Tricks of the Trade

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"Is this frequency in use please?" There will be many in VMARS who have heard, in recent years at least, this phrase used on the amateur bands. We say "in recent years" as in years previous we cannot recall its use; maybe it is the three tier training for new licencees that they are instructed to make such a call. On HF broadcast, with essentially send-only capability, something else is required to prevent a general free-for-all, which could result in serious interference. One of us worked in the HF scheduling office of the BBC in Bush House for many years and so has been able to contribute much historical information, so this first part explains some history and the need for regulation. Next time we will continue with how all this is used operationally and how the megawatts of HF energy were organised.

The ITU

It is interesting that the formation of what is now the International Telecommunication Union (ITU) predates the inventions both of the telephone and of radio. It was in 1865 that the International Telegraph Union was established to standardise rules for international exchange of telegraph messages. Hitherto, many countries had developed their own national system necessitating transcription, translation and re-transmission of messages across frontiers to neighbouring countries. That convention was held in Paris, possibly accounting for the acceptance of the name of that city as a standard word for speed measurement of morse-coded messages. Having been set up for information and communication, the ITU in 1885 started to draw up similar regulation for telephone systems and, in 1903, held a preliminary radio conference to study international radiotelegraph communications. The first International Radiotelegraph Conference was held in 1906 in Berlin. It introduced the first regulations governing wireless telegraphy, which have since evolved through numerous conferences to become the Radio Regulations, as we would now recognise them.

The IFRB

The 1947 Atlantic City conference set up the International Frequency Registration Board (IFRB) to coordinate RF spectrum management and the Table of Frequency Allocations became mandatory. Procedure was laid down in the Geneva Radio Regulations and created a master frequency list enabling frequency usage to be tracked. By the early 1960s the IFRB was essentially a clearing-house for HF broadcast frequency use.

Broadcasters were to submit their intended frequency usage including times and characteristics of transmitter and antenna to enable the IFRB to issue a schedule document showing all requirements as well as being able to indicate possible interference collisions. Users of the offending frequencies were invited to re-examine their proposed usage. However, from a practical position in those days of jamming, many parties often decided to maintain their proposal.

Being a post-WWII creation, there were of course elements of the Cold War present and, as you might expect, there were as in so many matters of the time, two separate camps.

The 'Easties' versus the 'Westies'

There was the Western camp comprising representatives from the BBC, Voice of America (VOA), Radio Canada International (RCI), Radio Free Europe/Radio Liberty, Deutsche Welle and Radio Nederland as well as the US Federal Communications Commission (FCC) representing private broadcasters including religious stations. They would meet quarterly and essentially agree around a table on their overall frequency usage for each channel.

The Eastern camp comprised the Soviet Union and the Satellite States, so included the USSR (for Radio Moscow, Radio Peace and Progress and considerable domestic HF broadcasting directed to both sides of the Ural Mountains), as well as Bulgaria, Czechoslovakia, the GDR (for Radio Berlin International), Hungary, Poland and Romania. The Eastern Bloc countries also closely coordinated their transmissions and, in any case, there was a seamless interdependency between their transmitter sites to provide facilities for the Moscow-based services across the whole area. Cuba also carried relays of Russian services for the Americas whilst receiving aid from the USSR.

Albania and Yugoslavia both fell out of the equations because of political changes.

Other countries, for example Sweden, Finland, Norway and Spain, were not affiliated to either camp and, having a smaller HF operation, could maintain similar frequency usage from year to year and would, thus, establish a 'history' of presence on their frequencies, respected by other broadcasters.

Having determined the intended frequency usage for the forthcoming season, the administration of each country originating transmissions would then compile submissions for sending to Geneva.

For each transmission it would be necessary to state the administration, the name and coordinates of the

transmitting site, the start and stop times of the transmission, the frequency, sender carrier output power, the format, gain and azimuthal bearing of the antenna and the intended audience area using ITU Ciraf (Conference internacional radiodiffusion des altos frequencies) zone numbers (see figure 1). The format of the antenna would give a take-off angle. This information was used by the IFRB to produce a tentative schedule based on all submissions and to assess the likelihood of harmful interference with reference to a fixed signal-to-interference protection ratio. In many cases, broadcasters were willing to tolerate certain known collision cases because it would have been more acceptable than encountering the spread from a jammed channel.

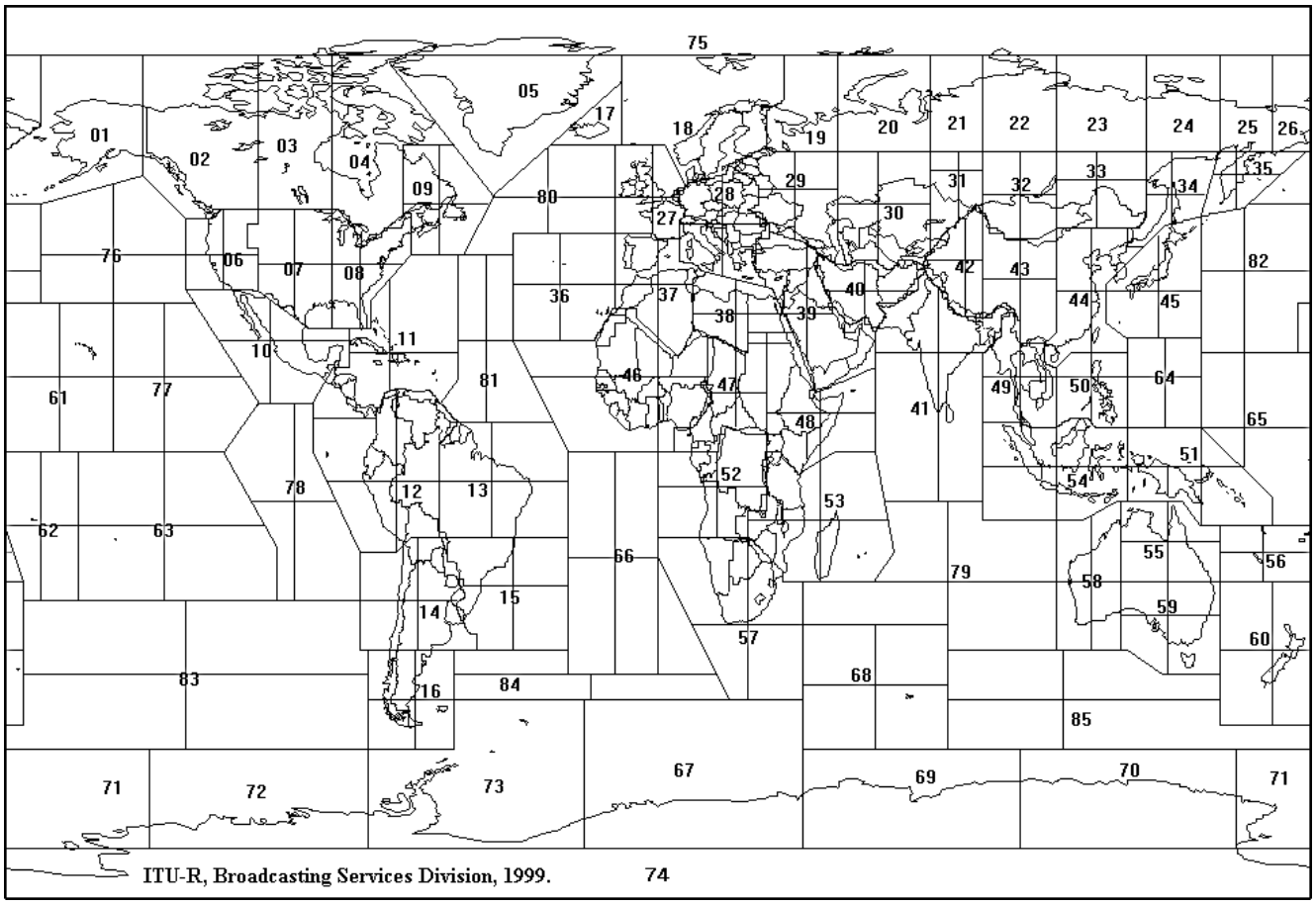

Figure 1. Cirfaf2 map. Source: http://www.itu.int/ITU-R/terrestrial/broadcast/images/broad-ciraf2.gif

In the case of the UK, it fell to the BBC to complete forms for all HF transmissions from UK sites, BBC as well as for RCI and VOA exchanges, and for all HF transmissions from overseas relay sites operated both by the BBC and on their behalf by the Diplomatic Wireless Service/Foreign and Commonwealth Office DWS/FCO. The forms for these relay transmissions were completed on behalf of other administrations who were landlords to our relay sites for forwarding to Geneva. Forms for BBC relays out of VOA and RCI transmitter sites would have been completed and submitted through their respective administrations.

IFRB submission was a very tedious word-processing exercise involving quarto-sized sheets for each and every transmission. The resulting forms, probably around a thousand in number, were then taken by taxi from Bush House across the river to Waterloo Bridge House for passing on to Geneva. Of course, information copies of each had to be printed off for several addressees who needed to know!

We have given an idea of the scale of IFRB submission involvement during the 80s.

Following the end of the Cold War, by 1990 the High Frequency Coordination Conferences (HFCC) have brought together broadcasters from both West and East around the same table, superseding the intended function of the old IFRB, and have gained recognition from the ITU. However, there may still be some big players missing from the HFCC coordination process, such as Taiwan and North Korea. Nevertheless, much work is now undertaken using electronic mailing. Further, a live web-based database of global HF usage is now available both to broadcasters for ongoing coordination of transmissions and to prospective listeners wishing to check out an up-to-date frequency schedule of their favourite HF station; see www.hfcc.org.

It is difficult though to visualise what happened in the earlier days from 1948 onwards into the 50s/60s, being denied the assistance of word-processing, photocopying or e-mailing to produce such documents having a fair measure of repetition in their content.

Jamming and Wooden Transmitters

The BBC, first at their receiving station at Tatsfield, on high ground straddling the Kent-Surrey border, and from the 1970s at Crowsley Park, just a few miles north of

Reading, maintained accurate records of jamming to their services as did other major Western broadcasters.

Jamming, deliberate interference, was a major factor which developed during the early 1950s and, taking into account consequential knock-ons, the HF broadcast allocations became vastly over-subscribed across Europe where there was a high concentration of different languages of interest to all of the major international broadcasters. In later years, post-jamming, just two or three frequencies would have been necessary to bracket the 90%-propagating frequency bands for a language service at a given time. But, at the height of the Cold War, a jammed service would have been loaded up with as many frequencies as facilities would have enabled, including the use of one or two frequencies in bands higher than the 'Maximum Usable Frequency' MUF for the required signal paths. Not only would a higher frequency yield a good usable received signal on perhaps just a few days of a statistical month, but the greater skip distance made it more difficult to ensure blanket coverage by the jamming transmitters around the audience area.

Higher-than-MUF channels were often also utilised during evening transmission periods in order to similarly benefit from a 'twilight gain' to signals from the westerly direction. All opportunities were taken to increase the chances of East European listeners hearing the Western broadcasts.

Another ploy in the armoury against jamming was the use of 'Barrage Starts' whereby several transmitters would open simultaneously at the start of a news bulletin but without the use of any previous tuning line-up or 'interval' signal. Whether or not this element of surprise perplexed Sergei and his friends in any way is open to conjecture!

It has also been suggested that several broadcasters colluded by commencing their Russian transmissions at the same time in the hope that something got through from one or the other before jamming was available for each of the frequencies in each large conurbation. Radio Liberty invariably operated longer-running transmissions, probably much of it news-based.

Of the other organisations broadcasting in Russian, it may have happened, fortuitously, that their respective programme organisers, who were sometimes exiles themselves, would have known when their audience was liable to be listening, wished the news slot to occur at a particular local time relative to the working day, or to avoid a local radio news bulletin time.

Although there were several types of jamming transmission, the sound of the most common was likened to that of a petrol engine generator. Because of their nature, they also affected adjacent channels on both sides of the target frequency and could sometimes blight a swathe of up to 50 kHz at a time. The problem was particularly troublesome in Europe where most of the target audiences were located but, depending upon prevailing propagation, jamming could often be heard worldwide.

'Tricks of the Trade' has already discussed the use by broadcasters of higher audio compression and clipping to raise the effective level of transmitter modulation. (See 'Signal' Issues Nos. 8 and 9).

A certain flexibility was deemed desirable to enable changes of Russian-language frequencies to be initiated from time to time; after all it was far quicker for a hopeful listener to retune his receiver for the news bulletin at the top of the hour than for a retune instruction to be originated from a monitoring station in the USSR for action at jamming sites near each of the big cities. It was also evident that a relaxed view on the long-standing use, by the BBC, of several out-of-band frequencies such as 9410, 9915, 12095 and 15070 kHz was in the best British interests at the time. For these reasons, that the use of these out-of-band frequencies might be rescinded at short notice as well as a wish for providing alternative frequencies for Russian broadcasts, frequencies were sometimes coordinated without a justifying programme commitment. However, the frequency managers around the Western table were very shrewd in assessing the overall number of commitments that could be carried by another broadcaster and usually saw through this over-use of 'wooden transmitters' with no output! Some countries were more likely to ask for these slots than others! A lot of horse-trading went on and some hard bargains were driven!

The Schedules

All of the major broadcasters worked to an annual four-schedule cycle to make the best use of seasonal propagation variations. This variability was brought about by the changing hours per day and relative incidence angle of solar radiation upon the ionosphere at the refraction (or 'reflection') points along each signal path. Two four month periods covered the Winter 'D' season (November to February) and Summer 'J' season (May to August) with two shorter equinox periods covering the Spring 'M' season (March and April), and Autumn 'S' season (September and October). The schedule changes occurred during the first weekend of the new season.

"We can't go on like this!"

There are often situations in life where a crunch point develops and either the method has to change or the requirements eased. There may also be the other less acceptable solutions of throwing more money in or redeploying more staff! The labour-intensive matter of IFRB submissions was fortunately eased a little by a dividend from the Cold War ending as well as the improvements to the computer and the use of electronic mail. But the issue of local clock time became a crunch point, which led to a complete re-arrangement of the scheduling periods.

A few countries world-wide have long advanced their clock-time during their local summer for 'daylight saving' and, probably for the best of reasons, UK and Australia, for example, used to change their clock-time at different times each year! However, since the late 70s-early 80s, more and more countries have adopted the practice of 'daylight saving'. Unfortunately, some of those countries were making their decision on whether or not to adopt the principle within just a few days of the proposed date of their initial clock time-change. Nevertheless, it was deemed sensible to broadcast to an audience at the same local time all year round if at all possible.

The BBC Operational Schedule—in theory!

The absolute gospel on the BBC HF stations, both in the UK and abroad, was the Operational Schedule. During its near-80 year history, it has evolved with the expanding transmission facilities to show developments reflecting programme demands and to be compatible with the prevailing technologies of the day.

The Operational Schedule for the twin sender Empire Service from Daventry in the early 1930s probably consisted of a single sheet of quarto-sized paper with no more than a dozen lines of typewriting, calling up the Australasia, South Africa or Canada beam*, etc.* The more graphical display, as we know it, would have become desirable as soon as more senders were added at Daventry before WWII and indispensable by the time other transmitting stations had been built in the early 1940s.

By the 1970s, halfway along the time line, the schedule already comprised several A0-sized sheets, graphically detailing quite precisely all of the hour-to-hour information necessary for running the BBC External Services transmitter network, including the programme feed line routing (Yes, *routing* had always been spelt that way, but I can't remember what we did about it *after* we found out it was incorrect!). The 24-hours time axis was scaled vertically and the senders, grouped by station, were arranged across the sheet from left to right. Positive transparent blanks were printed up with a graticule frame, thereafter all of the artwork was undertaken by hand using stencils. Bill Stickells, the chief draughtsman in Bush House for many years, eventually got to know as much about scheduling as the engineers. He achieved a standard of style which was envied by all visitors from other broadcasters. Figure 2 shows an example of a schedule from the mid 1990's.

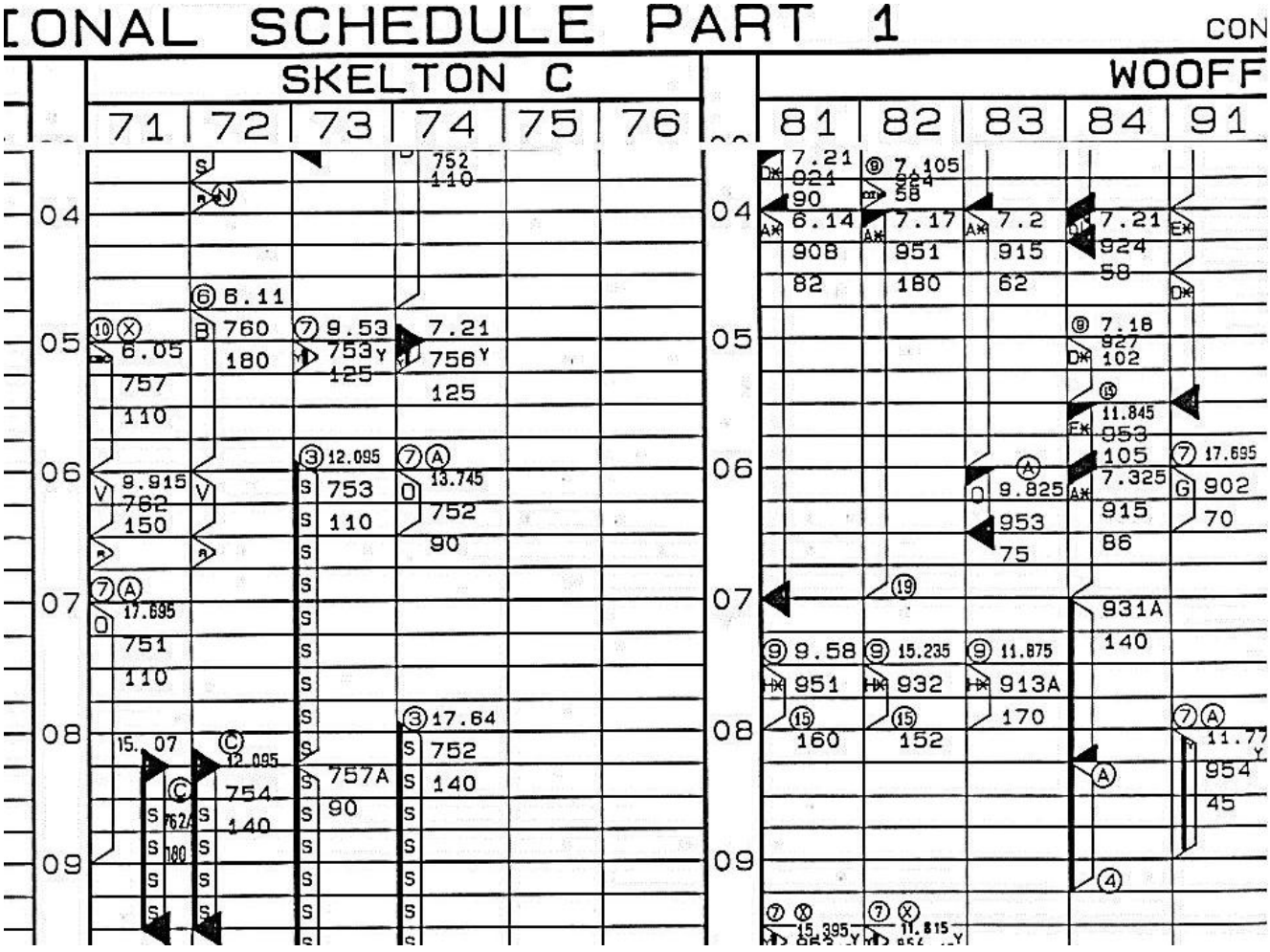

Figure 2. A section of the Skelton and Woofferton schedule showing detail of some of the broadcasts between 03.30 and 09.30 hours

However, the final few weeks before a schedule rollover were tightly choreographed because, in the interests of latest accurate information, the schedules would be published as close to rollover time as possible. But, on the other hand, the final copies had to be distributed by mail, including documents for overseas relay sites, to arrive before the weekend of the rollover. So every change to schedule content after the day of 'fixing' became part of an 'alteration', comprising grid extracts of the master schedule but with the new information replacing whatever had gone before. These extracts would then be manually 'cut and pasted' to the appropriate locations on the A0 sheets wherever the documents were used operationally.

A certain measure of 'belt and braces' was built in to the distribution process; in fact, the BBC might well have been the Belt and Braces Company in achieving its long-standing reputation for engineering reliability. The initial print run of schedules would be in black and white only and dispatched in a 'first distribution'. The privileged few (a matter of rank, grace and favour) were entitled to coloured schedules. They were produced by specialist printers from a hand-coloured master and were very expensive so the minimum were printed. The coloured schedules were dispatched in a 'second distribution' or 'at the last possible moment'. There was thus a certain lead-time between the first and second distributions when the alterations could be drawn up to achieve a later press time and then sent out with the second mailing. It was understood to be occupational therapy at the transmitting stations for the schedules and successive alterations to be coloured by hand.

This circuitous explanation of producing the schedule documents is simply to illustrate how late information of any kind necessitating transmission changes was tantamount to sabotaging the production process at one step or another along the critical path from the schedule engineer's desk to the transmitter control desks around the network.

The crunch point with clock-changing occurred in the early 1980s and, because other international broadcasters were similarly affected, a move was made toward two approximately 6-month scheduling periods to line up with the majority of the time changes so that listeners would hear their programmes at the same local time year-round. However, some propagational changes were still introduced for a notional equinox period if it was found that a frequency would not succeed throughout the extended summer or winter period for any reason.

The regulatory matter of IFRB submissions meanwhile continued for a few years as if for the former four-season pattern. Forms were generated for split periods, for example, from the first weekend in March until the majority clock-time change later in March (using, if possible, the winter frequency for the same service) and from the majority clock-time change until the first weekend in May (using, if possible, the corresponding summer frequency).

Thus, the solution for one crunch point invariably leads to the creation of at least one other crunch point.

Most of the countries changing clock time are within Europe and all relevant language services advance their transmission times by one hour during the summer seasons. Fortunately, the change date is coordinated across the continent to assist international travellers amongst others and only a few other countries worldwide have adopted 'daylight saving' on different dates each year to become the subject of relatively minor schedule amendments in isolation.

Later, an A0 plotter was obtained for running in conjunction with dedicated software so that schedules could be produced almost on demand although still requiring some manual intervention from Bill where an excess of detail was required in a small space. This was the start of computerised scheduling although, at this stage, the short-term aim was to produce the same style of schedule but with less reliance upon manual production. Extensive automatic control systems had already been in operation on transmitting stations for more than a decade, first using 'Norbits' then ferrite core stores and later Z80 processors, and the long-term aim was for the schedule office to 'talk' to the transmitters in their own language. But this was still some time off.

The BBC Operational Schedule—in practice!

Rule number one: For all international broadcasting Universal Coordinated Time (UTC) will be used, except by the BBC who will continue to use Greenwich Mean Time (GMT).

From the schedule extract (Figure 2) from the mid 1990s kindly provided by Ashley Jones G8VWN, formerly a Technical Operations Manager at Bush House, it will be apparent that all required information details would have been printed on the black and white version of the schedule. The duration of all transmissions could be seen very clearly and all programme switching operations were timed to occur 30 seconds before the respective quarter hour point. Approximately 20 seconds, therefore, remained available, if required, for a live or pre-recorded introductory announcement before a Greenwich time signal. The frequency, antenna array number and azimuthal bearing were shown alongside the head end of each transmission. An abbreviation letter within the transmission strip represented a coloured network carrying a single language or a stream of geographically grouped languages.

World Service WS English, long ago remembered as the General Overseas Service, was always scheduled as Green network and was identified by a broad stripe down the left hand side of the transmission.

The opening and closing sequences of all transmissions were clearly defined by notes referred by encircled numbers.

Variations of openers included the use of the Bow Bells interval signal for WS English, the V-drumbeats for all European language services, and the 'B...B...C' chime for the other overseas services and for English-by-Radio, the language-tuition lessons later renamed as BBC English (The tales of 'Anne and her Grandfather' are fondly remembered, particularly as they were often heard courtesy of 'Aspidistra'!). Other opening sequences were included in the BBC system for use with VOA and RCI relays.

There was less scope for variation in the closing sequences; local closing announcements could be inserted at relay stations to identify the source site, requiring the transmitter to stay on air after the usual 'minus 30-second' switching point and a similar sequence was used to close VOA and RCI relays. If a number of WS English frequencies were closing simultaneously a separate network segment would be contrived and the closing announcements packaged with the closing programme and duly noted.

'Crash-starts' and 'crash-finishes', shown as solid triangles at the beginning or end of a transmission, occurred at the 'minus 30-second' switching points and enabled frequency continuity between commitments carried on different facilities.

Not all transmission commitments were operated daily; for example, some language programmes were broadcast on a few days only each week while other programmes were extended at weekends. For example, the Falkland Islands Service was scheduled on Tuesdays and Fridays only, referred to as Note J.

Maintenance breaks were provided on the schedule for work on equipment and antennas at transmitting stations with all equipment off air and, dependent upon programme junction times, there would have been a requirement for day-to-day variation in operations. Notes, referred by encircled letters, defined all these and there were often pairings of complementary days, for example, note X corresponded to weekdays with note W as the complement for weekend days.

For English broadcasts, and to a lesser extent those in Arabic and Russian where large audience areas are to be served, predictions, or previous experience, might suggest that the same frequency band was propagationally viable for covering more than one continent or blocks of countries simultaneously. If the total azimuthal spread of the required target area as seen from the transmitting station was appreciably greater than the horizontal beamwidth of a single antenna, two or more senders would then be used synchronised on the same frequency whenever possible to reduce the total number of frequencies involved. This would be indicated on the schedule by the letter 's' repeated down the full length of the synchronised operations. However, care is required on several counts whenever synchronised transmissions are employed.

Because, in such use of directive transmitting antennas, the received signal at the distant end may contain components derived from a sidelobe of one antenna as well as from the main lobe of the other, successive senders joining a transmission already in progress should have programme modulation applied from start; radiation of plain carrier by one sender would be liable to 'de-modulate' the overall received signal whilst use of any line-up tone could obviously be very destructive. Synchronised senders operating from the same station should have audio in phase; equipment phasing usually being checked at commissioning stage. Lastly, any use of satellite-borne programme feed should entail the same number of 'hops' for each sender using a satellite source or, of course, all fed from the same satellite.

There was a time when a shortage of 49-metre channels led to the same 6195 kHz frequency being used simultaneously for WS English out of Skelton, UK, for Europe and from Singapore for East Asia. The time of day was deemed to be too early to advertise coverage for the Subcontinent (2200 GMT, being very early morning locally), nevertheless, there were complaints from India about the inherent delay from the satellite feed of modulation for the dominant signal resulting in a pre-echo effect which was completely destructive to the frequency. It was the converse of the bathroom, mini-echo effect, which in moderation, appears to enhance comprehension of a speech channel probably from some subliminal effect with the human brain.

Rule number two: All BBC transmitter and programme switching operations will be carried out 30 seconds prior to quarter-hour points, except in exceptional circumstances!

At this point, G3LXQ must confess to a misdemeanour at Daventry around 1962, his first year in transmitter operations. He was a young sprog let loose on the control desk of a couple of 100 kW SWB18 senders.

There is a casual air about airline pilots, which is intended to ooze competence and instil confidence among the passengers being conveyed. Can one thus imagine a similar situation in the sender hall when Ray King, one of the older engineers, with his pipe set to one side of his mouth, casually said from the other side of his mouth in his easy deep-voiced manner that, at three o'clock (in the middle of the night shift), the North American service sender would be switched off and wavechanged in readiness for the African service. Approaching three o'clock one would have expected someone to amble down and supervise the close-down. Nobody came, so at 0300, or more precisely 02:59:30, G3LXQ flipped over the HV DC raise-lower switch and the EHT cut off. All of the senders on a short-wave station were equipped with carrier-fail alarm bells, however, they would only alarm if EHT and, therefore, radiation had been selected! It would therefore have been at least a couple of minutes or more before the action was rumbled, possibly by the almighty Tatsfield monitoring station.

What should have happened was a three-minute news summary to round off the transmission and then someone would have ambled down to supervise the operations. Instead of which Ray came running down the sender hall wondering what the .... was happening or in fact, not happening! It's strange because Ray hadn't ever been seen running, either before or since, just to help out with a wavechange!

And that's how one young G3LXQ learned about the only exception in the closing note list!

The display, compilation and management of the operational schedule have changed vastly in recent years not only to reflect developments in HF broadcasting but also as a consequence of computer-convergency.

Several companies now broker transmitting facilities for hire or exchange in strategic locations and sophisticated equipment is made available to smaller organisations not wishing or able to invest in a high power transmitting station of their own. Consequently, many broadcasts are now relayed from a site within good sky-wave range of the target audience and remote from the originating country.

Final-Final: A ‘reflection’ by G3LXQ

The 1960s to 1990s were for me an interesting time to be in short-wave broadcasting; when I joined it was just advancing from the basic text-book engineering and was faced with cat and mouse operations, station staff versus Tatsfield, let alone countering the jammers! But it evolved to include some of the clever tricks in transmitters and antennas (as Dave G4OYX has already shown us) before eventually being diluted by the widespread use of satellites and digital technology, which I found a little bland and clinical, very clever though it was.

My knowledge of the black art of frequency management was scant, being more involved with the hardware utilisation. My contribution to 'Tricks of the Trade'

therefore comprises snapshot views of incidents and situations from my fringe involvement.

But I would like to record appreciation of the efforts made by Frequency Management Engineers to the success of the broadcast operations. A false moment of judgement at the coordination table can completely negate the high investment of resources towards an effective transmitter and antenna as far as a distant listener is concerned. They are apparently blessed with a shrewdness and tenacity that horse-trading poker-players would be proud of; an intimate feel for solid geometry using intangible commodities, such as being able to visualise where on earth another broadcaster's second- and third-hops will fall as well as his back-radiation!

It should be borne in mind by all who have the privilege of using amateur frequency allocations, that interference from others sharing that privilege may completely nullify all one's efforts towards improving the transmitter, receiver, antennas and ancillary gear by a half-dB here, a couple of dBs there and so on. Obviously, on some occasions, for us that will be part of the sport!

Next time in ToTT we will get to grips with Bill Stickells' artwork and see how it all fits together to ensure seamless running of a broadcast service.