The Loran-C Resource in China and Its Potential Applications

WU Haitao BIAN Yujing LI Zhigang
Shaanxi Astronomical Observatory, The Chinese Academy of Sciences,
P.O.Box 18,Lintong
Shaanxi , China, 710600

ABSTRACT

There are two Loran-C systems in China. One is a Loran-C navigation system, which includes three Loran-C chains, China North Sea chain, ¸China East Sea chain and China South Sea chain (‘China Sea Chains’ for short in this paper). They are used for marine navigation, and can provide coverage of eastern part and marginal seas of China. Another is a longwave timing station, which is located in Xi’an, Shaanxi province, the western part of China, belongs to Shaanxi Astronomical Observatory. It was designed as a Loran-C master station and has been operating for about twenty years. The name of the transmitting signal is BPL. BPL longwave timing service system is also an important Loran–C resource in China ("BPL system" for short in this paper). This system is always neglected. Its coverage area includes western and middle regions of China.

Combining the China Sea Chains with BPL, we can find Loran-C coverage of almost whole mainland and marginal seas of China. The approximate coverage is showed in this paper. We also pay close attention to the development of Loran–C around the world. We have also evaluated the predicted coverage if the contemporary Loran receivers are used. Shaanxi Astronomical Observatory is planning to rebuild its longwave transmitter, and the additional data modulation onto the BPL will be implemented. The time code, to be as a first kind of data, will be transmitted through the BPL signal channel. Preparations are underway. The feasibility exploration of transmission of UTC corrections or DGPS is in our plan, too. Because there is not a satellite system in China presently, so we think the Loran-C system in China will still be operating in relative long duration.

I Introduction

In 1970's, China began to build the longwave systems for the purpose of navigation and time service. To be as an experiment unit in this field, a long-wave timing station was firstly set up. The station is located in Pucheng county, Shaanxi province, the western part of China. It was designed as a Loran-C master station, with the carrier wave frequency on 100KHz, and had been transmitting time signal since 1986. The name of the transmitting signal is BPL. BPL time service system ("BPL system" for short in this paper) is an important Loran–C resource in China. Its coverage area includes western and middle regions of China (**See Figure 1**). BPL system belongs to Shaanxi Astronomical Observatory (CSAO), the Chinese Academy of Sciences. CSAO also holds a set of

short-wave timing service system, BPM is the name of the short-wave signal. Based on these two time service systems, as well as the high performance Cesium clocks to be as the national frequency standards, CSAO is now known as the National Time Service Center and the standard time and frequency center in China.

The important technique specification and performance of BPL transmitter system are given as fellows:

The BPL transmitter has Cesium Beam Frequency Standards that is synchronized to UTC(CSAO), and it is within approximately±1μ s of UTC(CSAO).

- The accuracy of the carrier frequency is maintained at $\pm 1\times10^{-12}$

Besides the BPL system, there are three Loran-C chains in China, including China North Sea chain, China East Sea chain and China South Sea chain. They have been operating for the purpose of marine navigation since 1991, and can provide coverage of eastern part and marginal seas of China.[1] (**See Figure 2,3,4**). The transmitters of China Sea Chains are solid state.

At present, The BPL and China Sea Chains operate normally.

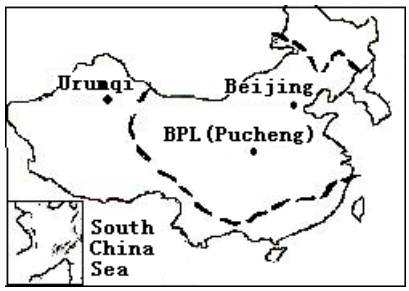

Figure1 Approximate coverage of BPL

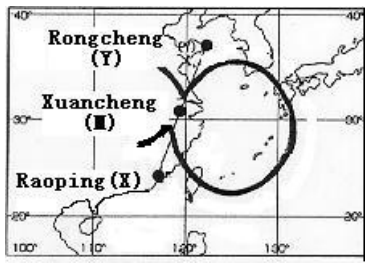

Figure2 Approximate coverage of China East Sea Chain

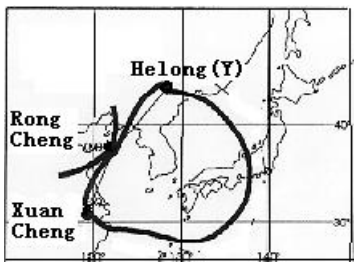

Figure3 Approximate coverage of China North Sea Chain

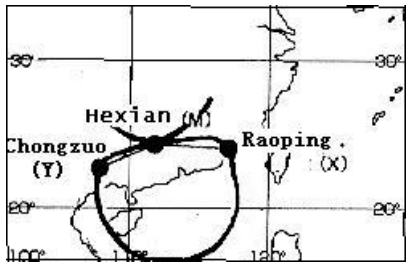

Figure 4 Approximate coverage of China South Sea Chain

II Potential Applications of Loran-C in China and Corresponding Problems

We have taken note of that great changes have been made about Loran-C abroad in the past twenty years. Contemporary Loran receiver performance is vastly improved beyond the 10-20 year old technology, and new magnetic antennas are used. Eurofix technique opens a new area, which maybe helps the Loran-c finding a new survival space in the future.

The development of Loran-C abroad calls our attention to the situation of BPL and China Sea Chains. The approximate coverage of China Sea Chains and BPL signal are shown in this paper. Then we can find Loran-C coverage of almost whole mainland and marginal seas of China. Clearly, we could and should do a lot of things on our resource. In this paper, we have described the potential applications of BPL system (because we, the authors of this paper, come from the CSAO, the BPL system will be mainly discussed, China Sea Chains will be mentioned sometimes). In fact, we have done some research work on these aspects.

1 Transmitting the BPL Time Code From the BPL Signal Channel.

Time code is important information. The format of BPL signal is the same as the general Loran-C signal, the same carrier frequency (100KHz), the same phase modulation, etc. The GRI of BPL is 60000 microseconds (60 ms), the TOC of BPL is every 3 seconds. Unfortunately, BPL users can only get the reference second pulse which is synchronized to UTC (CSAO), they don't know the corresponding time (year, month, day, hour, minute, second). At present, the BPL users have to determine the corresponding time information of a reference second pulse (TOC) by other reference sources. This is the disadvantage of BPL signal. A researcher in CSAO even presented that the blink pulse could be used to carry the time code information, but this thought has not been realized in our system.

On the concept of Eurofix, then we can use the PPM (Pulse Positioning Modulation) technique to transmit time code. Obviously, this work belongs to reliable data transmission using Loran-C, so the Loran-C datalink model can be used here. Channel modulation schemes, forward error correction, datalink integrity and decoding of the received messages are the same as the usual. The problem here is how to encode the time information. We have brought forward some schemes.

2 Network Timing and Synchronization

China holds the largest developing telecommunication network market in the world. Synchronization systems are the foundation of all kinds of networks, including telecommunication networks, computer networks, and power distribution networks, etc. Accurate time dissemination plays a critical role in these infrastructure systems. Obviously, GPS and GLONASS has become the primary reference source (PRS) for transferring precise time and time intervals in these systems or fields. We have observed that several larger telecommunication companies in China, such as

Huawei Technologies Co., Ltd., ZTE Corporation and Datang Telecom, have selected the GPS/GLONASS receivers to support their synchronization systems at present.

Then problems present here. It is well known that the GPS system is controlled by the US government. Many researchers have pointed out the sole-mean risks and given some ways to eliminate them. China doesn't currently own a satellite system which is similar to GPS (or GLONASS). We have to face the serious reality. We think the Loran-C systems in China can support the networks in technique, or be as a backup. In fact, the specifications and performance of BPL timing signal as shown above paragraph, indicate that BPL system can meet the basic requirement of networks in quality.

Lamentedly, there still exist some problems inside the BPL timing system, either in the transmitter or the receivers at present. The BPL transmitters are still in tube-type, not in solid state. We have to operate them only 8 hours a day. This shortage restricts the function of BPL to be as the national long-wave time service signal. Accordingly, the Loran-C receivers we have been using are dated.

Undoubtedly, BPL will still play an important role in the future networks in China, if the shortages can be overcome.

3 The Possibility of Establishing DGNSS Systems through Loran-C

We also give a whole coverage of China Sea chains and BPL in this paper (**See Figure 5**). If we can establish a Eurofix DGPS system by combining these resources, similarly, the advantages will be shown to us. In the eastern part of China, many DGPS systems have been built, including radiobeacons, FM data broadcast, VHF or UHF stations. These actions bring confusion and unwanted wastage that should be avoided if we could implement the Eurofix DGPS system early. The opportunity is still there, western part of China keeps a vast terrestrial area.

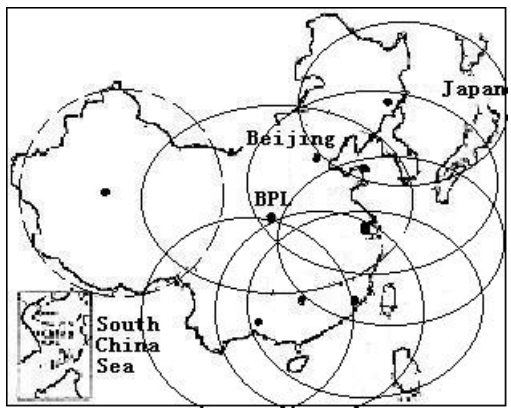

Figure 5 Approximate Coverage of Loran-C System in China

(**Note**: In figure 5,the broken line circle expresses a projected coverage.)

III Several Suggestions and Future Work in BPL Rebuild

1 BPL Transmitter Modernization

The antiquated Loran transmitter and control system currently limits Loran receiver performance in our BPL system. Two primary areas of concern are the Cs clocks and timing control electronics, they are used at each transmitter to synchronize and control Loran signals. SAO holds six Cs clocks, and we have established a monitoring and controlling system to maintain the stability and accuracy. Just as we have pointed, our transmitters are tube-state, but not solid-state, so we have to reduce the transmitting time so that the system can operate for a relatively long time. On the other hand, the performance of current system tube-state limits its use.

2 Contemporary Loran Receivers and Antenna

For the purpose of the vitality of BPL signal, we need contemporary Loran receivers and antennas. Because of the economy and good performance of GPS, many users lost their interests in insisting on the use of old Loran-C receivers. In fact, to a common operator, the performance and convenience of an instrument are important. Their selection and suggestion will affect the managers to make a decision. Because of the safety reason, we think, at least, we should use BPL signal as a backup. So, developing advanced receivers is the most important thing we should deal with. We have noticed that some companies have designed and manufactured the advanced products. We may give an example here to indicate the possible benefits we will get, if the contemporary Loran-C receiver is used. In general, the current Loran receiver performance shows that SNR improvement can be over hard limited receivers exceeding 20dB, it also means an increase in range of approximately 300kM. On the basis of this information, we can make a conclusion that the BPL signal would be received in Urumqi, if the advanced Loran receivers are used **(See Figure 1)**. In the same time, we think it is important that several types of receivers based on Loran-C should be used, such as Simple Loran-c receiver, DGPS data receiver, Integrated GPS/Loran-C receiver and Eurofix special receiver.

We think the H-field is another hope in the future. The obvious advantage of reduced size will enlarge the use area, especially in the telecommunication which means a large market. In addition, it is now possible to integrate an H-field Loran antenna with a GPS antenna into a single device.

3 The Function Integrity of BPL and China Sea Chains

Navigation is the primary task and purpose of China Sea Chains at present. Because of this reason, the reference second pulses in the navigation signals were designed to synchronize to the GRI, but not the UTC (CSAO). So these chains have not the function of time service. On the other hand, the BPL system was designed as a Loran-C master station, and has been working without any secondary stations. It means the BPL system has not the function of navigation. Then there will be a lot of works in upgrading and extending the Loran-C systems in China.

4 To Provide the Whole Coverage of China, a New Station Should Be Set up

Basically, the existing Loran-C systems only can provide the coverage of middle and eastern part of mainland and marginal seas of China. The most area in western part can't be covered **(See Figure 5).** A suggestion to set up a Loran-C station in an appropriate position, which can provide the coverage of western part, has ever been put forward by researchers in China.

Reference

[1] IALA List of Radionavigation Services Loran-C/Chayka
International Association of Lighthouse Authorities, July 1996

[2] G. Linn Roth. The Case for Loran. Journal of Air Traffic Control, July - September 1999

Biography

WU Haitao, received the BS and the MS degrees in radio engineering from Xi'an Jiaotong University, Xi'an, China .PR, in 1988 and in 1990, respectively. He held the position of associate professor at Three Gorges University from 1997. Since 1999 he has been working towards the Ph.D. degree in communication and electronic engineering at Shaanxi Astronomical Observatory, The Chinese Academy of Sciences. His current work concerns the applications of low frequency Loran-C system.

Wu Haitao