

THE ROLE OF THE CONSULTATIVE COMMITTEE ON INTERNATIONAL RADIO (CCIR) IN TIME AND FREQUENCY*

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Abstract

The Consultative Committee on International Radio (CCIR) is a technical advisory group that, within the International Telecommunications Union (ITU), provides formal Recommendations, technical advice, and technical information related to the allocation and use of the radio spectrum. The CCIR does its work through a number of separate Study Groups, each of which deals primarily with one or more radio-based services recognized by the ITU. One of these, Study Group 7, is called "Science Services" and deals with, among other things, time and frequency services and related topics. This part of CCIR is probably best known for its development and implementation of the UTC time system in 1972. The U.S. national Administration develops proposed Recommendations and provides other technical input to the CCIR through an organization of U.S. Study Groups that parallel those functioning internationally. Both the private and government sectors participate actively under the general oversight of the U.S. State Department and its U.S. CCIR National Committee. Current and projected future activities of U.S. and international Study Group 7 will be described, including some examples of current Recommendations, Handbooks, and other documentation that might be useful for those working with time and frequency applications.

INTRODUCTION

The Consultative Committee on International Radio (CCIR) is one of several international organizations that play an important role in time and frequency activities. These organizations may be grouped roughly into three main categories as illustrated in Figure 1: those that deal primarily with the "standards" aspects of time and frequency (for example, the definition of the second); those that are concerned mainly with the scientific aspects; and those that are involved more with the regulatory aspects affecting time and frequency dissemination services. The standards-related organizations shown on the left side of the chart derive from the Treaty of the Meter and include, at the highest level, the General Conference of Weights and Measures (CGPM) and the International

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Committee of Weights and Measures (CIPM). These bodies, acting upon the technical advice of its consultative committees, such as those for the definition of the second (CCDS) and the meter (CCDM), adopted the current definition of the second in terms of the cesium atom. The International Bureau of Weights and Measures (BIPM) serves as an international measurement laboratory and includes a Time Section in Paris, which has important responsibilities for the timing community in terms of maintaining and coordinating the international UTC and TAI international atomic time scales. These responsibilities were previously handled by the former International Time Bureau (BIH).

A number of scientifically oriented international organizations also have strong interest in time and frequency and make important contributions to the field. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) includes an International Council of Scientific Unions (ICSU). Two of its member organizations, the International Astronomical Union (IAU) and the International Radio Science Union (URSI), have particularly strong interest in time and frequency from the points of view of astronomical time and radio-signal propagation, respectively. One of the permanent service organizations established by ICSU, the International Earth Rotation Service (IERS), has direct impact on time and frequency services and other operations by having responsibilities for determining and announcing the dates for insertion of leap seconds into the UTC time scale. The IERS also determines and announces the value of the difference between UTC and the UT1 astronomical time scales that is included on most standard time and frequency broadcasts.

The third type of organization important to time and frequency and the principal one of interest for this discussion is the regulatory structure briefly outlined on the right side of Figure 1. The parent organization is the International Telecommunications Union (ITU) which, while maintaining an affiliation with the United Nations, traces its roots back to 1885. Under terms of the International Telecommunications Convention the ITU is charged to, among other things, "study technical and operating questions relating specifically to radiocommunications without limit of frequency range, and to issue recommendations on them ..." The ITU, among many other functions, issues and updates the International Radio Regulations that play a major role in regulating how the radio spectrum, including that used by standard time and frequency broadcast services, is allocated and used. The ITU depends heavily on its technical advisory body, the CCIR, in all of its activities relating to the various radio-based international services. The Consultative Committee on International Telephone and Telegraph (CCITT) performs a similar role in the area of telephone and telegraph communications. One of the CCIR Study Groups, Study Group 7, is assigned specific responsibility for the Standard-Frequency and Time-Signal Service, which includes time and frequency broadcasts operating in the specific frequency bands allocated by the ITU.

CCIR OBJECTIVES, ORGANIZATION, AND WORKING METHODS

The CCIR has three principal objectives:

1. to provide the technical bases for use by administrative radio conferences and radiocommunication services for efficient use of the radio-frequency spectrum and the geostationary-satellite orbit, bearing in mind the needs of the various radio services;
2. to recommend performance standards for radio systems and technical arrangements which assure their effective and compatible interworking in international telecommunications; and

3. to collect, exchange, analyze, and disseminate technical information resulting from studies by the CCIR, and other information available for the development, planning, and operation of radio systems, including any necessary special measures required to facilitate the use of such information in developing countries.

In order to address these objectives the CCIR has formed 10 Study Groups, the majority of which deal with one or more radiocommunication services as defined by the ITU. Other Study Groups deal with more general topics, such as propagation, spectrum management, and inter-service sharing and compatibility issues. As revised by the 1990 CCIR Plenary Assembly, the current Study Groups are:

- Study Group 1: Spectrum Management Techniques
- Study Group 4: Fixed-Satellite Service
- Study Group 5: Propagation in Non-Ionized Media
- Study Group 6: Propagation in Ionized Media
- Study Group 7: Science Services
- Study Group 8: Mobile, Radiodetermination, and Amateur Services
- Study Group 9: Fixed Service
- Study Group 10: Sound Broadcasting Services
- Study Group 11: Television Broadcasting Services
- Study Group 12: Inter-service Sharing and Compatibility

In addition there are two other groups which deal with certain interactions with the CCITT and common CCIR vocabulary issues.

The CCIR's activities relating to time and frequency are now conducted within a recently reorganized Study Group 7, called "Science Services." Prior to May, 1990, this group's responsibilities were carried out in two separate Study Groups: Study Group 2 (Space Research and Radioastronomy) and the old Study Group 7 (Standard Frequencies and Time Signals). The new "Science Services" Study Group 7 is further subdivided into the following 4 working groups, known as Working Parties:

- WP 7A: Time and Frequency Services;
- WP 7B: Space Research;
- WP 7C: Earth Exploration and Meteorological Satellites; and
- WP 7D: Radio and Radar Astronomy.

The 1990 CCIR Plenary Assembly, in setting up this structure, authorized the following "Scope" statement for WP 7A: "Dissemination, reception, and coordination of standard-frequency and time-signal services, including the application of satellite techniques, on a world-wide basis." With a narrow interpretation of this scope statement, the CCIR and Study Group 7 might seem to be interested only in those aspects of time and frequency that relate directly to standard time and frequency broadcast services, such as WWV, that use the specific frequencies allocated to the Standard-Frequency and Time-Signal Service. As will be indicated later, however, the CCIR has traditionally adopted a much broader view of its scope in the time and frequency area and, in fact, has expanded its interests significantly beyond the narrow topic of standard frequency and time broadcasts using the allocated bands.

The international CCIR organization is, for the most part, mirrored in the U.S. by a parallel national structure of Study Groups charged with developing documentation proposals in various forms that reflect the views of U.S. organizations (public and private) and the U.S. government. For example, there is a U.S. Study Group 7 and a U.S. Working Party 7A that deals with time and frequency matters. Participation is open to any organization with interests in the subject involved. Historically, the most active organizations participating in the work of WP 7A include the National Institute of Standards and Technology (NIST), the U.S. Naval Observatory (USNO), the National Aeronautics and Space Administration (NASA), Jet Propulsion Lab (JPL), and the Applied Physics Lab (APL) of Johns Hopkins University.

CCIR working methods are currently undergoing a significant streamlining process, designed to shorten the time required for approval and publication of important Recommendations and to reduce operating costs, particularly at the international level. Typically, proposals for new or revised documentation (for example, Recommendations, Reports, Questions to be studied, Handbook contributions) are generated by various national Administrations. In the case of the U.S. time and frequency area, this occurs in a series of 3-4 meetings of WP 7A conducted before each international CCIR Working Party meeting. Documents approved by WP 7A are then submitted to the full U.S. Study Group 7 for revision or approval. The next step is a review by the U.S. CCIR National Committee, consisting of all U.S. Study Group Chairmen, frequency management personnel, and other private and government representatives. This part of the review process permits coordination with other U.S. Study Groups and the State Department. Approved documents are then forwarded to Geneva as input documents for the next international meeting. U.S. proposals, along with those from other nations, are considered by the international Working Party meetings and then forwarded in appropriate form to the following international Study Group meetings. The full Study Group either accepts or rejects each document. Those that are accepted either go directly to Administrations for final approval by correspondence (urgent Recommendations) or are sent on to the next CCIR Plenary Assembly. The approval process for Recommendations can thus take as little as a few months or as long as several years.

CCIR IMPACT ON TIME AND FREQUENCY ACTIVITIES

CCIR actions can affect time and frequency in several ways: (1) frequency allocations and their use; (2) formal Recommendations relating to the operation of Standard-Frequency and Time-Signal Service broadcasts; (3) other Recommendations relating to time and frequency activities, such as standards, time scales, dissemination, and coordination; and (4) other information outputs in the form of Reports, Recommendation texts, and Handbooks. Each of these aspects is discussed in more detail below.

ALLOCATION ASPECTS

Frequency allocations are usually made by World Administrative Radio Conferences. General WARC's are held at least every 20 years, and special ones dealing with a subset of radio services are held more often as needed. Appropriate CCIR Study Groups prepare technical Reports for these allocation conferences, providing background information on such issues as propagation considerations, sharing possibilities, and preferred frequencies and bandwidths. A complete table of allocations for all frequency bands, including sharing constraints where appropriate, is published

by the ITU as part of the Radio Regulations.

Currently (1991), the following frequency allocations are assigned to the Standard-Frequency and Time-Signal Service:

1. 20 kHz \pm 0.05 kHz
2. 14-19.95 kHz, 20.05-70 kHz, 72-84 kHz (Region 1), and 86-90 kHz (Region 1) Stations operating in these bands are permitted by footnote to broadcast time and frequency signals with full protection rights.
3. 2.5 MHz \pm 5 kHz
4. 5 MHz \pm 5 kHz
5. 10 MHz \pm 5 kHz
6. 15 MHz \pm 10 kHz
7. 20 MHz \pm 10 kHz
8. 25 MHz \pm 10 kHz
9. 400.1 MHz \pm 25 kHz
10. 4202 MHz \pm 2 MHz (space-to-Earth)
6427 MHz \pm 2 MHz (Earth-to-space)
11. 13.4-14.0 GHz (Earth-to-space)
20.2-21.2 GHz (space-to-Earth)
12. 25.25-27.0 GHz (Earth-to-space)
30.0-31.3 GHz (space-to-Earth)

Allocation 1 was formerly used by WWVL in the U.S. but is currently inactive. The low-frequency allocations in 2 are footnote allocations under which stations such as WWVB in the U.S., HBG in Switzerland, and DCF77 in Germany operate. Allocations 3-8 are those used by various high-frequency services such as WWV and WWVH in the U.S. Allocation 9 was obtained in 1971 in anticipation of a WWV-type service from satellites. To date it has not been used for this purpose. All these allocations mentioned thus far have "primary" status, which means that they have guaranteed protection under the Radio Regulations and do not have to share with other services. The allocation pairs in allocations 10-12 are footnote allocations and are subject to some constraints according to the Radio Regulations.

While some of the time and frequency allocations are clearly capable of supporting time transfer at the highest possible accuracy levels (for example, the pairs of high-bandwidth satellite allocations), the main use to date has been for the widespread LF and HF broadcast services, providing only modest accuracy capabilities by today's standards. However, such services offer many other advantages in terms of wide coverage, low cost of receivers, reliable reception in many areas, and multiple sources for UTC time. The vast majority of users, even in today's high-technology environment, simply do not require accuracies beyond that offered by many LF and HF services. Thus, these allocations and CCIR's role in generating and maintaining them will continue to have important

impact on large numbers of users in the future. On the other hand, many of the more demanding applications for time and frequency are being served in other ways, particularly by making use of opportunities for time-and-frequency transfer using other available services. Two examples are the use of the Global Positioning System (GPS) satellites of the Radiodetermination Service and two-way time transfer through communication satellites operating in the Fixed-Satellite Service. In these cases, of course, the CCIR also plays an important allocation role through its Study Groups 8 and 4, respectively.

RECOMMENDATIONS ON OPERATING STANDARD TIME AND FREQUENCY SERVICES

The CCIR, through its Study Group 7 and Working Party 7A, formulates various formal Recommendations that relate to the operation of broadcast services using those allocations assigned to the Standard-Frequency and Time-Signal Service. Such Recommendations effectively have the force of international law, at least for the more than 150 member nations of the ITU. In the U.S. these Recommendations apply directly to the WWV, WWVH, and WWVB broadcast services operated by NIST and, in the rest of the world, they impact similar services. In addition, some other time and frequency services that do not operate in the allocated bands nevertheless follow many of these Recommendations. The time code transmitted over the U.S. GOES satellites is an example.

The best known Recommendation of this type is CCIR Recommendation 460, which established the UTC (Coordinated Universal Time) system in 1972. Today, UTC is the time disseminated not only from standard time and frequency stations, but also from virtually every generally available source for precise time. Related Recommendations propose using UTC as the general reference for time and frequency measurements and in all international telecommunication activities. Corresponding recommendations from other international organizations such as URSI and the IAU have supported the intent of the original CCIR recommendations.

Another CCIR Recommendation that has proved very useful is one that recommends use of various existing standard time and frequency broadcasts and certain other available signals, such as Loran-C and Omega Navigation System broadcasts, for precise time and frequency references. Detailed operating characteristics and broadcast formats for the various broadcasts are given in an Annex to this Recommendation. CCIR Study Group 7 makes a strong effort to keep this information updated approximately every two years.

Other CCIR Recommendations that impact standard time and frequency broadcasts and their effective use involve topics such as the use of other frequency bands for broadcast services, the avoidance of interference to these services, the use of the "Modified Julian Date," time scale notations, and the international synchronization of time scales. The latter Recommendation is especially important in today's environment since it recommends that the various timing centers maintain their local UTC time scales to within 1 μ s of UTC. This tight tolerance is stated as a "desirable goal".

RECOMMENDATIONS RELATING TO OTHER ASPECTS OF TIME AND FREQUENCY

As mentioned earlier, Study Group 7 has historically taken a rather broad view of its scope as defined by the CCIR. The breadth of the current Working Party 7A work program can be seen

from the following listing of the titles of the 9 formal "Questions" that provide the bases for input documentation and related actions:

1. Methods for Improving Terrestrial Frequency and Time Dissemination
2. Stability of Standard-Frequency and Time-Signal Emissions as Received
3. Time Codes
4. Worldwide Dissemination of Time Signals to an Accuracy of 1 μ s or Better for Industrial Purposes
5. Techniques for Time Transfer
6. Performance and Reliability of Frequency Standards and Their Use in Time Scales
7. Standard Frequency and Time Signals from Satellites
8. Two-way Time Transfer Through Communication Satellites

To date Working Party 7A has produced several Recommendations in response to this set of Questions that go somewhat beyond the narrow topic of operating the Standard-Frequency and Time-Signal Service. For example, there is now a rather comprehensive Recommendation on "Frequency and Time (Phase) Instability Measures." The latest version of this Recommendation now includes instability measures for clocks, measurement systems, and dissemination systems. Its Annex contains helpful background information and references on instability characterization. There are two Recommendations relating to satellite techniques; a general encouragement to consider satellite methods and a more specific one relating to the use of GPS satellites for timing under varying conditions of intentional signal degradation. Another Recommendation supports the dissemination of time information in coded form without specifying a particular code format. Working Party 7A also generated a Recommendation providing definitions of more than 60 terms commonly used in CCIR time and frequency activities. While the Glossary of Terms is primarily intended for use within the CCIR, efforts have been made in constructing it to coordinate as closely as possible with other vocabulary efforts, such as that being addressed within the IEEE organization.

In recognition of the current and projected future importance of satellite methods, Working Party 7A also operates a special Task Group 7/2, which is charged to consider developing appropriate Recommendations and other documentation relating to satellite time transfer on an expedited basis (next 1-2 year period). It is likely that this group, working partly by correspondence, will propose future Recommendations on the use of GPS and GLONASS, the use of two-way time transfers through communication satellites, and possibly on methods for calibrating delays through ground-station equipment.

CCIR-GENERATED INFORMATION ON TIME AND FREQUENCY

Aside from formal Recommendations, the CCIR also plays an important role by generating, compiling, and publishing useful technical information in several different forms. The intended audience may vary from document to document. In some cases, the information is intended for a rather

restricted audience, for example, the participants in World Administrative Radio Conferences. Other material may be designed for a more general audience of technical engineers or scientists who are not specialists in the particular technical area. Much of the information is also intended to be useful to personnel in developing countries who are responsible for developing or operating radiocommunication systems.

This technical information is published in several different forms. The principal traditional method is the so-called "Green Books" that are published for each Study Group at the completion of each 4-year CCIR working cycle. These Green Books currently contain all the active Recommendations, Reports, and other documentation of the Study Group. The Reports contain factual technical information and analyses which are helpful in producing Recommendations. Under current CCIR policy, the Report form is being de-emphasized and considered more as a temporary internal working document used in the process of developing Recommendations. As a result, there is a current tendency to annex some of this background technical information to the texts of the formal Recommendations. Occasionally, a Study Group may decide to compile information on a particular topic into a Handbook format, which is then published by the CCIR in Geneva. One better known Handbook, produced by Study Group 4, deals with Satellite Communications. Working Party 7A is currently working on two different Handbooks relating to time and frequency. The first, which is expected to be published in 1992, deals with satellite time dissemination. It includes information both of a background nature on topics such as propagation effects, satellite orbits, signal structures, and relativity considerations, as well as more specific information on satellite systems available for time transfer applications. Working Party 7A has recently (1991) decided to produce a second Handbook, tentatively titled "Selection and Use of Precise Frequency and Time Systems." The content will include material on various frequency standards; operational experiences, problems, and pitfalls; time scale aspects; time and frequency measurements and characterization; and some uses for frequency sources. The Handbook will be prepared by a group of international experts from Working Party 7A.

Any of the ITU/CCIR publications may be ordered directly from the ITU by contacting: International Telecommunications Union, General Secretariat - Sales Section, Place des Nations, CH-1211, Geneva, Switzerland.

CONCLUSION

The CCIR is one of several international organizations that play an important role in international aspects of time and frequency. It is the key organization in matters relating to the allocation and use of the radio spectrum for time and frequency dissemination services. Its impact goes well beyond the formal Standard-Frequency and Time-Signal Service, however, in terms of providing Recommendations and technical information in a variety of forms. The Recommendations and other publications are useful for technical professionals working with time and frequency applications but who are not specialists in the field.

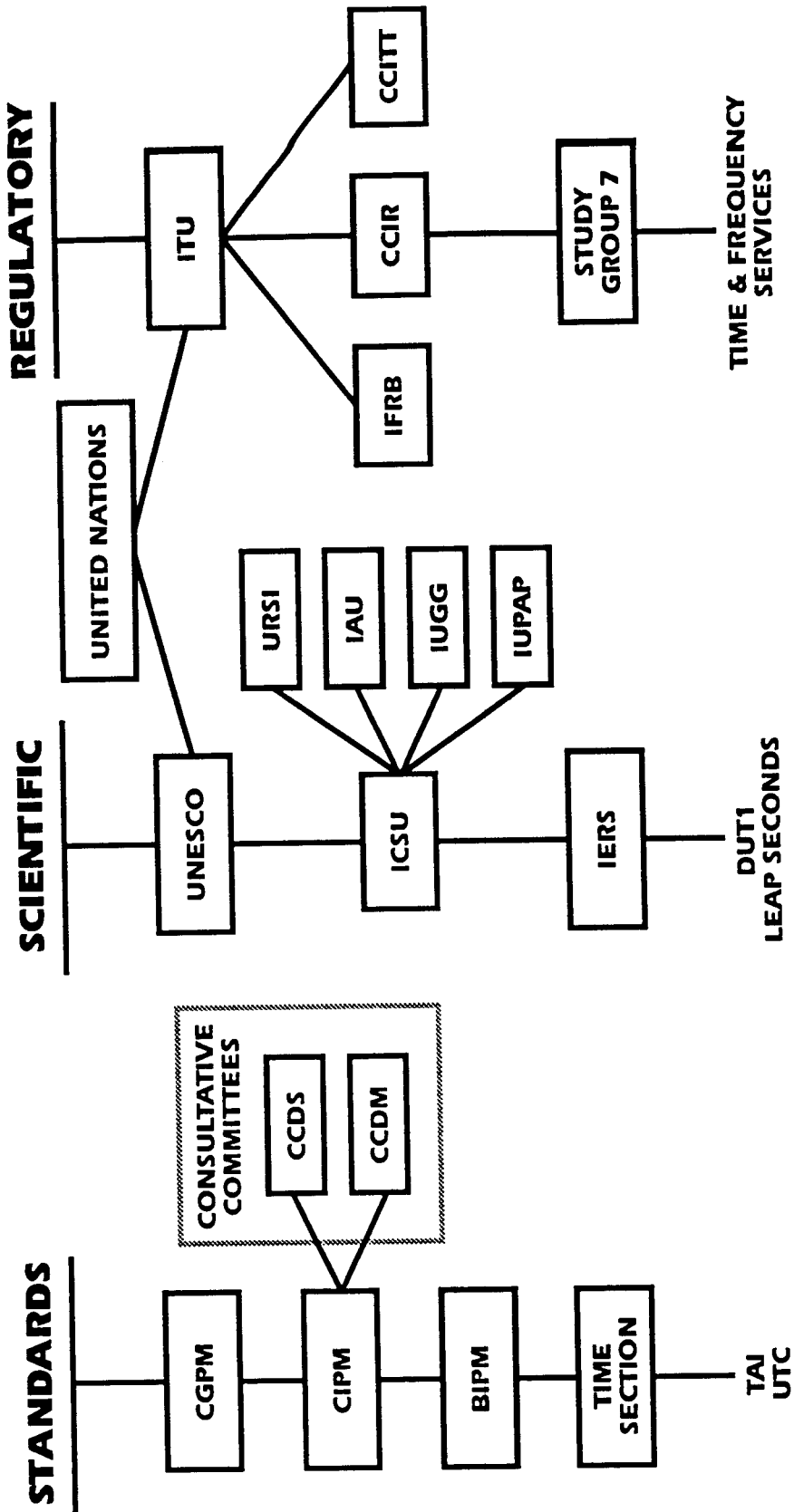


Figure 1. International Organizations With an Impact on Time and Frequency. For simplicity only those suborganizations are shown that are relevant to time and frequency.