Managing Change at the ITU-R:

Simulation, Coordination, & Verification using Visualyse

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1. Why are there so many ITU-R meetings?

On the ITU web site there is the meetings schedule for the next year: there are about 50, of groups with acronyms like JTG 5-6, WP 3M, and SG 5. Some meetings are huge undertakings. World Radio Conferences (WRCs) last 4 weeks and are attended by over 2,000 delegates at a total cost of tens of millions of dollars. Thousands of experts and officials spend large parts of their life flying round the world and then being buried in buildings such as the CICG in Geneva. As one who has done my share of ITU-R work, I have asked myself why do we do this?

The reasons for all the meetings are:

- The need to manage the change occurring in the world outside the ITU-R,
- To adapt spectrum to new circumstances
- To modify the instruments of the ITU-R that assist in the management of the spectrum.

In this paper I shall look at how change is managed within the ITU-R, giving Case Studies as appropriate, and showing how this process can be assisted using software tools that predict the potential for interference between services and systems.

2. Forces of Change: External Pressures

It is well known that the telecommunications industry is in a period of unprecedented rapid development and that it is continually finding new and innovative ways of using radio ways. Change can result from many external pressures including:

Economic: for example as mass production reduces the price of equipment it becomes possible to introduce new services or as countries develop and their GDP increases they can afford new advanced systems.

Technological: for example the development of the use of higher frequencies, use of constellations of non-GSO satellites, and the rise of Internet protocols based upon IP.

Market: as users request new services such as higher data rate services, increased mobility, or need new types of scientific measurements.

Data: as the behaviour of radio waves and equipment are better understood, how they are characterised in propagation models can be improved.

While these are the “big picture” pressures driving the industry there can be more personal motivations. Iridium was in part inspired due to a question asked by the wife of Motorola executive Bary Bertiger. While on holiday in the Bahamas Karen Bertiger asked whether he could devise a way for her to phone home wherever she was – even on holiday on a remote island. It was a good time to ask such a question as there were rapid technological changes that would soon allow systems to be designed to provide such a service.

While usually there are one or more organisations that instigate change, there may be many more who are effected by the changes proposed or have alternative, conflicting suggestions.

Changes can be minor – for example a parameter of a propagation model is updated to reflect new measurements. Or a change can dominate the ITU-R for years, such as the development of IMT-2000 standards or the proposals for non-GSO FSS such as Teledesic and SkyBridge.

To make this paper relevant to those involved in both satellite and terrestrial systems, most of the examples involve introduction of a new system that results in Earth-space or space-Earth sharing.

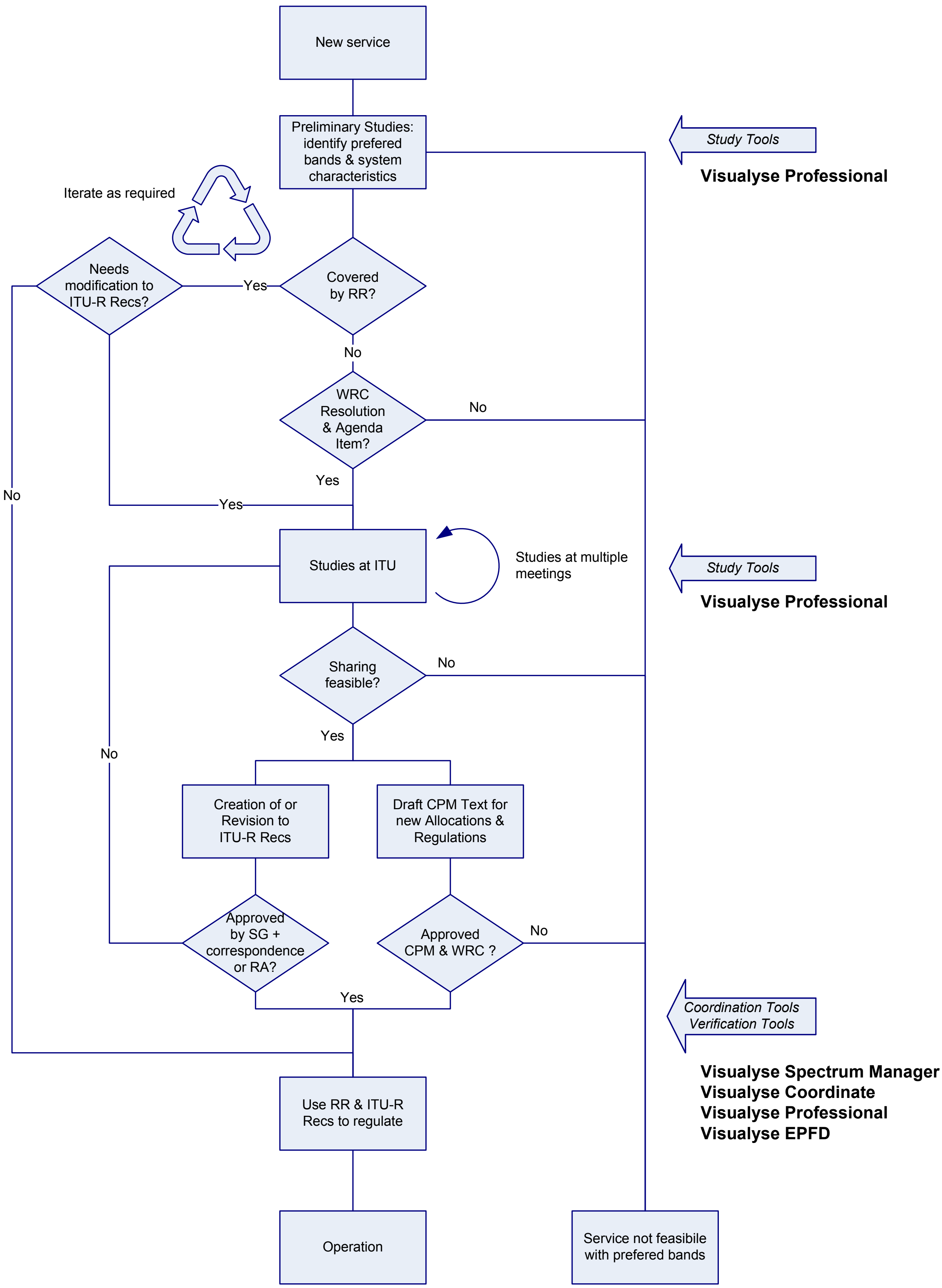
3. What has to be changed?

The two principal tools employed at the international level to manage use of the radio spectrum are the Radio Regulations and the ITU-R Recommendations. Major changes, such as the introduction of new types of system, are unlikely to be accommodated by the existing RR and Recommendations. Therefore the protagonists are likely to need to change the RR and modify existing or create new Recs. This is particularly true if the service requires a new allocation.

This process can require the following stages:

1. Identification RR and ITU-R Recommendation requiring changes
2. If necessary, creation of WRC Agenda items
3. If necessary, creation of ITU-R Questions
4. Analysis at ITU-R SGs
5. If necessary, creation of or revision to ITU-R Recs.
6. If necessary, update of RR at WRC
7. If successful, operational use of measures in RR and Recs.

These steps in the simplified process are shown in the diagram below.


New service
Preliminary Studies: identify prefered bands & system characteristics
Study Tools
Visualyse Professional
Iterate as required
Needs modification to ITU-R Recs?
Yes
Covered by RR?
No
WRC Resolution & Agenda Item?
No
Yes
No
Yes
Studies at ITU
Studies at multiple meetings
Study Tools
Visualyse Professional
Sharing feasible?
No
Yes
No
Creation of or Revision to ITU-R Recs
Draft CPM Text for new Allocations & Regulations
Approved by SG + correspondence or RA?
Approved CPM & WRC ?
No
Yes
Coordination Tools
Verification Tools
Visualyse Spectrum Manager
Visualyse Coordinate
Visualyse Professional
Visualyse EPFD
Use RR & ITU-R Recs to regulate
Operation
Service not feasibile with prefered bands

This diagram is simplified, as the actual process:

- Could require multiple cycles to make all the required updates
- Updates to the regulations for one service can result in updates to other services in reaction
- There can be several interdependent changes being processed simultaneously
- The figure excludes update of Questions (in practice work at the ITU is driven by the level of activity of participants: Questions have been updated retrospectively to reflect work already underway)
- There can be several routes to achieve the same goals (for example approval of Recommendations by Approval or via the Radio Assembly)
- Failure can lead to several alternative courses of action (minor errors might be fixed editorially, more significant ones could result in documents being returned to Study Groups for further work, while situations like study showing sharing is not feasible can result in completely new strategies or recognition that the goal is not achievable).

A number of Case Studies will be used in this paper when describing the process:

- *Identification of Changes* and *Creation of WRC Agenda Items*: these will consider the proposals for introduction of AMSS into bands used by the FS/FSS at 14 GHz
- *Study within the ITU-R*: this will include analysis of interference between terrestrial services such as IMT-2000 and satellite earth stations in C-band and RLANs sharing with satellites at 5 GHz.
- *Operational use of measures in RR and Recs*: this will include coordination of satellite ES with FS and the automated planning & coordination of terrestrial fixed links.

4. Identification of Changes

The extent and type of change to RR and Recs. will depend upon the external pressure. For example introduction of a standard point-to-point FS station in an FS band would not require any changes at all because the regulatory framework is in place. Small changes, such as updating a Recommendation in result of new propagation data, can be done through the relevant Study Group.

More dramatic changes could be required for the introduction of a whole new service, which can involve a new allocation or change of an existing allocation. To do this needs a good understand of the characteristics of the new service and the relevant RR and Recs.

For example at WRC 2000 there was discussion about the need to provide high-speed interactive data services such as the Internet to aircraft. Existing AMSS allocations, such as in L band, might have insufficient bandwidth to provide the required broadband data services. Therefore it was necessary to consider a new allocation for AMSS or to extend the current MSS (excluding Aeronautical) to generic MSS.

This can be done by either modifying an existing allocation or creating a new one. Either of these changes needs the subject to be discussed at a WRC, and the usual procedure for this is to create an Agenda Item for a future conference. However, at the start of recent Conferences there has been intense debate between Administrations as to what is actually on the Agenda, so this process is not necessarily straightforward.

The proposal to use high altitude platforms (HAPS) raised a more fundamental question: Which service is it?

At the time the FS included stations fixed to the ground, while the FSS included satellites, but there was no service definition for stationary high altitude platforms.

At the WP 4A meeting in Rio (September 1996) the first step was made with the US input document WP 4A/130, which suggested that HAPS operate "as a FS and/or a FSS". At this meeting the concept of HAPS was discussed and a liaison statement sent to WP 4-9S and WP 9D that suggested that "such as system had more characteristics in common with FS systems than with FSS systems". This principle was broadly agreed and future work was done within FS groups.

5. Creation of WRC Agenda Item

Each WRC decides the Agenda for the next meeting. There are two general approaches to consider new allocations:

- Request that the ITU-R search for suitable spectrum within a certain range. An example of this would be Agenda 1.15.1 (see Resolution 721 WRC 97) that requested that WRC 2000:

  1.15.1 to consider new allocations to the radionavigation-satellite service in the range from 1 GHz to 6 GHz required to support developments;

- Request that the ITU-R study allocation of spectrum for a specific band. An example of this was Agenda Item 1.11 approved at WRC 2000 for WRC 03:

  *1.11 to consider possible extension of the allocation to the mobile-satellite service (Earth-to-space) on a secondary basis in the band 14-14.5 GHz to permit operation of the aeronautical mobile-satellite service as stipulated in Resolution **216 (Rev.WRC-2000)**;*

The associated Resolution requests the ITU-R to study sharing with existing primary services (FS and FSS) so that WRC-03 is in a position to decide whether to extend the current secondary allocation for MSS (excluding Aeronautical) to include Aeronautical.

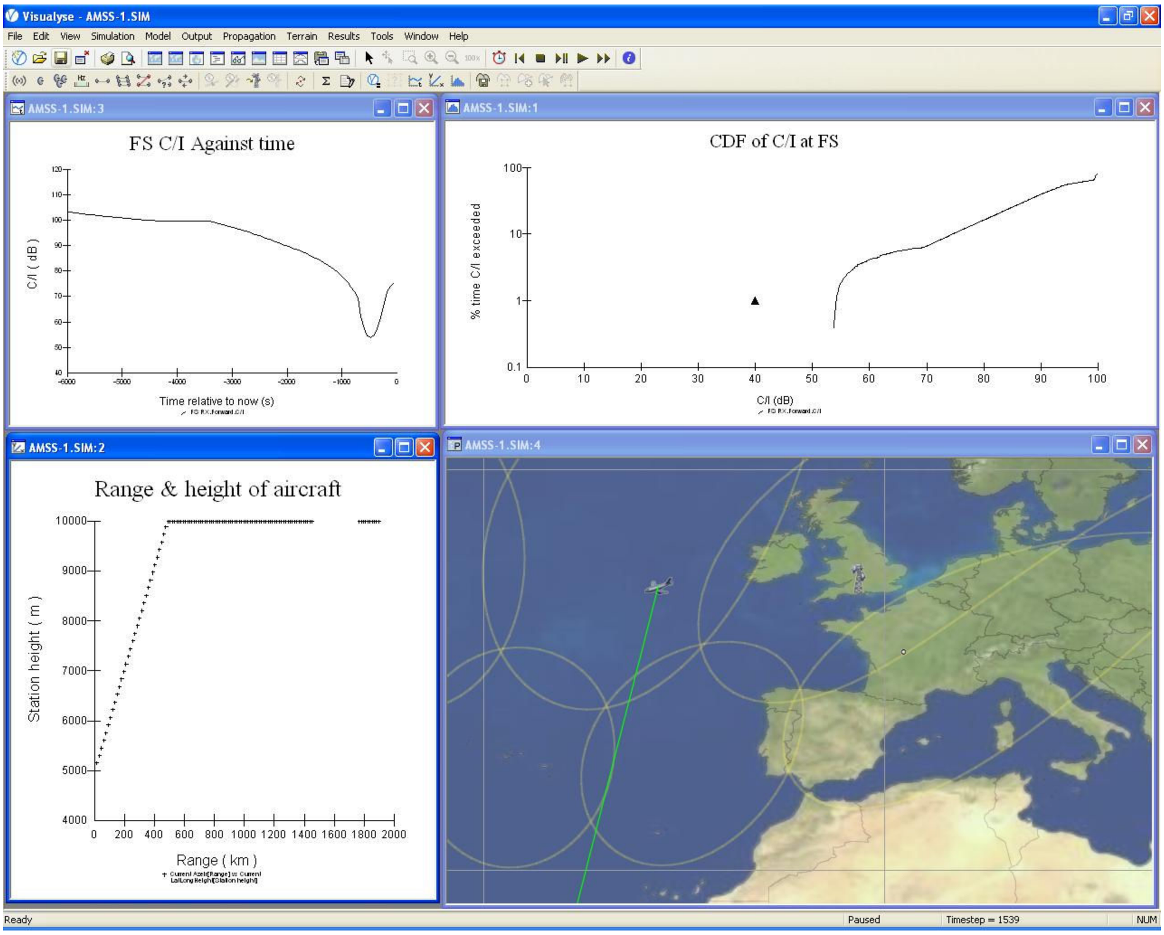
However WRC Agendas are usually very crowded and are compromises based upon input contributions from many Administrations. The sponsoring Administration or the organisation within its territory proposing change must undertake initial analysis of the feasibility of using the preferred band, plus, potentially, alternative bands.

Feasibility of sharing can be determined using simulation. Computer software such as Visualyse Professional can be used to predict interference that would be generated by the new service.

Case Study 1: Sharing of AMSS with FS in the bands 14-14.5 GHz

External pressure for change: operators wanting to provide internet access to aircraft

The figure below shows Visualyse Professional configured to analyse interference from an AMSS terminal into the FS in the 14 GHz band.



Simulation software for interference analysis such as Visualyse Professional is based upon:

1. Defining an algorithm to use in simulation, that can be static, dynamic, or use Monte-Carlo techniques
2. Determining dynamic characteristics of transmitters and receivers, such as locations, heights, and speeds, orbit models
3. Defining antenna characteristics such as gain patterns, pointing angles
4. Including RF characteristics such as powers, bandwidths, polarisations and carrier shapes
5. Including propagation effects such as dry air, water vapour, rain, and terrain
6. Calculating receive signal strength using a link budget similar to:

Received Signal	=	Transmit Power
	+	Transmit Peak Gain
	+	Transmit Relative Gain
	-	Propagation Losses
	+	Receive Peak Gain
	+	Receive Relative Gain

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- Feed Losses

7. Calculating interference based upon criteria such as I, I/N, DT/T, C/I, C/(N+I), PFD, EPFD, and FDP
8. Comparing interference against a threshold that defines degradation of service

The simulation above shows interference from an aircraft with an AMSS terminal into the FS, measuring the C/I. This initial analysis shows the C/I is usually above 50 dB, sufficiently high to suggest that sharing may be possible and worth further consideration within the ITU-R.

In this particular example the Administration that proposed this Agenda Item (the USA) based its input contribution WRC 2000/12-A17 upon work at the earlier WRC-97 conference. However the studies could not be included in the ITU-R schedule due to budgetary constraints. It should be noted that the original request for this work, at CPM-97 in document CPM-97/67 was for the introduction of narrow band MSS systems such as OmniTracs and BoatTracs. Operating broadband internet services under this proposed allocation maybe a different application to these narrow band systems, but it remains the same ITU-R service type.

6. Analysis at ITU-R

Just one side often does this initial analysis, which in this case would be an operator that would like to offer AMSS services. During the study phase in the ITU-R, work can be done by both representatives of the incumbent service (the FS and FSS) as well as the newcomer, allowing the rights of existing and new services are balanced.

The Working Parties, Task Groups, and various Joint Groups do the actual study work, with usually several meetings per group within a WRC cycle. This results in development of or revisions to Recommendations (via the Study Groups) and text for the CPM Report for the next Conference to update the RR. There is often overlap between the two - for example a Recommendation to define PFD limits that also is included in the RR.

The work undertaken by SGs is very varied, and depends upon the external pressure. For Recommendations it can include the update or definition of:

- Databases with new system characteristics
- Definition of terms
- Propagation models or gain patterns to reflect new systems or new information
- Algorithms that can be used in sharing studies or coordination exercises
- Results of sharing studies between proposed studies
- System performance thresholds, including interference thresholds
- Technical characteristics such as EIRP, power, PFD or EPFD limits that would assist sharing

For CPM text it can include:

- Conclusions about potential for systems to share
- Information on demand for new systems and implications regarding need for Allocations

- Information about algorithms defined in Recommendations that can be used in sharing studies or coordination exercises which could be included in the RR
- Technical characteristics such as EIRP, power, PFD or EPFD limits that would assist sharing

To support this work, delegates use a wide range of tools, from pencil and scraps of paper to software packages such as Visualyse Professional, designed with flexibility in mind to be “Study Tools”. As new types of systems are always being proposed with all sorts of applications in almost any band, it is necessary to have tools that can analyse the widest possible range of sharing scenarios, in detail sufficient to be able to update Recommendations and the RR with confidence. More information, including a list of ITU-R input papers produced using Visualyse Professional, can be found on our web site at http://www.transfinite.com.

Two examples that needed simulation tools are given below. Both involve space and terrestrial systems, but many involving purely terrestrial or purely satellite system could also be described.

Case Study 2: Sharing between terrestrial mobile services and satellite earth stations

Pressure for change: Pressure to allocate more spectrum for mobile broadband services

One of the major recent projects within the ITU has been the development of the regulatory framework to facilitate the introduction of the next generation of terrestrial mobile applications. This includes not just IMT-2000 but also addressing the needs of systems beyond IMT-2000.

This topic has been the subject of a wide ranging series of studies within a number of ITU-R groups, focussed most intensely in what was WP 8F and is now WP 5D. The remit for studies has come from a series of WRC Agenda Items and Resolutions, such as Resolution 228 “*Studies on frequency-related matters for the future development of IMT-2000 and systems beyond IMT-2000 as defined by ITU-R*”.

This Resolution has been updated at recent WRCs to reflect the changing requirements of work with the ITU-R, and agenda items for the following conferences updated correspondingly. For example at WRC 2000, Resolution 228 was mentioned both in the Agenda for the immediately next conference in Resolution 800 (WRC-2000), and also in the Agenda for the following conference in Resolution 801 (WRC-2000).

One of the key issues was how much spectrum would be required and compared with how much would be available under the table of allocations in Article 5. Studies suggested that significantly more additional spectrum could be required if demand reached the levels forecast. As spectrum required would be within frequency bands in highest demand from other applications, it became necessary to consider whether this additional demand could be achieved by sharing with other services.

At WRC 2003 the changing requirements for IMT related studies were considered and hence Resolution 228 revised from general studies into “*spectrum requirements and potential frequency ranges*” to the more specific:

resolves:

1 to invite ITU-R to further study technical and operational issues relating to the future development of IMT-2000 and systems beyond IMT-2000, and develop Recommendations as required;

2 to invite ITU-R to report, in time for WRC 07, on the results of studies on the spectrum requirements and potential frequency ranges suitable for the future development of IMT 2000 and systems beyond IMT-2000, taking into account:

- *the evolving user needs, including the growth in demand for IMT-2000 services;*
- *the evolution of IMT-2000 and pre IMT-2000 systems through advances in technology;*
- *the bands currently identified for IMT-2000;*
- *the time-frame in which spectrum would be needed;*
- *the period for migration from existing to future systems;*
- *the extensive use of frequencies below those identified for IMT-2000 in No. 5.317A;*

3 to invite ITU-R to conduct regulatory and technical studies on the usage of frequencies below those identified for IMT-2000 in No. 5.317A for the future development of IMT-2000 and systems beyond IMT-2000, notably assessing their advantages and disadvantages, taking into account recognizing e) and j) above;

4 that the studies referred to in resolves 1 and 2 should take into consideration the particular needs of developing countries including use of the satellite component of IMT 2000 for suitable coverage of these countries;

5 that the studies referred to in resolves 1, 2 and 3 should include sharing and compatibility studies with services already having allocations in potential spectrum for the future development of IMT-2000 and systems beyond IMT-2000 taking into account the needs of other services;

6 that WRC 07 should consider frequency-related matters for the future development of IMT-2000 and systems beyond IMT 2000, taking due account of the results of ITU-R studies, in accordance with this Resolution,

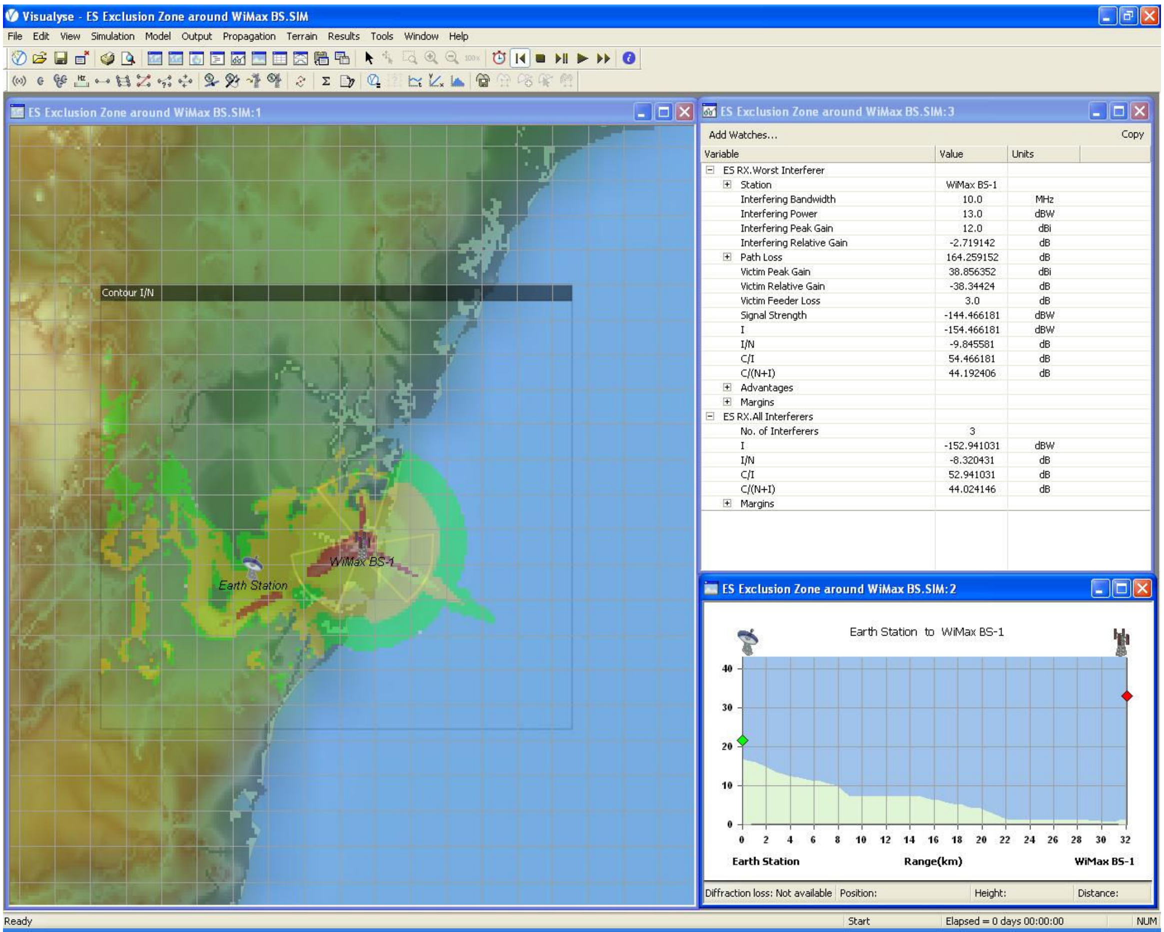
In particular resolves 4 requested the ITU-R to study potential for IMT to share spectrum with other services. A number of bands and sharing scenarios considered, and the one of interest in this case study were bands between 3 400 MHz and 5 000 MHz currently allocated to the Fixed Satellite Service (FSS).

A significant number of studies were undertaken within parts of C band at the ITU by experts from WPs 4A and 8F, including analysis of:

- Typical parameters of satellite networks
- Typical parameters of terrestrial mobile networks using IMT-2000 standards such as WCDMA, LTE, WiMax etc
- Sharing scenarios to consider

- Coordination contours for IMT base stations around satellite earth stations
- Exclusion areas for IMT base stations around satellite earth stations
- Coordination contours for satellite earth stations around IMT base stations
- Exclusion areas for satellite earth stations around IMT base stations
- Methods to facilitate coordination of IMT networks and satellite earth stations
- Impact of aggregate of interference into satellite earth stations from deployments of multiple IMT base stations
- Sensitivity of results to variations in key inputs
- Impact of terrain and propagation models

An example of the type of analysis can be seen in the Visualyse Professional screenshot below which shows graphically the area that an earth station could not operate due to harmful interference from a single WiMax base station in central Sydney, Australia, including the effect of terrain and a three sectored antenna.



At WRC-07 this issue was discussed and it was agreed the preferred way forward would be via country footnotes rather than Region-wide allocations in Article 5, the Table of Allocations. Hence it was up to each country to make its own decisions, using tools such as Visualyse Professional shown in the figure above.

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Case Study 3: RLANs sharing with non-GSO MSS Feeder Links

Pressure for change: manufacturers developing RLAN devices for the 5 GHz band

RLAN devices can be used to connect a wide variety of electronic devices such as PC, printers, displays, cameras, videos, scanners, and phones without the need for wires. The 5 GHz band allows higher data rates than alternatives such as Wifi at 2.4 GHz, which is now being introduced for use both in offices and at home. Manufacturers are producing models using standards such as Hyperlan that would be sold direct to customers without any coordination or licensing procedure.

The table below shows the relevant extract from the Table of Allocations for the band 5 150 - 5 250 MHz:

MOD

4 800-5 830 MHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
5 150-5 250	AERONAUTICAL RADIONAVIGATION FIXED-SATELLITE (Earth-to-space) S5.447A S5.446 S5.447 S5.447B S5.447C	

This set of allocations and footnotes is the result of decisions from three of the four most recent WRCs, which would need a complex flowchart to track.

WARC 92: Introduced Footnote 5.447 which specifies that for 26 Administrations there is an allocation to the Mobile Service:

> ***S5.447*** *Additional allocation: in [list of 26 Administrations], the band 5 150-5 250 MHz is also allocated to the mobile service, on a primary basis, subject to agreement obtained under No.* ***S9.21****.*

WRC 95: Added a Primary Allocation to the FSS with Footnote 5.447A identifying it for use by non-GSO MSS Feeder links

WRC 97: No change to this band.

WRC 2000: Updated Footnote 5.447 to increase number of Adminstrations to 27 and approved Resolution 736 that states:

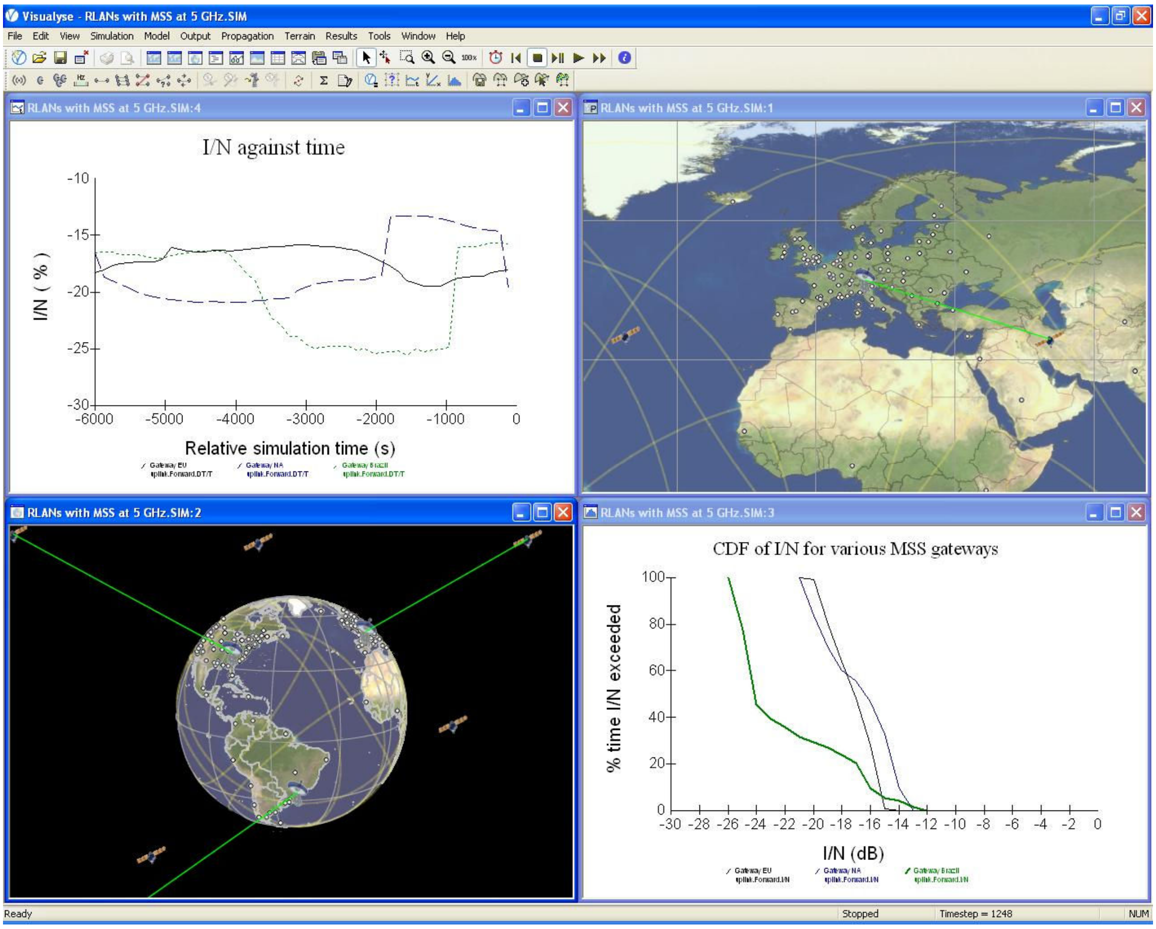
> *that on proposals from administrations and taking into account the results of studies in ITU-R and the Conference Preparatory Meeting, WRC-03 should consider:*
>
> *1. allocation of frequencies to the mobile service in the bands 5 150-5 350 MHz and 5 470-5725 MHz for the implementation of wireless access systems including RLANs;*

Despite no changes at the relevant parts of the RR at WRC 97 there was considerable work in the period running up to WRC 2000 due to the imminent production of Hyperlan and related products. This raised a number of questions as existing non-GSO MSS Feeder links with a primary allocation had to be protected, but it would not be possible to coordinate with RLAN systems that were operated and managed directly by users, millions of whom would be distributed across the world. It was not even clear what the regulatory status of the RLAN devices was, given that the primary allocation to the mobile service in the footnote was subject to coordination under 9.21, which was agreed to be impossible in practice.

Work was therefore done to:

- Produce an algorithm that could be used to calculate levels of interference that the non-GSO MSS feeder links would suffer from distributions of RLAN devices
- Define a sharing criteria that would protect the non-GSO MSS feeder links
- From the two above and parameters for both types of systems define operating restrictions on the RLANs that would permit sharing

The figure below shows such an analysis in Visualyse Professional, where a non-GSO MSS feeder link, with global coverage, can suffer interference from a large part of the Earth's surface.



After much debate three Recommendations were developed:

S 1427: Methodology and Criterion to assess interference from radio local area (RLAN) transmitters to non-GSO MSS Feeder links in the band 5 150 - 5 250 MHz

S 1426: Aggregate power flux density limits, at the FSS satellite orbit, for radio local area (RLAN) transmitters operating in the 5 150 - 5 250 MHz band sharing frequencies with the FSS (RR No. S.447A)

M 1454: E.i.r.p density limit and operational restrictions for RLANs or other wireless access transmitters in order to ensure the protection of feeder links of non-geostationary systems in the mobile satellite service in the frequency band 5 150 - 5 250 MHz

Even with these Recommendation more work has to be done at the ITU-R. Resolution 736 (WRC 2000) requests studies to consider an allocation for at least one Region (rather than for named countries in a Footnote). This would define the regulatory status of RLANs in countries not in the Footnote, which otherwise would have to be under Article 4.4, i.e. non-interference.

Use of 4.4 is available as a last resort but is not recommended as it leaves both parties open to problems in the future such as:

- The RLAN community would not have the security of an allocation, making production and marketing of potentially illegal devices risky
- The non-GSO MSS community would not have controls on the distribution and parameters of RLAN devices: there are cases where large numbers of devices have been sold to end users under S4.4 which have gained higher effective status than Primary Services because politicians are unwilling to upset a large body of potential voters by enforcing the actual rights of the Primary Service.

ITU-R groups can see intense debate between Administrations and Operators as both attempts to defend their systems from regulations that could result in an inability to operate due to unacceptable interference or harsh operating constraints. In this case the fear that lack of agreement could result in RLANs operating under 4.4 was a strong argument for compromise.

Another remaining problem is that Rec. 1426 defines maximum PFD in orbit but gives no guidance to what should be done by Regulators when it is reached.

7. Update of RR and Recs

As described above there are two main results from work at ITU-R SGs (including their WPs, TGs, and JTGs):

- Creation of or revision to Recommendations
- Production of text to be included in the CPM report to advise WRC on changes to the RR including allocations

So after many years of debate, analysis, arguments, negotiations, and political compromise text can be prepared for approval. For Recommendations this can either be at the Radio Assembly, or in many cases now, using Approval via Correspondence.

For CPM text it is agreed at WPs, possibly provisionally with square brackets, and then at the final CPM text is collated into a single Report for the following Conference. At the Conference Administrations propose changes to the RR via their input contributions, with the CPM Report a guide to assist the work of the Conference.

Changes to RR and new Allocations are the result of many years work - not just the study work at ITU-R groups, but prior to the previous WRC, where much preparation was needed to get the issue on the Agenda.

An example from WRC 2000 was the allocation to RNSS in the 5000 - 5010 MHz band for satellite navigation systems such as Galileo. As described earlier, at WRC 97 this subject was put on the Agenda for the following conference under Agenda Item 1.15.1.

At WRC 2000 the following changes were made to Article S5 Frequency Allocations:

MOD

4 800-5 830 MHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
5 000-5 150 AERONAUTICAL RADIONAVIGATION S5.367 S5.444 S5.444A S5.444B S5.444C		

ADD

S5.444B *Additional allocation:* The band 5 000-5 010 MHz is also allocated to the radionavigation-satellite service (Earth-to-space) on a primary basis. See Resolution **603 (WRC-2000**).

8. Operational use of measures in RR and Recs.

When RR and Recommendations are approved they then form the basis for regulating the radio spectrum by Administrations world-wide. In the majority of cases this is done by national Administrations who are responsible for management of the radio spectrum in their territory. The ITU-R BR assists, mostly in cases involving satellites that are by their nature international.

An example of the use of RR by the ITU-R BR is the checking that filings for non-GSO FSS systems meet the Validation EPFD limits approved at WRC 2000. This uses the EPFD limits in Article S22 of the RR together with the software that follows the algorithm in Recommendation BO.1503. Transfinite Systems have developed a package called Visualyse EPFD that performs these calculations.

National regulators are more likely to manage terrestrial sharing scenarios such as coordination between satellite ES and FS, coordination between FS operators, and calculation of PFD on service area boundary for BFWA operators.

Two examples described below involve purely terrestrial sharing between satellite ES and FS, and automatic planning and coordination of fixed links at 28 GHz.

Case Study 4: Coordination of Satellite Earth Stations and Fixed Service

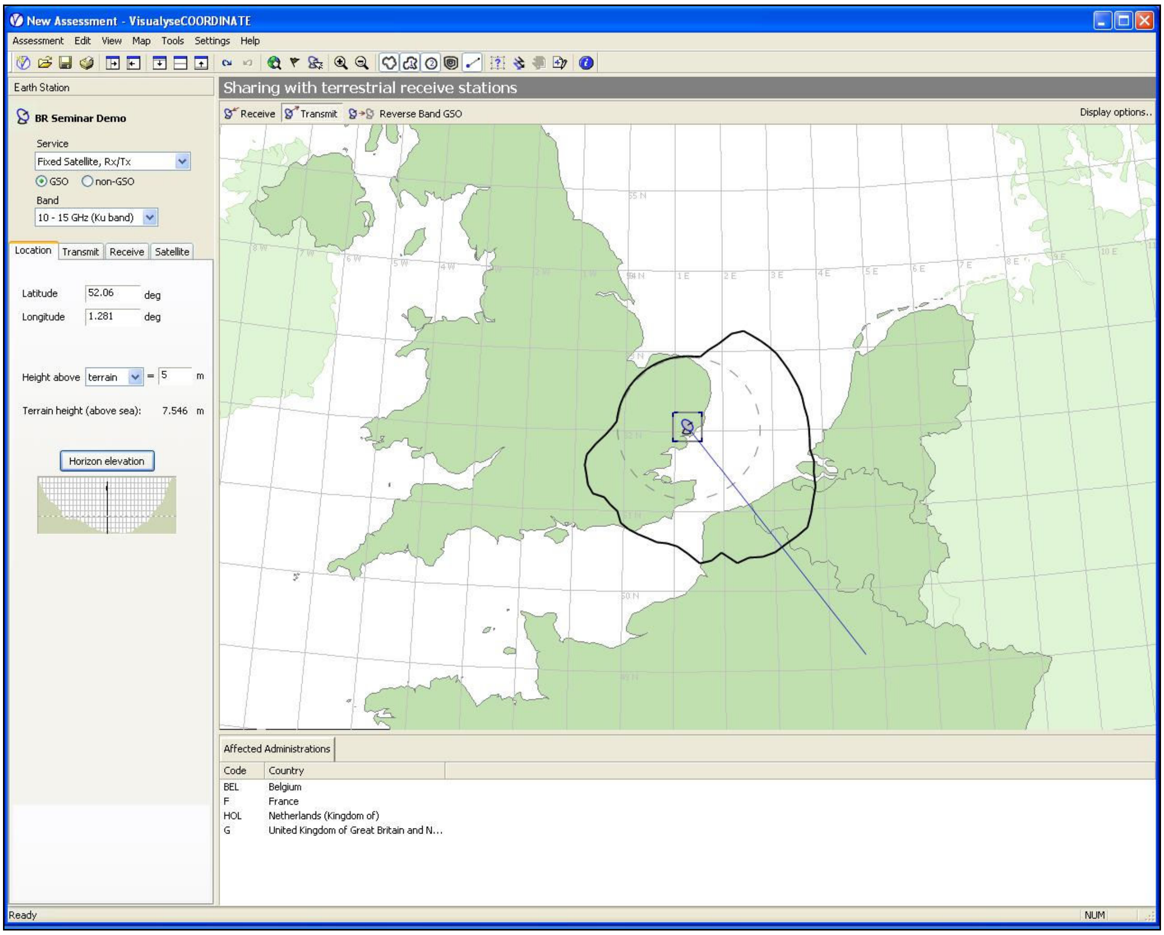
Pressure for change: increased number of SES and introduction of non-GSO ES

There are a number of bands where there are Primary Allocations for both the FS and FSS. One reason for this is that sharing is easier between these two services as typically they both use directive antennas, which can reduce the received interference.

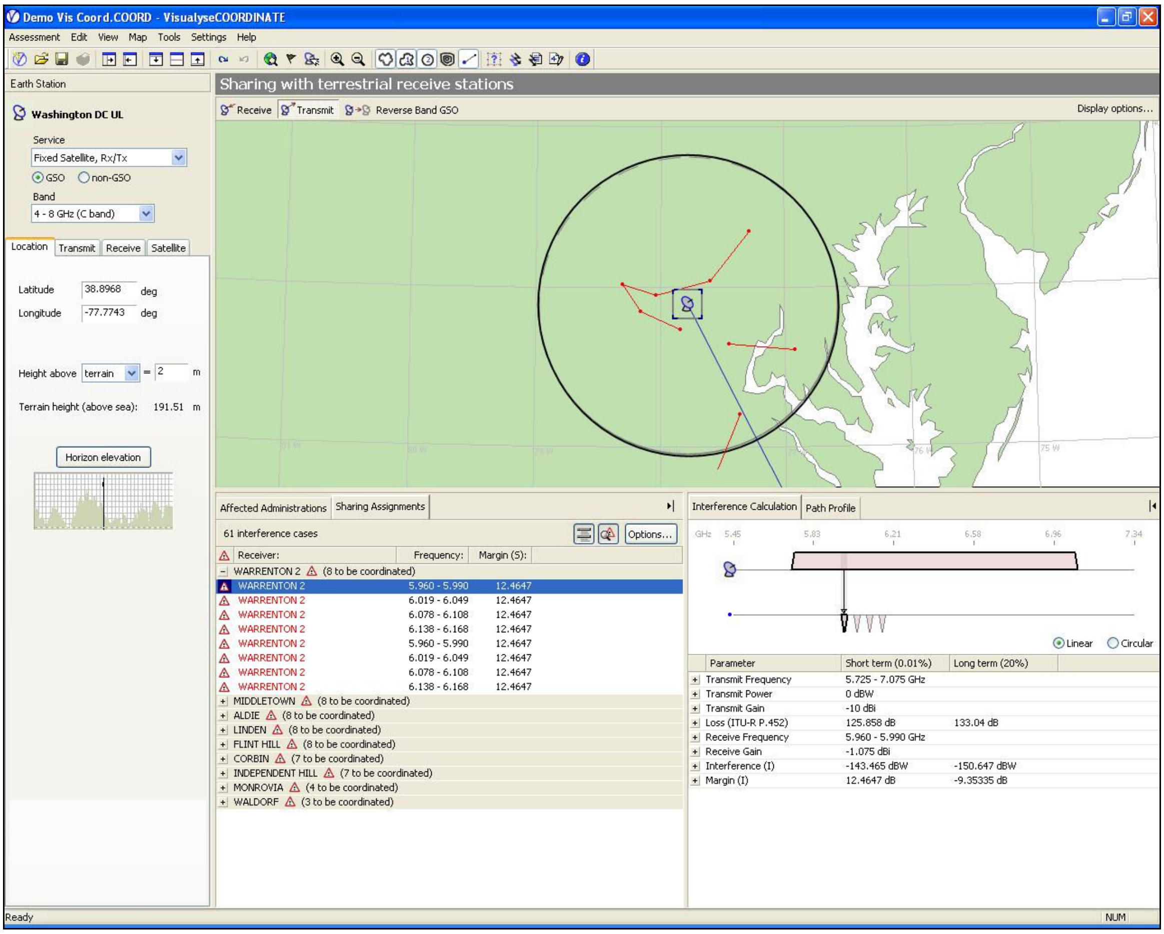
Procedures have been developed to determine where there is the potential for unacceptable interference, based upon a coordination trigger. This is a contour centred on the SES within which there is the potential for interference based upon worst case assumptions. This SES could be working with a GSO or non-GSO satellite, TX or RX, and providing communication services, TT&C or other RF service.

It is then possible to determine all the FS stations that are co-frequency and within this coordination contour. This sub-set can then be examined in detail, for example using real gain patterns, locations, the impact of terrain, and site shielding.

The figure below shows an example scenario in a specialised tool to support the coordination of satellite earth stations, namely Visualyse Coordinate. An earth station can be seen in the UK with a coordination contour that includes most of south-east England plus parts of nearby countries such as France, Belgium and The Netherlands.



If there is access to information about the location of terrestrial stations the tool is also able to undertake detailed coordination using terrain databases and ITU-R Rec.P.452 as the propagation model. An example of such analysis is shown in the figure below.



The algorithm to generate the coordination contour is included in the RR in Appendix 7. This was revised at WRC 2000 to include the new propagation model in Rec. P.620 and also extending the algorithm to include ES of non-GSO satellites.

Note that the coordination contour algorithm is also a Recommendation, Rec. SM. 1448.

Case Study 5: Automated Planning and Coordination of Fixed Links

Pressure for change: increased demand for backhaul for mobile services

A recent change with the mobile communications industry is the rapid increase in use of data services. New handsets such as the Apple iPhone have generated significantly larger amounts of high speed data traffic than earlier generations, and this is stretching the existing back-haul capacity of the operators. Additional links are therefore required.

This backhaul must be planned and coordinated, to ensure it provides the required quality of service and to avoid interference to/from other links. This analysis can be supported by a number of key ITU-R Recommendations, including:

- Rec. ITU-R P.452: Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz
- Rec. ITU-R P.530: Propagation data and prediction methods required for the design of terrestrial line-of-sight systems

- Rec. ITU-R F. 699: Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to about 70 GHz
- Rec. ITU-R F. 748: Radio-frequency arrangements for systems of the fixed service operating in the 25, 26 and 28 GHz bands
- Rec. ITU-R F. 1101: Characteristics of digital fixed wireless systems below about 17 GHz

These can be used within simulation software that has access to terrain databases to calculate:

1. Pointing angles for transmit / receive antennas
2. Forward / return minimum transmit power to achieve required availability requirements
3. Forward / return centre frequencies that would avoid harmful interference

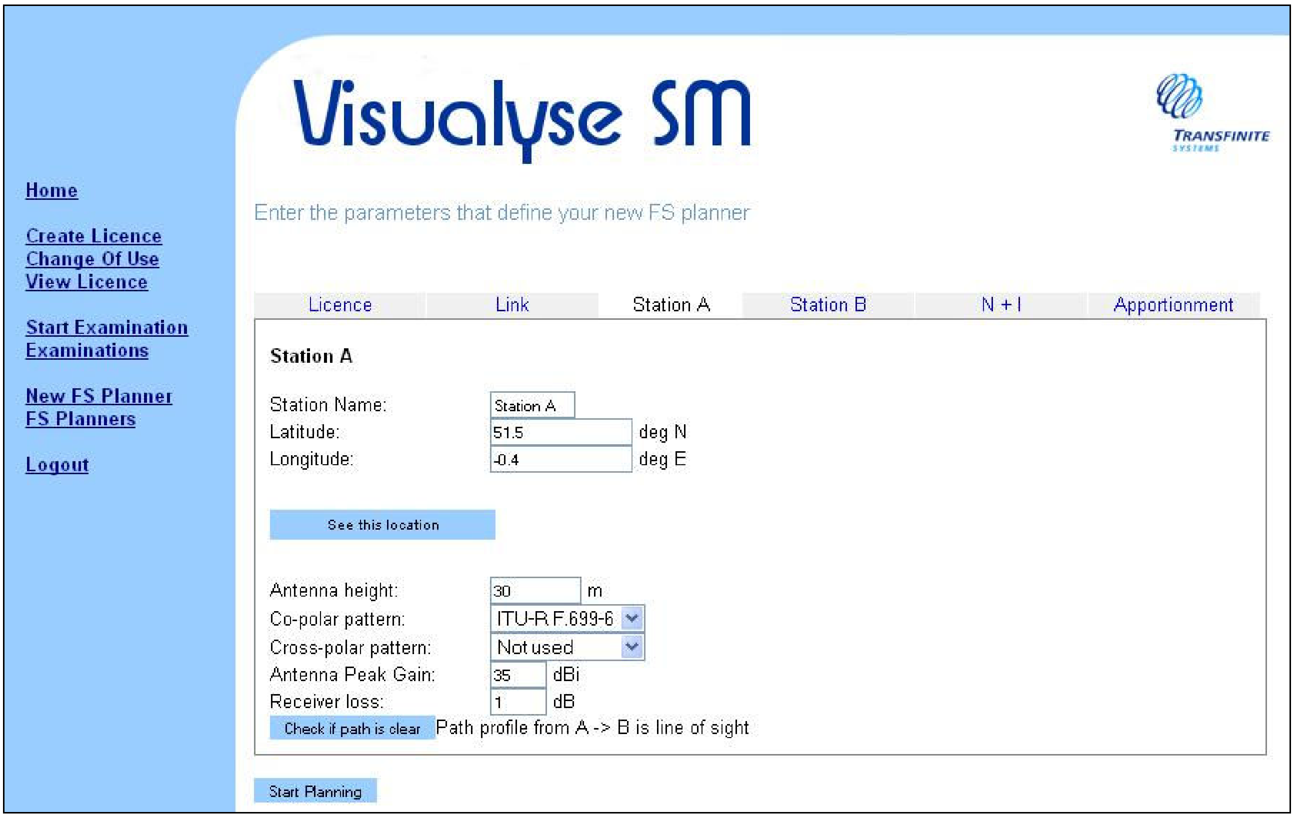
These calculations can be undertaken using desktop tools. However it is noted that point to point fixed links have high levels of spectrum efficiency as the same channel can be re-used many times. Therefore multiple mobile operators could be accomodated within the same spectrum block and hence could use the same planning tools.

This requires a central planning service: if undertaken by the regulator using standard desktop tools with manually entering data this would require a high administrative overhead.

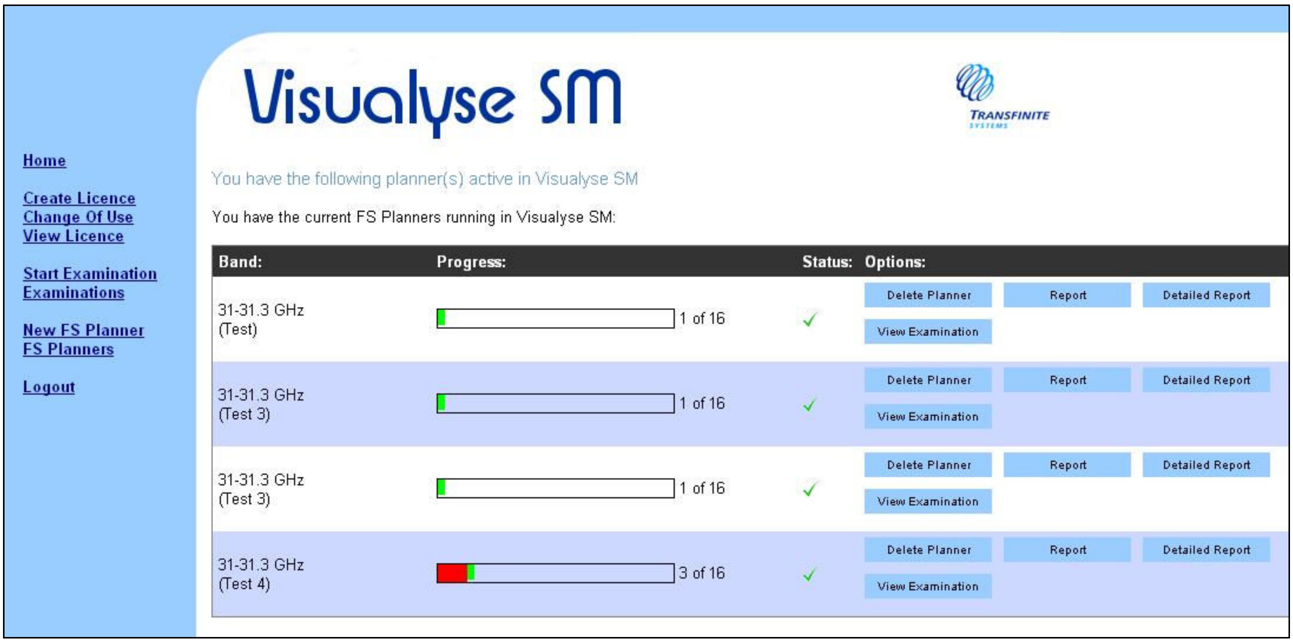
Instead a more efficient approach is to use a web-based software application that handles requests from operators directly undertaking all necessary calculations online.

An example of this is the Visualyse Spectrum Manager, which provides licence management services including fixed link planning over an intranet or internet.

The screen show below shows the web interface used to enter the data in a smart-form that is configured for point to point fixed services:



The screen shot below shows the interactive interface to the planning process, graphically updating the status as each channel is considered.



9. Conclusions

This paper has considered how the ITU-R adapts to change. Case Studies have been presented that show how change can lead to extensive work updating the RR and ITU-R Recommendations, and it is for this reason that there are large numbers of ITU-R meetings.

Work within the Study Groups requires flexible tools to analyse the wide variety of sharing scenarios that might have to be considered. When the regulatory framework is stable the ITU BR and Administrations need Verification and Coordination tools to manage the spectrum.

Transfinite Systems can assist in providing analysis tools, including Visualyse Professional for study work, Visualyse EPFD for EPFD verification, and Visualyse Coordinate for Appendix S.7 coordination of satellite ES and FS.

For more information about Visualyse Professional, other software tools and consultancy services provided by Transfinite Systems Ltd, please contact us at:

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