THE TIME AND FREQUENCY COMPARISONS VIA LORAN - C AND NATIONAL TV NETWORK IN YUGOSLAVIA

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ABSTRACT

Many years comparison results of the cesium clocks, which are done in the Laboratory of Federal Bureau of Measures and Precious Metals are presented in this paper. Regional standard frequency and time signals dissemination is over National TV network by so-called active TV system. International comparisons are performed via Loran-C system and by clock transportation.

The way of calculation and approximation of the time signal propagation delays in the aim of the clocks comparisons is given. Settled comparison results of the cesium clocks via TV network, Loran-C, both of them and by clock transportation are also discussed in this paper.

The aim of comparison and synchronisation is to form and maintain the Yugoslav time scale. The presented values of the UTC - UTC(YUZM) show the stability of frequency comparisons of 10^{-13} for the presented period.

INTRODUCTION

In the Laboratory of Federal Bureau of Measures and Precious Metals the Yugoslav primary standard of time and frequency is maintained for more than eight years. It consists of cesium beam tube standard and a rubidium gas cell standard as a backup. Comparisons of our primary standard is carried out with the international clocks as well as with the cesium clocks owned by certain

institutions in Yugoslavia. These comparisons are via Loran-C system, National TV network and by clock transportation.

The measurement process of comparisons is fully automatised by using the microcomputer which is for our purposes made in Yugoslavia. In that way the measurements of appropriate time intervals have been carried out every day a year.

The TV studio Belgrade, Yugoslavia began over ten years ago the experimental transmission of time and standard frequency signals by using the so-called active TV system, which secures the Time of Coincidence every second. In this system, second pulses, standard frequency and the coded time of day are all derived from the cesium clock which itself is located within the TV studio premisses. The principles of this system was reported on IX PTTI, November 1977. |1|

CLOCK COMPARISONS

For our UTC time comparison we used the signals transmitted from the master station of Mediterranean Sea chain of Loran-C system in Sellia Marina, Italy. In our everyday work we compare the clock in our Laboratory and the clock in TV studio Belgrade (TVB) with master clock of Mediterranean Sea chain, Figure 1, via Loran-C system. Also, via TV network our clock is compared with clock in TV studio Belgrade.

Figure 2. shows Coordinated Universal Time of our Laboratory UTC(YUZM) relative to UTC(BIH) for 1000 days at the intervals of ten days as it would be sent to BIH.

The origin of Coordinated Universal Time (UTC) Scale of the Federal Bureau of Measures and Precious Metals of Yugoslavia UTC(YUZM) is determined with the direct measurement by clock transportation in Geneve, Switzerland on December 21, 1981 (MJD 44959.59).

The second direct measurement of UTC(OP) - UTC(YUZM) by clock transportation was in Paris, France from June 26, 1984 (MJD 45877.8) till June 29, 1984 (MJD 45880.4). The time difference on MJD 45877.8 was UTC(OP) - UTC(YUZM) = -61.9 μs. With this direct measurement the calculated value of the total timing delay of Loran-C signals has been experimentally proved again. For the period of our experimental work, before the clock transportation to Geneve we used the calculated value of total timing delay for Loran-C signals which has been calculated in our Laboratory using USNO recomendations and Millington method for secondary phase corrections. |2|

To the data obtained by the time interval counter measurements we applied the corrections from USNO daily phase values and time differences Series 4 of UTC(USNO-MC) - Mediterranean Sea chain and from BIH Circular D of UTC - UTC(USNO-MC). Also, we subtracted the value of total timing delay with the assumption that the propagation delay between the Loran-C transmitter and our receiver are

constant for the time of observation.

The data plotted on this figure include the relative phase variations of received Loran-C signals and the frequency drift of our clock. From that data one can observe the seasonal variations of the phase of the received signals, which is the most stable in summer. The maximum value of the time difference between the plotted data and the approximated mean is 2.5 μs, and for the last year it is typically less than 0.5 μs. From this it is obvious that the long-term stability is better than 10^{-13}.

In this paper the comparison of cesium clocks using the time transmission of the active TV system is also analysed. The differences of time transmitted by TV Belgrade relative to the UTC(YUZM) for 1040 days are shown in Figure 3. The value of frequency drift of the clock in our Laboratory is removed from the data, and the drift shown on this figure is of the clock in TV studio Belgrade.

Together with the every day comparisons of our clock with the clock in TV studio Belgrade via TV network, clock transportations in certain time intervals (once a year) is used. The origin of time scale which is transmitted via TV network is determined by clock transportation. During the comparisons by clock transportation certain step time corrections are introduced in order to maintain the transmitted time within the ± 30 μs relative to the UTC(YUZM). By clock transportation the calculated value of total timing delay of TV signals is experimentally proved.

Data for ΔT are plotted at the intervals of ten days and they include the relative phase variations of the signals received via TV network.

Comparisons of the clock in TV studio Belgrade using the Mediterranean Sea chain of the Loran-C system and the National TV network obtain the difference of UTC - UTC(TVB). Figure 4. shows the time difference of UTC(TVB) relative to UTC(BIH) for 1000 days. To the data plotted at the intervals of ten days are applied the corrections from USNO Series 4 and BIH Circular D in the same way as it is previously described. The introduced steps in transmitted time were removed from the data by calculation in order to make easier observation of relative phase variations of the signals received via Loran-C and TV network. On this data there is no influence of the performance of the clock in our Laboratory, and the shown drift is of the clock in TV studio Belgrade.

On that way, by simultaneous comparisons of clocks over each transmitting path, the particular performance of each cesium clock can be distinguished as well as the influence on stability of the particular transmitting path. The standard deviation (1σ) measured by the counter is typically 10 - 18 ns for the comparisons via Loran-C and TV network, 7 - 11 ns for the comparisons via Loran-C system and 7 - 10 ns for the comparisons via TV network. Due to the change of our TV receiver set with the newly

designed one this standard deviation for the comparisons via TV network is now 3 - 6 ns. Hence, it can be distinguished which transmitting path has the greater uncertainty.

CONCLUSION

In Federal Bureau of Measures and Precious Metals the international comparisons of our cesium clock are performed via Loran-C and by the clock transportation, and via National TV network it is compared with other cesium clocks in the country. The results of these comparisons for the time of observation from year 1981 till now are good enough for the maintaining of the Coordinated Universal Time Scale UTC(YUZM). Under such conditions it is possible to start sending our comparison results to and introduce our country in Bureau International de l´ Heure.

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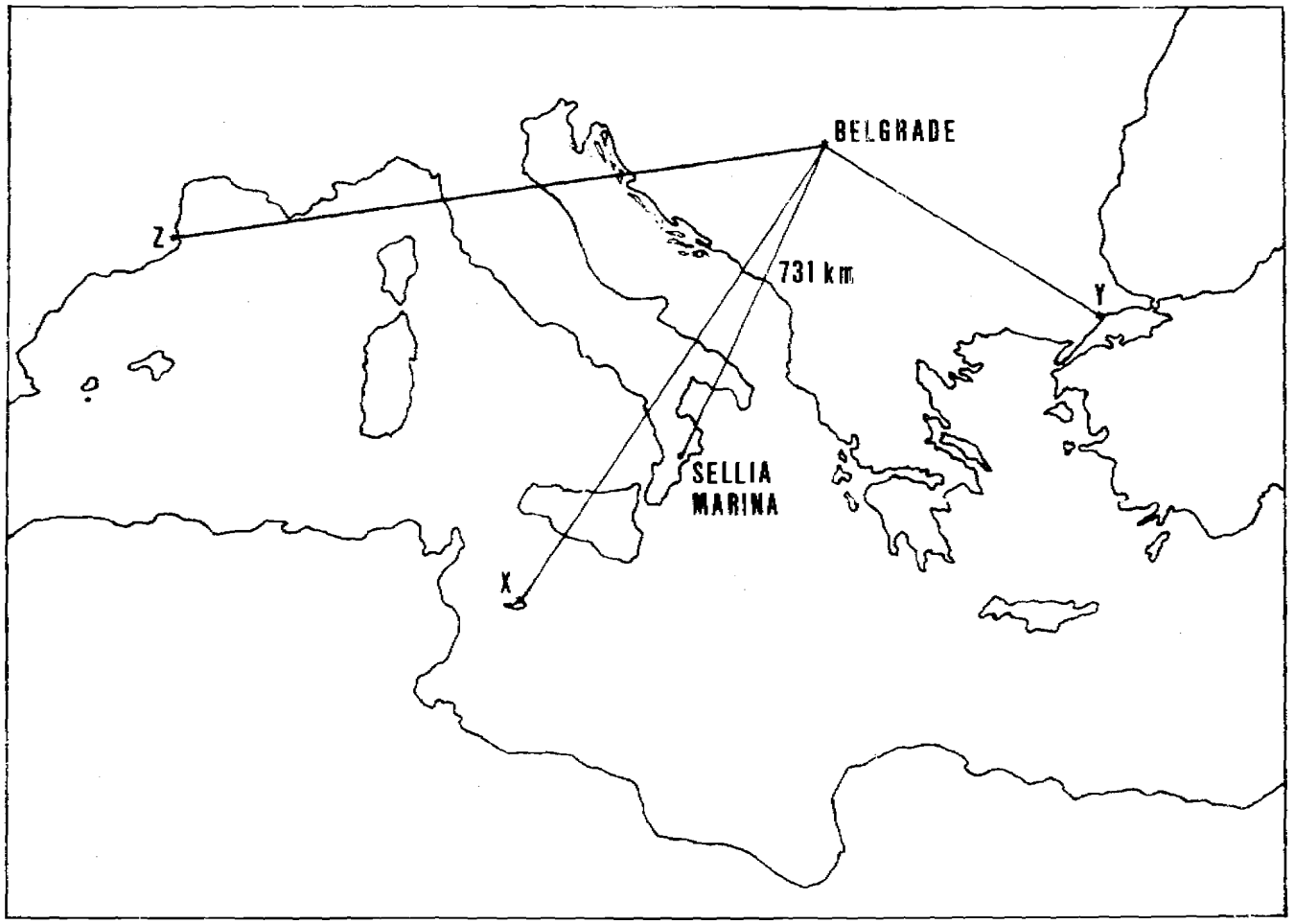

Figure 1. Mediterranean Sea Chain of Loran-C System

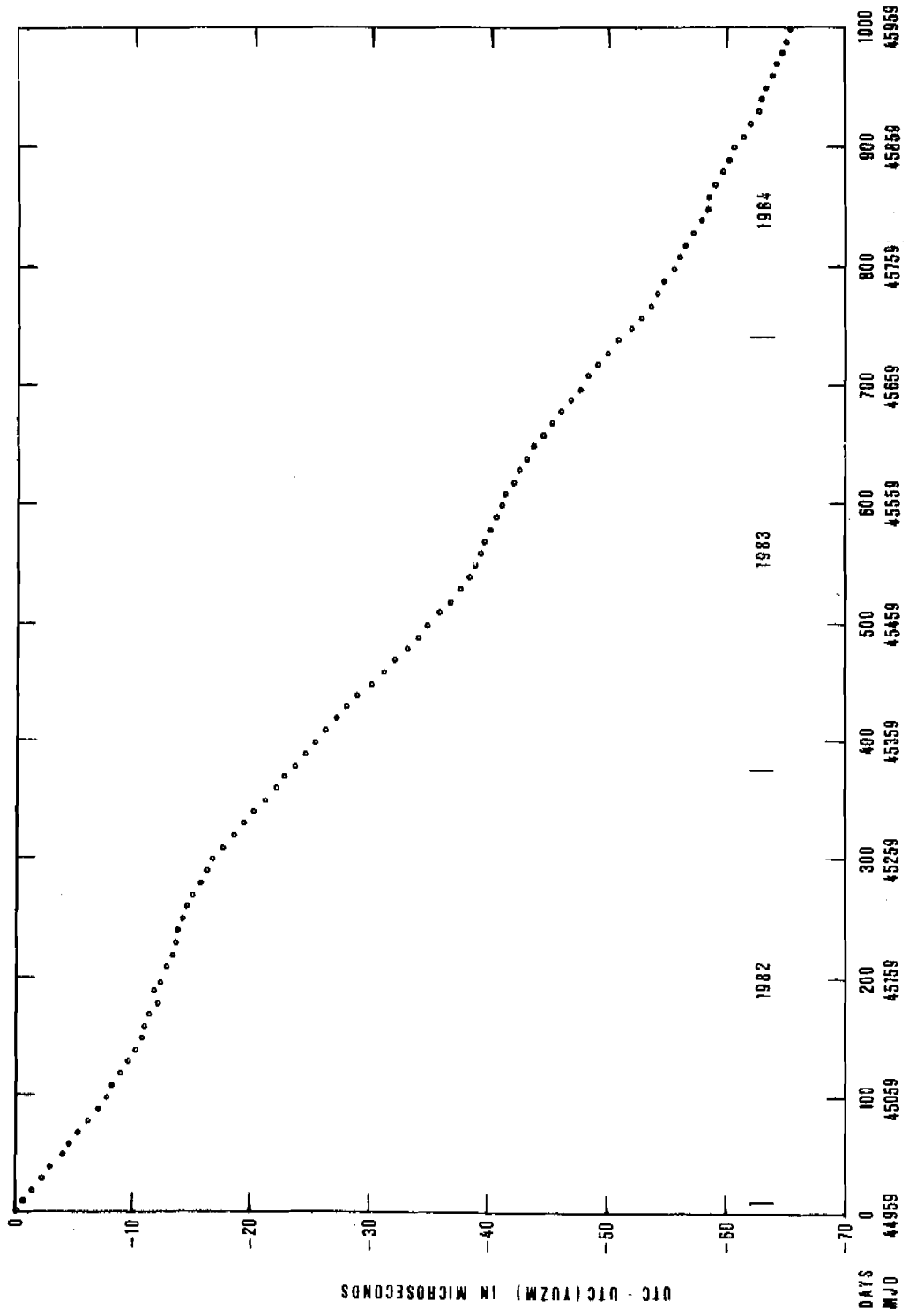

Figure 2. Coordinated Universal Time (UTC) Scale of YUZM Laboratory Relative to UTC(BIH)

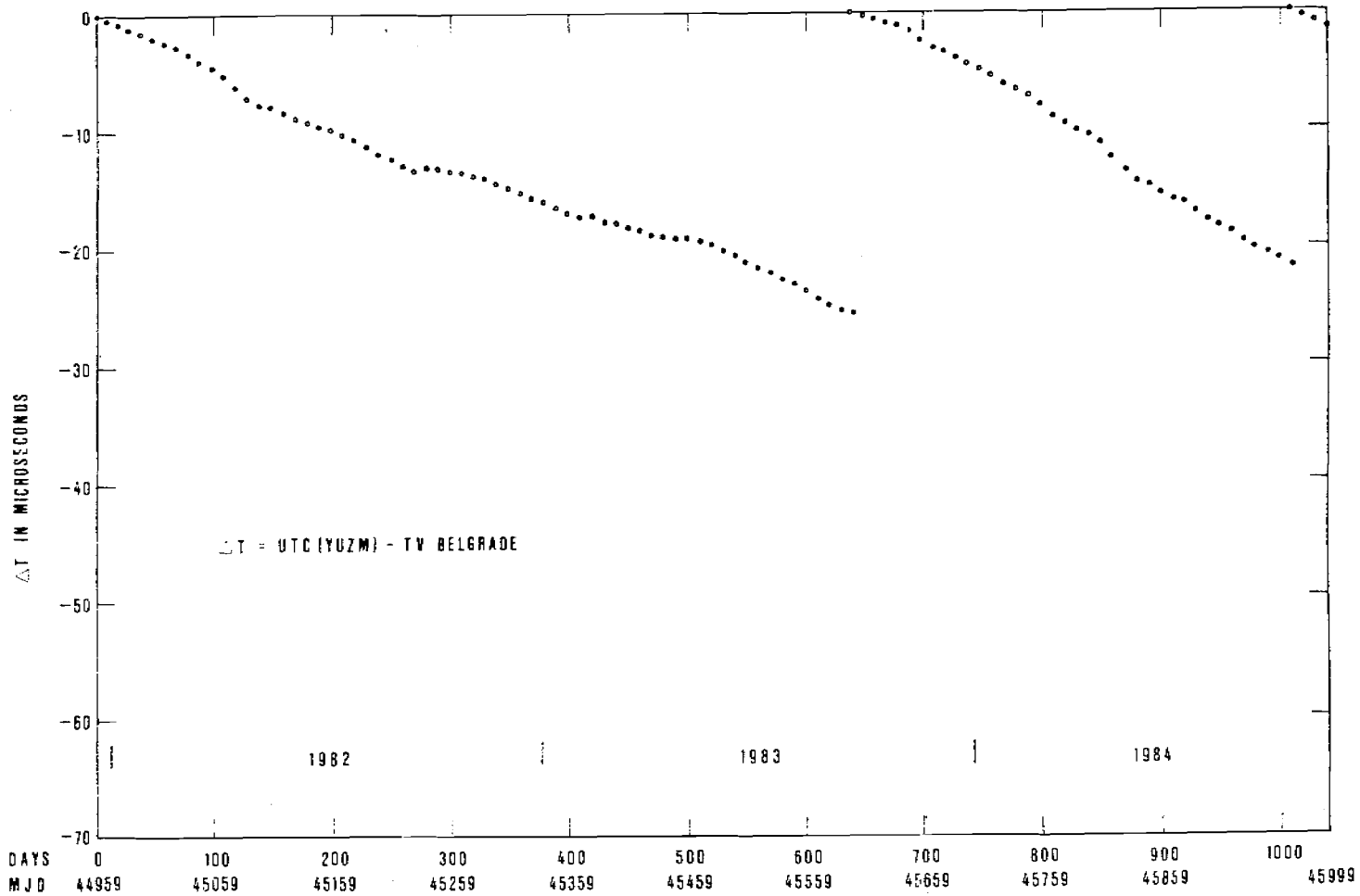

Figure 3. Comparison of Time Transmissions of TV Belgrade Relative to the UTC(YUZM)

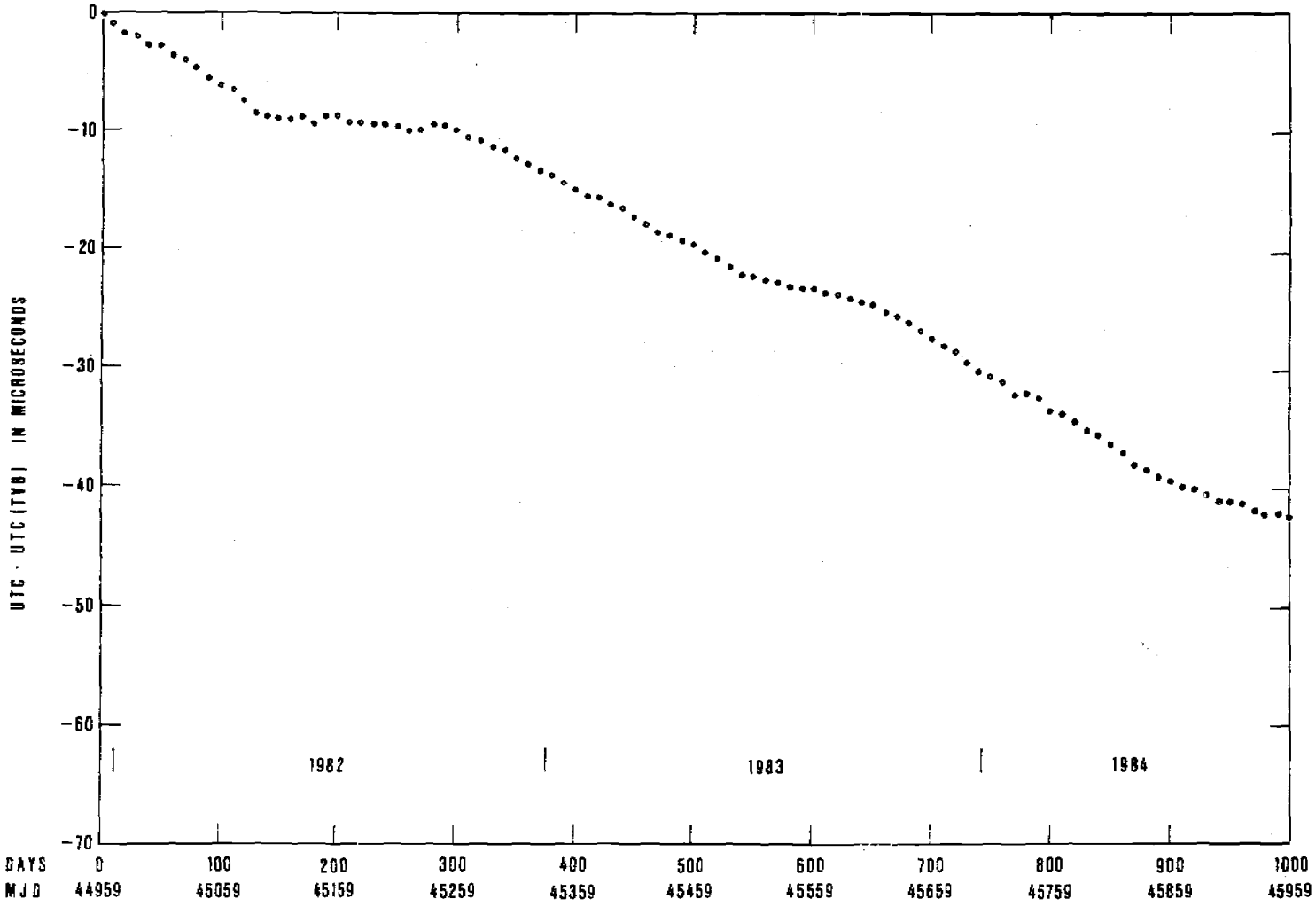

Figure 4. Comparison of Coordinated Universal Time Scales Via Loran-C and National TV Network