible to achieve and hence a single satellite solution offers a different method for the location of the source. One example of this technology is the SIECAMS® ILS ONE service developed by Siemens Convergence Creators.

Future technologies

The DVB-S/DVB-S2 systems underpin all satellite DTH services and will persist for many years. There are though some potential new technologies (including the use of IP distribution and flat panel receiver arrays for DTH) that may themselves provide mitigations. The convergence between satellite, 5G and broadband, together with the dominance of IP as the delivery stream, could assist services to become less dependent upon specific transponders for delivery of DTH services. That, coupled with the capability for a flat panel array to re-point electronically from one satellite to another (without physical re-alignment), potentially reduces the prominence of key orbital positions. This should certainly mean moving a service from one orbital position to another can be achieved either transparently to the audience, or with no more difficulty than the current re-tuning process. Either one or both technologies will in theory limit further the impact of intentional uplink interference, but this will take many years to achieve.

Guidelines and Code of Conduct for Responses to Intentional Interference

Dealing with satellite interference requires a combination of technical skills, familiarity with the operational environment and international regulation, and considerable patience and persistence. But it also requires a mind-set: that interference needs to be addressed, rather than ignored or downplayed.

There was a time when some in the satellite industry argued that drawing attention to interference was unwise – indeed, risky – behaviour, because it drew attention to the vulnerability of satellite systems to interference. But over a decade of experience has led to substantial changes in that attitude.

That is due, in part, to better training and substantial technical advances (detailed elsewhere in this report), and successful efforts to raise the profile of interference in international fora, including the International Telecommunications Union (ITU).

It was also spurred by work within the satellite industry, including such organizations as the World Broadcasting Unions, the Space Data Association, the Global VSAT Forum, the Satellite Interference Reduction Group, the EMEA Satellite Operators Association (ESOA) and numerous other parties. Specifics of these technical advances are detailed elsewhere in this report.

These efforts are undergirded by a foundational document - the Universal Declaration of Human Rights:

"*Everyone* has the right to freedom of opinion and expression; this right includes freedom to hold opinions *without interference* and to seek, receive and impart information and ideas *through any media and regardless of frontiers*."[8]

Accordingly, there is a growing consensus on certain core principles:

> Ignoring or minimizing interference is not an option; solutions need to be pursued by all affected parties, through collaborative efforts.
>
> The dispute resolution process of the ITU should be used to the maximum extent possible, but ways to expedite that process should be explored.

[8] United Nations General Assembly, Universal Declaration of Human Rights, Article 19 (Paris 1948); italics added.

Broadcasters should publicize incidents of intentional interference, consistent with their own judgements of inherent news value.

Satellite operators should make public the underlying evidence of the source of jamming, including but not limited to graphs, charts and maps.

Satellite operators should work with broadcasters and other clients to provide alternate signal paths, in order to mitigate or, ideally, end interference.

Governments, satellite operators and broadcasters should support efforts by the ITU to create a worldwide network of monitoring stations to geolocate the source of interference, in a manner consistent with findings of the Plenipotentiary conferences, the Radio Regulations Board, and decisions of the World Radiocommunications Conferences.

In an effort to raise awareness and promote transparency, all parties – operators, broadcasters and regulators – should make public reports, documentation and resolutions of incidents of interference.

In particular, contracts between broadcasters and service providers can include specific clauses describing actions to be taken in the event of interference. The objective of all parties is to maintain the service to the audience whilst at the same time producing evidence as to the nature of the interference, particularly if it is of an intentional nature.

Code of Conduct: principles for inclusion in a contract between a Broadcaster and a Satellite Service provider

The objective is to achieve a balance between the rights of the broadcaster, recognising the rights of the service provider (Mux operator/satellite operator) and taking into consideration the other channels within the multiplex. A set of Guidelines was produced by ESOA and signed by a number of their members. Subsequently, contracting parties have developed agreements based on the principles it described. The following are taken from a number of actual contracts:

1. The service provider will use all reasonable means to identify the source/location of the interfering transmission. They will then work with the relevant ITU-recognised Administration to register the appropriate complaint.

2. A process is defined that in the event of interference is to be followed. In certain circumstance, the 'target' channel is removed and replaced firstly by a caption slide and then by an anonymous test signal. The service provider may be requested to provide alternative capacity on a different transponder at the same orbital location (polarisation and coverage) to carry the service for a temporary period.

3. The process can also be written to accommodate the steps to be taken in the event of repeated incidents during an elapsed period such as a year.

Conclusions and Recommendations

In conclusion, the following points are noted:

- Although instances of some types of intentional interference to satellite services have reduced, instances still occur with regularity and when it does, it has significant impact.
- For actors with sufficient resources, intentional interference is relatively easy to do, difficult to prevent and the regulatory and legal environment is not always equipped to resolve it.
- Broadcasting services dependent on reliable and interference-free satellite services are high-value, whether that is the free-flow of information globally or commercial revenue.
- Today's unstable geopolitical environment carries increased risk for the targeting of satellite services whether for political or economic reasons.
- Due to the combined effort of broadcasters, satellite industry and regulators, the profile of intentional interference has been raised and useful initiatives and discussions have followed.
- Advances in innovation, technology and operational practices by the satellite industry have increased the options available to mitigate the risk and impact of intentional interference for broadcasters.
- Developments in technologies to improve geolocation of the sources of interference have improved identification and assessment of interference and helped in the gathering of data and evidence.

Recommendations

Broadly, these fall into a number of areas: actions that can be taken by broadcasters, those to be pursued in the regulatory arena, or those which are technology based.

Broadcasters are encouraged to:

- Have procedures in place to deal with issues of interference, and to have the best possible contract terms with their satellite service providers.
- Compile and share information and data on cases with WBU-IMCG.
- Consider continuing to monitor and maintain contact with UN-associated bodies concerned with space security, to enable the sharing of information of mutual interest.

The satellite operators and service providers are recommended to:

- Encourage the industry to agree on a working definition of intentional interference to satellite services, identifying its characteristics, and to assist with the collection and collation of data on interference.

- Encourage the industry to continue the development of technologies that will increase the security and robustness of the uplinks.

- Encourage the industry to continue to develop technical solutions for intentional interference to satellite services including geolocation of sources.

- Follow guidelines in this report on reporting cases to the ITU and compile and share information on cases with SDA.

And we suggest that the WBU-IMCG continues to:

- Support measures to automate the filing and processing of data, recording incidents of interference and open discussions with ITU-BR on interference monitoring, monitoring facilities and how data is recorded, stored and analysed.

- Work in ITU Steering Groups 1 and 4 to encourage best practices for dealing with interference to satellite services and consideration of whether the regulatory process to address this could be improved.

- Encourage Administrations and regulators in different countries to have their own geolocation facility in order to confirm reports received from satellite operators concerning harmful interference.

- Work with the ITU to identify how geolocation reports can be confirmed and adopted and how effective action can be taken against harmful interference once the source has been confirmed.

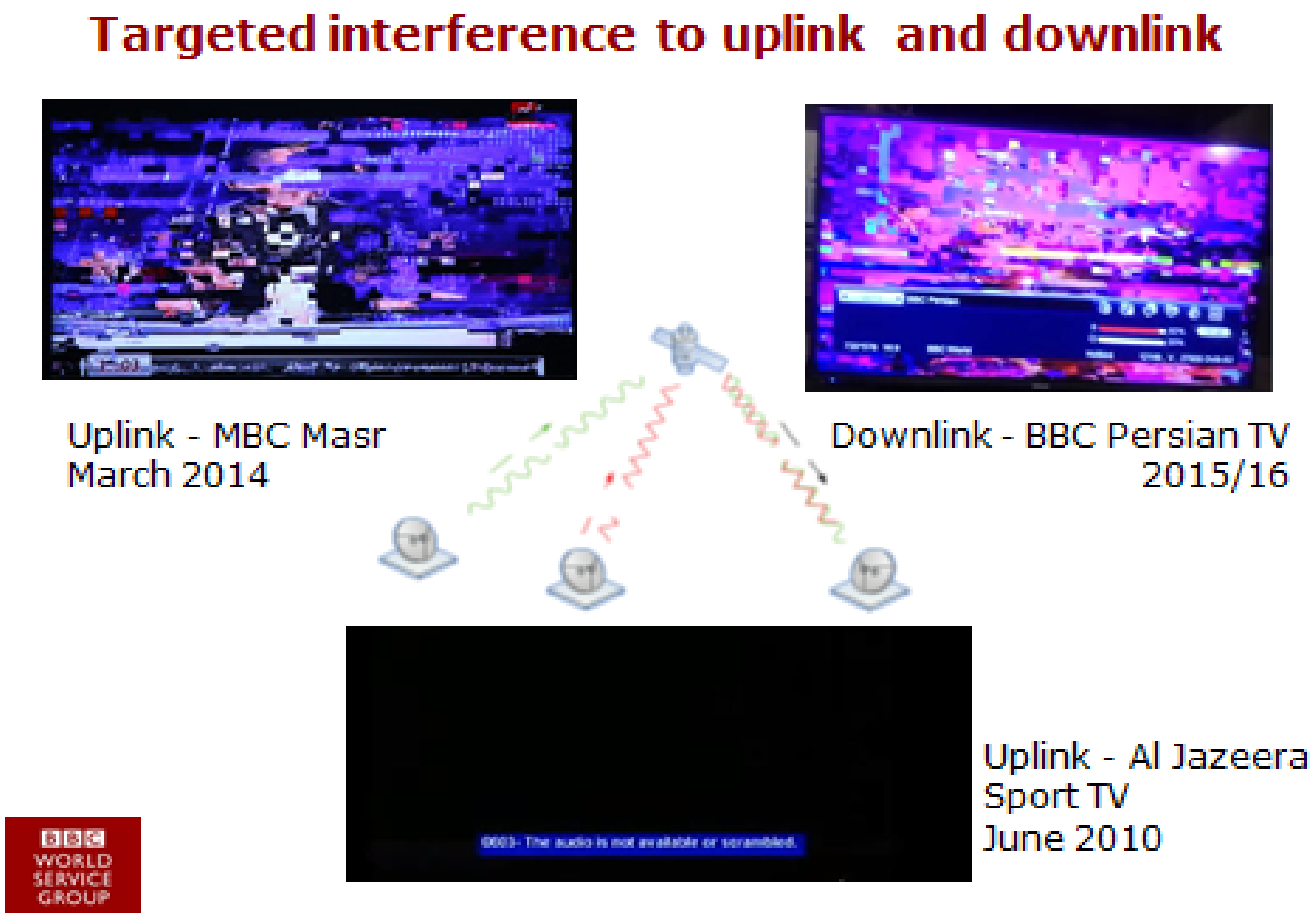
Appendix 1

Interference Causes and Description

CAUSE	DESCRIPTION
Human Error	Usually accidental due to error made by earth station operator (e.g., transmitting to incorrect satellite, mispointing antenna to a side-lobe, or at incorrect time/power level/frequency/polarisation, with incorrect MODCOD parameters affecting bandwidth, or through antenna instead of into dummy load).
Adjacent Satellite Interference (ASI)	Also generally accidental due to operational error made by earth station operator, poor system design or installation practices. Becoming more prevalent as 2° (or less) spacing between satellites in geostationary arc becomes more common. Also increasing use of small aperture terminals with wider main beams makes accurate pointing of the antenna more critical. Typical 3dB beam widths approach +/- 0.75° or greater, thus illuminating an adjacent satellite spaced at 2°is more likely.
Re-transmission of Terrestrial Signals	Many satellite ground stations use Intermediate Frequency (IF) blocks of 70 MHz, 140 MHz or L-Band (950 - 2150 MHz). These IF signals are up-converted to satellite frequency bands using Block Up-Converters (BUC). If frequencies are used for provision of terrestrial services such as FM broadcast radio, or cell phone networks (e.g., 3G and 4G networks); hence poorly planned or maintained ground stations or poorly aligned terrestrial systems may result in retransmission of these terrestrial signals to the satellite.
Cross Polarisation Interference	Causes of cross polarisation interference are: 1) Antenna becomes misaligned, especially in cases where linear polarisation used (typically the case for many transmissions via satellite in Ku-band). Misalignment may be due to several factors, ranging from antenna being moved by high winds or other weather conditions, or poor installation. 2) Misoperation and consequent misalignment by Ku-band maritime operators where automatic polarisation correction facility is switched off or areas of “masking” not correctly configured (where antenna line of sight is blocked by ship’s superstructure) 3) Bad planning practices e.g. where transmit signals become modulated with local analogue carriers (such as FM TV) in the polarisation opposite to a digitally-modulated carrier.
Co-Pol	Any signal appearing on the same transponder and polarisation as the "victim" signal, probably intended to be on that transponder, but at an unauthorized frequency or power level. Alternatively, the intermodulation product of two identified carriers that are being misoperated – (see below)
Intermodulation	Occurs when sums and differences of the harmonic frequencies (inter-modulation products) of two or more RF signals cause harmful interference. “Third order harmonic” is most common amongst the various products. Often caused by: 1) An increase of uplink transmission power above link budget requirements. 2) Overdriven ground equipment, as spurious carriers at harmonic frequencies may “appear” outside the allocated bandwidth of the wanted carrier and cause Adjacent Carrier Interference (ACI).
Intentional Interference	Interference due to political or commercially-motivated “jamming” mainly of broadcast FSS.
Other Sources	Intermittent sources such as airborne radar altimeters, WiMAX, neon signs, etc. can be very difficult to capture unless there is dedicated monitoring equipment installed.

Appendix 2

Examples of Jammed Satellite Broadcasts at Ku-band



(From a presentation delivered at the Global Conference on Space and the Information Society – GLIS 2016)

Appendix 3

ITU RR Appendix 10, Draft Pro-Forma for Satellite Interference

PART 1.

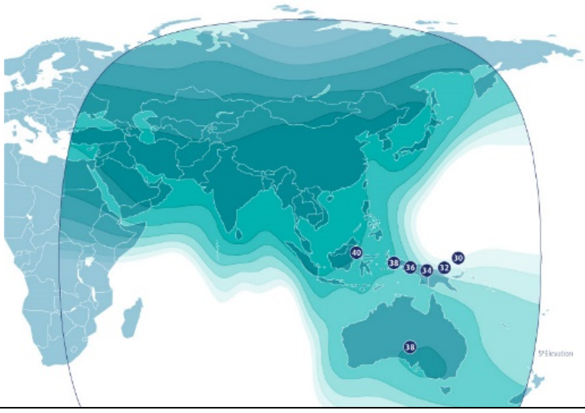
Information to be provided when reporting harmful interference (ITU RR Appendix 10 + Additional geolocation information) - with description on what to be filled in

Notes in square brackets give a brief description on what is suggested to be filled in and examples in the right-hand column marked e.g. give examples on the kind of information to fill in. The suggested information to be filled in is more designed for satellite interference and might give more information than what was originally asked for in RR Appendix **10**.

Report of harmful interference (AP10)

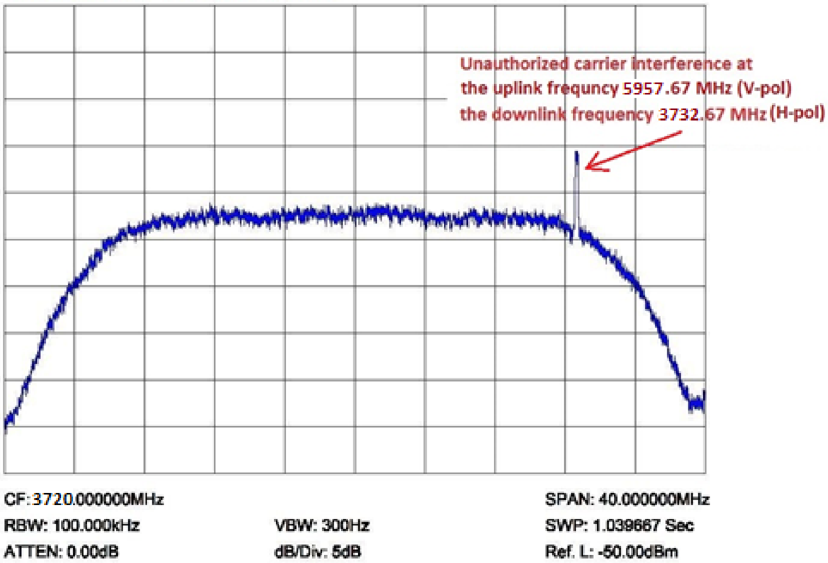
Particulars concerning the station causing the interference:	
a. Name, call sign or other means of identification [Note: This item is more designed for terrestrial services and it is possible to leave this field blank or marked as unknown.]	e.g. Unknown
b. Frequency measured [Note: The frequency range of the harmful interference.]	e.g. 5957.658MHz–5957.682MHz 3732.658MHz–3732.682MHz
Date: [Note: Date of the harmful interference spectrum plot taken. It is also possible to describe the occurrence of interference to give more information.]	e.g. Occurrence of interference: DD MMM YYYY to DD MMM YYYY/date of reporting interference
Time (UTC): [Note: Time of the spectrum plot taken. If on the above item (date), a range of date is given to describe the occurrence of interference, it is possible to specify also the exact date of the spectrum plot here.]	e.g. TT:TT-TT:TT DD MMM YYYY (Spectrum plots time)
c. Class of emission [Note: Class of emission of the interferer as defined in RR AP1, is normally difficult to classify. However, it is possible to provide a description of the interference. Where possible, please specify if the interference is either on the uplink (meaning that terrestrial emissions or Earth Stations create interference on the wanted space segment capacity) or on the downlink only (meaning that an unwanted satellite transmission or terrestrial services create interference on the Earth Stations).]	e.g. 1 Unknown. Description of the occurrence of harmful interference: Time and frequency stable signal. e.g. 2 Unknown. Description of the occurrence of harmful interference: Sweeping / drifting

d. Bandwidth (indicate whether measured or estimated) [Note: Bandwidth of the interference]	e.g. 1 24KHz, measured e.g. 2 CW
e. Measured field strength or power flux-density [Note: Measured power flux density of the interference, it is also possible to provide spectrum plot instead]	e.g. See Attachment 1 and 2 for the plot of interfering signal
Date: [Note: Date of the measurement/spectrum plot]	e.g. DD MMM YYYY
Time (UTC): [Note: Time of the measurement/spectrum plot]	e.g. TT:TT – TT:TT
f. Observed polarization [Note: Polarization of the interference]	e.g. V-pol, uplink; H-pol, downlink
g. Class of station and nature of service [Note: The class of station and nature of service is defined in Table 3 and Table 4 of the Preface in BR IFIC, the preface can be downloaded in http://www.itu.int/en/ITU-R/space/Pages/prefaceMain.aspx. The class of station and nature of service may in many cases not be possible to identify. It is then possible to leave this field blank or marked as unknown.]	e.g. Unknown
h. Location/position/area/bearing (QTE) [Note: The location of the source of interferer. It is possible to provide the geolocation result, see section 4 on how to get geolocation result.]	e.g. According to the geo-location result, the uplink interference station is located at [Latitude Longitude] near [City], [Country] (See Annex 1 for geolocation result)
i. Location of the facility which made the above measurements [Note: The location of the measurement (e.g. where the spectrum plot was taken) and the location of facility for performing geolocation and monitoring dish size.]	e.g. 1. Spectrum plots (attachment 1 and 2) were taken in AsiaSat Tai Po Earth Station (22.453°N 114.189°E) in Hong Kong and monitoring antenna size was 3.7m. 2. Geolocation were performed in Beijing, China (39.66°N 116.23°E)
Particulars concerning the transmitting station interfered with:	
j. Name, call sign or other means of identification [Note: This item is more designed for terrestrial services. It is possible to indicate the affected satellite, the NORAD ID of the satellite and the affected transponder number.]	e.g. AsiaSat 5 (Norad ID: 35696) Transponder CXH
k. Frequency assigned [Note: The frequency of the wanted carrier]	e.g. 36MHz wanted carrier: 5927MHz–5963MHz (V-pol, uplink) 3702MHz–3738MHz (H-pol, downlink)
l. Frequency measured [Note: Frequency range of the measurement/spectrum plot]	e.g. Spectrum plots: (attachment 1 and 2) 5925MHz–5965MHz (V-pol, uplink) 3700MHz–3740MHz (H-pol, downlink)
Date: [Note: Date of the measurement/spectrum plot]	e.g. DD MMM YYYY
Time (UTC): [Note: Time of the measurement/spectrum plot]	e.g. 07:24 - 07:26

m. Class of emission [Note: Class of emission of the affected carrier as defined in RR AP1. If unsure, it is possible to specify signal bandwidth, modulation and coding or leave it blank.]	e.g. 1 36M0G7W e.g. 2 36 MHz signal bandwidth, 8 PSK FEC 3/5 DVB-S2
n. Bandwidth (indicates whether measured or estimated, or indicate the necessary bandwidth notified to the Radio-communication Bureau) [Note: Bandwidth of the wanted carrier, it is also possible to provide both wanted and interferer carrier to make it clear.]	e.g. Wanted carrier: 36MHz, measured Interferer carrier: 24kHz, measured
o. Location/position/area [Note: Orbital location of affected satellite]	e.g. 100.5 deg E in the GSO arc
p. Location of the facility which made the above measurements [Note: it can be the location of where the spectrum plot is taken and monitoring dish size.]	e.g. Spectrum plots (attachment 1) were taken in AsiaSat Tai Po Earth Station (22.453°N 114.189°E) in Hong Kong and monitoring antenna size was 3.7m.
Particulars furnished by the receiving station experiencing the interference:	
q. Name of station [Note: Affected earth station]	e.g. AsiaSat Tai Po Earth Station in Hong Kong and other receiving earth stations under the footprint of AsiaSat 5 transponder CXH
r. Location/position/area [Note: Location of the affected earth station and dish size.]	e.g. Hong Kong and other receiving earth stations under the footprint of AsiaSat 5 transponder CXH (see below for footprint). Interference present on the uplink, therefore all dish sizes are affected. 
s. Dates and times (UTC) of occurrence of harmful interference	e.g. DD MMM YYYY to the date of reporting
t. Bearings (QTE) or other particulars [Note: This item is more designed for terrestrial service and can be left blank.]	e.g. -
u. Nature of interference	e.g. 1 Unauthorized carrier interference
v. Field strength or power flux-density of the wanted emission at the receiving station experiencing the interference [Note: it is possible to provide spectrum plot for this.]	e.g. See Attachment 1 for the plots of wanted signal and interfering signal

Date: [Note: Date of the measurement/spectrum plot.]	e.g. DD MMM YYYY
Time (UTC): [Note: Time of the measurement/spectrum plot.]	e.g. TT:TT – TT:TT
w. Polarization of the receiving antenna or observed polarization [Note: Polarization of the receiving earth station.]	e.g. V-pol, uplink H-pol, downlink
x. Action requested [Note: The action you want the Administration responsible for the station causing the harmful interference to perform.]	e.g. Elimination of the interfering signal. Reduction of power level by [X] dB.

Attachment 1:
[Note: Spectrum plot regarding the interference]
e.g.



ANNEX 1

Additional information regarding the geolocation information:

1. Geolocation result:

[Note: Latitude Longitude near City, Country]
e.g. 13.19°S 135.47°E near Gapuwiyak, Australia

2. Confidence level of the geolocation measurement:

[Note: xx %]
e.g. 95%

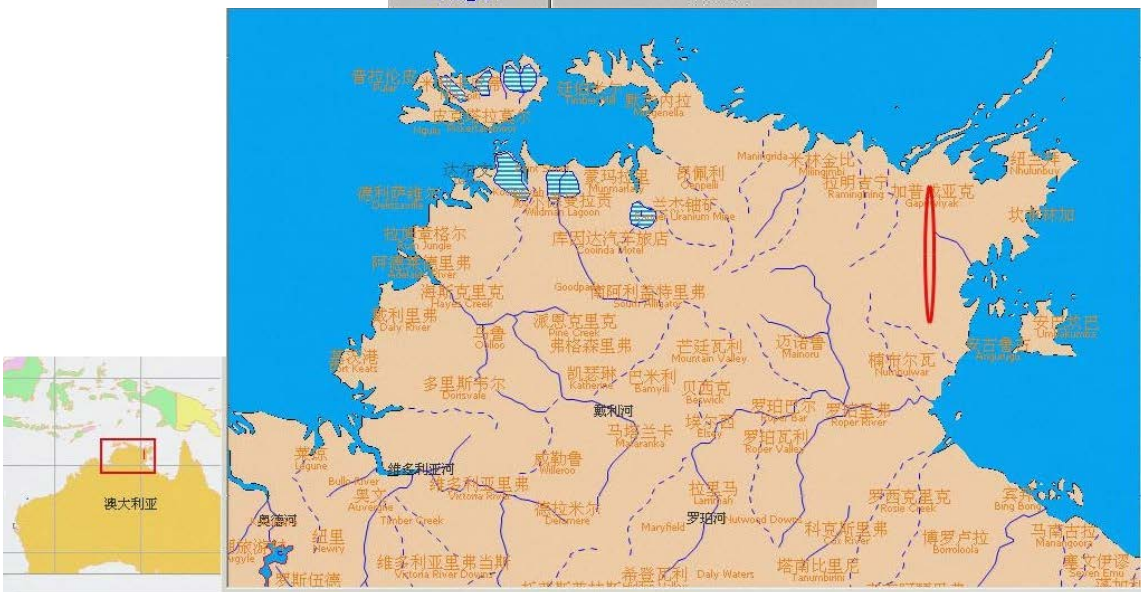
3. Accuracy prediction for the time of measurement:

[Note: XX km or AA x BB km (where AA and BB is the major/minor axis of the ellipse)]
e.g. 10 x 2 km

4. Plot of geolocation measurements:

e.g. (Geolocation measurement example)
[Note: this is just an example showing the geolocation result and is not the real geolocation result of the interference case]

Latitude	-13.19
Longitude	135.47
Semi-Major Axis	0.68963119
Semi-Minor Axis	0.05328662
Angle	-85.1195

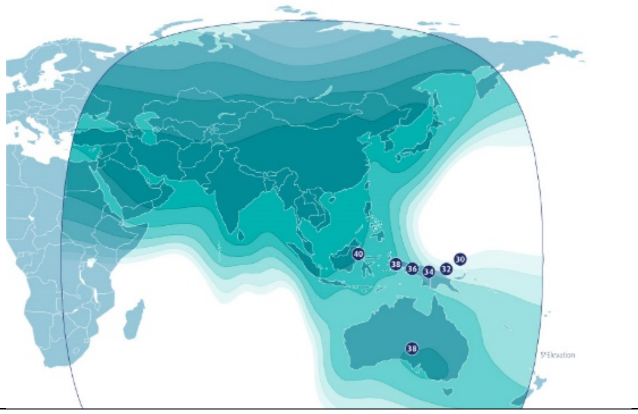


Part 2.

Information to be provided when reporting harmful interference (RR Appendix10 + Additional geolocation information) – An example

Report of harmful interference (AP10)

Particulars concerning the station causing the interference:	
a. Name, call sign or other means of identification	Unknown
b. Frequency measured	5957.658MHz–5957.682MHz 3732.658MHz–3732.682MHz
Date:	Occurrence of interference: 1 Jan 2017 to DD MMM YYYY/date of reporting interference
Time (UTC):	00:00-00:02 1 Jan 2017 (Spectrum plots time)
c. Class of emission	Unknown. Description of the occurrence of harmful interference: Time and frequency stable signal.
d. Bandwidth (indicate whether measured or estimated)	24KHz, measured
e. Measured field strength or power flux-density	See Attachment 1 and 2 for the plot of interfering signal
Date:	1 Jan 2017
Time (UTC):	00:00-00:02
f. Observed polarization	V-pol, uplink; H-pol, downlink
g. Class of station and nature of service	Unknown
h. Location/position/area/bearing (QTE)	According to the geolocation result, the uplink interference station is located at [Latitude Longitude] near [City], [Country] (See Annex 1 for geolocation result)
i. Location of the facility which made the above measurements	1. Spectrum plots (attachment 1 and 2) were taken in AsiaSat Tai Po Earth Station (22.453°N 114.189°E) in Hong Kong, and monitoring antenna size was 3.7m. 2. Geolocation were performed in Beijing, China (39.66°N 116.23°E)
Particulars concerning the transmitting station interfered with:	
j. Name, call sign or other means of identification	AsiaSat 5 (Norad ID: 35696) Transponder CXH
k. Frequency assigned	36MHz wanted carrier: 5927MHz–5963MHz (V-pol, uplink) 3702MHz–3738MHz (H-pol, downlink)
l. Frequency measured	Spectrum plots: (attachment 1 and 2) 5925MHz–5965MHz (V-pol, uplink) 3700MHz–3740MHz (H-pol, downlink)
Date:	1 Jan 2017
Time (UTC):	00:00 – 00:02
m. Class of emission	36M0G7W
n. Bandwidth (indicates whether measured or estimated, or indicate the necessary bandwidth notified to the Radio-communication Bureau)	Wanted carrier: 36MHz, measured Interferer carrier: 24KHz, measured

o. Location/position/area	100.5 deg E in the GSO arc
p. Location of the facility which made the above measurements	Spectrum plots (attachment 1 and 2) were taken in AsiaSat Tai Po Earth Station (22.453°N 114.189°E) in Hong Kong and monitoring antenna size was 3.7m.
Particulars furnished by the receiving station experiencing the interference:	
q. Name of station	AsiaSat Tai Po Earth Station in Hong Kong and other receiving earth stations under the footprint of AsiaSat 5 transponder CXH
r. Location/position/area	Hong Kong and other receiving earth stations under the footprint of AsiaSat 5 transponder CXH (see below for footprint). Interference present on the uplink, therefore all dish sizes are affected. 
s. Dates and times (UTC) of occurrence of harmful interference	1 Jan 2017 to the date of reporting
t. Bearings (QTE) or other particulars	-
u. Nature of interference	Unauthorized carrier interference
v. Field strength or power flux-density of the wanted emission at the receiving station experiencing the interference	See Attachment 1 and 2 for the plot of wanted signal and interfering signal
Date:	1 Jan 2017
Time (UTC):	00:00 - 00:02
w. Polarization of the receiving antenna or observed polarization	V-pol, uplink H-pol, downlink
x. Action requested	Elimination of the interfering signal

ANNEX 1

Additional information regarding the geolocation information:

1. Geolocation result:

XX°N YY°E near [City], [Country]

2. Confidence level of the geolocation measurement:

95%

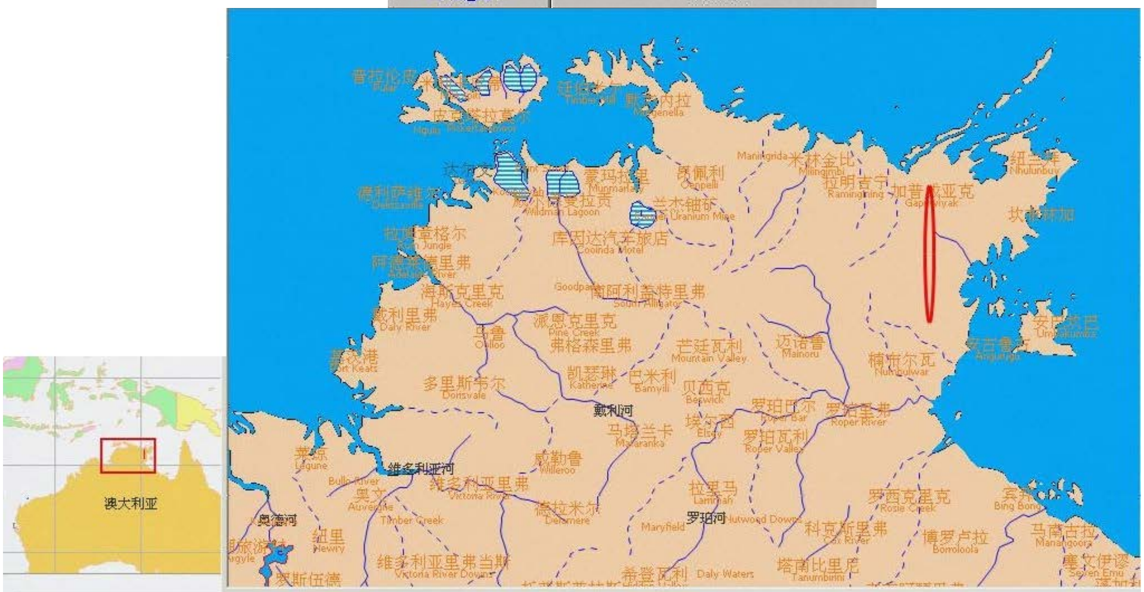
3. Accuracy prediction for the time of measurement:

10 km x 2 km

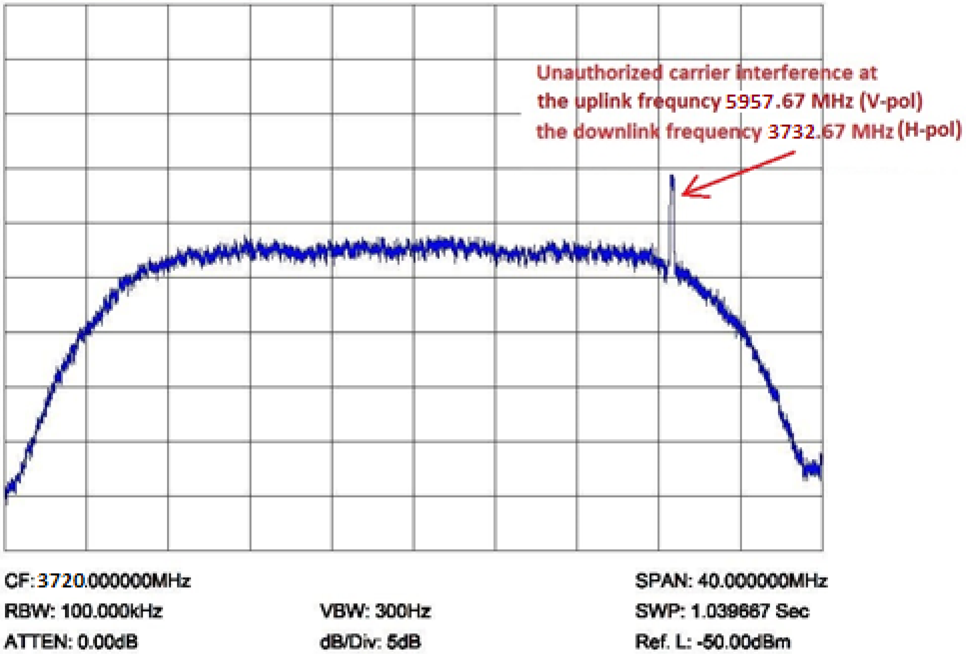
4. Plot of geolocation measurements:

[Note: this is just an example showing the geolocation result and is not the real geo-location result of the interference case]

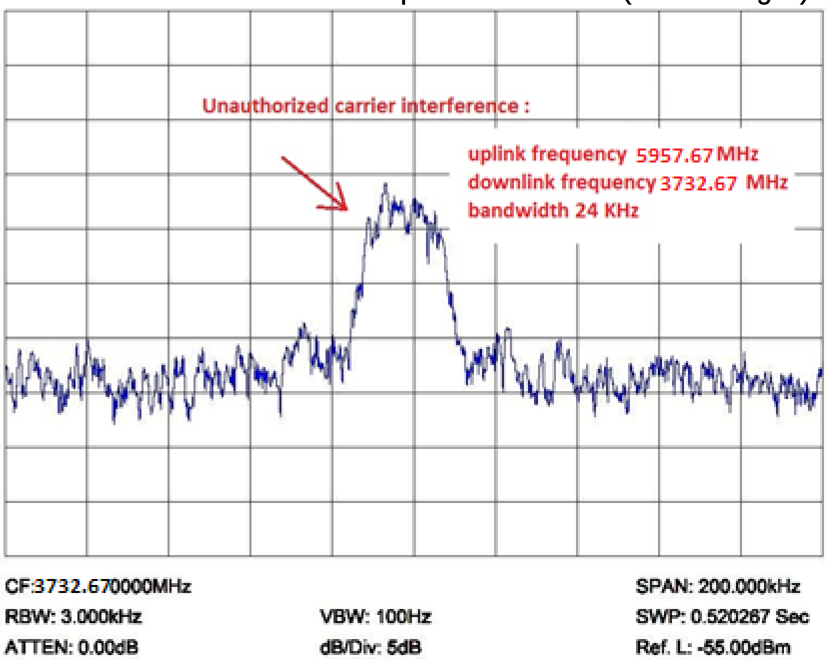
Latitude	-13.19
Longitude	135.47
Semi-Major Axis	0.68963119
Semi-Minor Axis	0.05328662
Angle	-85.1195



Attachment 1: Downlink plot of A5-CXH (100.5 deg E) full transponder



Attachment 2: Downlink plot of A5-CXH (100.5 deg E) centered at 3732.67 MHz



Appendix 4

World Broadcasting Unions

The World Broadcasting Unions (WBU) is the coordinating body for broadcasting unions who represent broadcaster networks across the globe. It was established in 1992 as a coordinating body at the international broadcasting level. Since then, the WBU has provided global solutions on key issues for its member unions. The North American Broadcasters Association (NABA) acts as secretariat for the WBU. The broadcasting unions who belong to the WBU are the Asia-Pacific Broadcasting Union (ABU), the Arab States Broadcasting Union (ASBU), the African Union of Broadcasting (AUB), the Caribbean Broadcasting Union (CBU), the European Broadcasting Union (EBU), the International Association of Broadcasting (IAB/AIR), and the North American Broadcasters Association (NABA).

The WBU currently has four working committees:

1. International Media Connectivity Group (WBU-IMCG)
2. Technical Committee (WBU-TC)
3. WBU-WIPO Broadcaster Treaty Working Group (WBU-WIPO BTWG)
4. Sports Committee (WBU-SC)

The WBU-IMCG was founded in 1985, as the International Satellite Operations Group (ISOG). It was rebranded in 2015 as the International Media Connectivity Group (IMCG) and provides a global forum for members of the WBU to exchange information, outline requirements and resolve common operational problems.

WBU-IMCG's mission is to identify, evaluate, educate and, where appropriate, implement solutions for all operational matters associated with transmission (collection and delivery) by any means and to any platform of video, audio, and broadcast-related data from any location where news, sports, special events and entertainment coverage originate and/or is distributed. The WBU-IMCG will work neutrally with all relevant international groups, institutions, organizations, and appropriate bodies to achieve these ends. By doing so, the WBU-IMCG reflects one of the core aims of the WBU by supporting the needs and the requirements of broadcasters around the world.

The WBU-IMCG is a tri-partite organization whose participants consist of members from the WBU including broadcasters, satellite and fibre optic carriers, transmission service providers and invited participants associated with the industry.

The WBU-IMCG Working Group on Intentional Interference to Satellite Services comprised the following members:

- Mr Mohamed Abdalla / Mr Bassil Zoubi, Arab States Broadcasting Union
- Mr John Ball, Turner Broadcasting, Chair of WBU International Media Connectivity Group
- Mr Gonzalo de Dios, Intelsat
- Mr Hazem Moakkit, Intelsat
- Dr Mohaned Juwad, Intelsat
- Mr Nigel Fry, BBC, Chair of the WBU-IMC Working Group on Intentional Interference to Satellite Services
- Mr Yasir Hassan, Arabsat
- Mr Ethan Lavan, Eutelsat
- Mr Akira Ogawa, NHK, Former Chair of WBU International Media Connectivity Group
- Mrs Elena Puigrefagut, European Broadcasting Union
- Mr Amal Punchichewa, Asia-Pacific Broadcasting Union, Former Vice-Chair of WBU Technical Committee
- Mr Gary Thatcher, Broadcasting Board of Governors (USA)
- Mr Roger Tong, Asiasat
- Ms Vicky Wong, Asiasat
- Ms Cath Westcott, BBC

Contributions to the Reports produced were also made by:
Martin Coleman (Executive Director, Satellite Interference Reduction Group - SiRG)