
Music Expression Using Space Technology and Space Physics

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To cite this article:

Hayaki Tsuji, Taichi Yamazaki. Music Expression Using Space Technology and Space Physics. *American Journal of Aerospace Engineering*. Vol. 8, No. 1, 2021, pp. 9-13. doi: 10.11648/j.ajae.20210801.12

Received: May 23, 2021; **Accepted:** June 11, 2021; **Published:** June 26, 2021

Abstract: As humans advance into space, the artistic expression of space is unknown. Culture and art play an important role for mankind, and artistic expression using space technology and activity expression related to space physics deserve the evolution of the art field. This paper explores new ideas in the space age, focusing on the Global Space Orchestra, a music art using satellites and space physics. The Global Space Orchestra is designed to play music created for world peace on a global scale. Musicians of musical instruments are stationed in each country, and the musical performance data is linked to an artificial satellite for simultaneous performance. The composers go into space to lead them and organize their performances as conductors. The master pitch is calculated from the earth's natural frequency, Schumann resonance, and is executed in multiples synchronized with the earth's frequency. The first observation of Schumann resonance is 7.83 Hz, the second observation is 14.1 Hz, and the third observation is 20.3 Hz. This is very similar to the human brain wave, wave is 8 to 14 Hz, wave is 14 to 20 Hz, and 2 wave is 20 to 32.5 Hz. From a scientific point of view, it is natural to play music according to the condition of the earth and the natural condition of human beings. In 1925, the U.S. government set the standard frequency at 440 Hz, and in 1939, after an international conference in London, the ISO officially changed the international standard to 440 Hz in 1953. However, in the days of Mozart and others, many resonance frequencies such as 421 Hz and other frequencies that fit into the multiple of Schumann resonance were used, and the same can be said for Karajan's conduct an orchestra. I can't sum up all the reasons why their music was so good, but it goes without saying that their judgment has a great impact. Since 2014, changes in the Schumann resonance phenomenon have been reported from the Russian space observation system. With the advance of humankind into space, we are conducting research on the evolution of music arts using astrophysics and space technology on a global basis, paying attention to these changes.

Keywords: Global Space Orchestra, Time Latency Adjustment, Schumann Resonance

1. Introduction

Until now, the musical expression has been bounded by many things, such as time, space, distance, and gravity. As humanity moves into space, however, this notion is breaking down, and with SpaceX's Starlink [1] and other low-orbit constellations of satellites encircling the earth, and all the information spreading everywhere, both performers and audiences will be freed from the constraints of the past. I am sure you will experience a new kind of

excitement. In this paper, I will focus on three main themes: "Low-orbit satellite constellation and music", "The concept of Global Space Orchestra", and "Harmony with Schumann Resonance", which is a unique frequency on Earth. (See Figure 1)

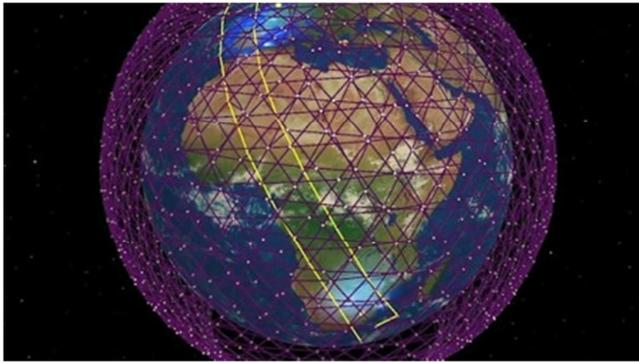


Figure 1. Diagram of SpaceX's Starlink [1].

2. Satellite Constellations and Musical Performances

Satellite communication technologies have been used in the past. International telephone calls, television BS broadcasts, and in-flight Internet services have been provided by geostationary satellites located at an altitude of around

36,000 km above the equator. However, due to the distance from the ground, communication speeds were slow and delays were significant. There have been previous attempts to use satellites for musical performances: on 7 February 1998, at the closing ceremony of the Nagano Olympics, a world chorus of five continents was synchronously projected on a screen in Nagano South Sports Park stadium under the direction of Seiji Ozawa. (See Figure 2) [2]

At this time, communication technology and systems used Time Latency Adjustment to synchronize the chorus of each country. In other words, although the project was successful, the Time Latency Adjustment was editing it, so it could not be formally performed at the same time. If we don't have to pay attention to the concept of this project - each continent's performance - and just focus on ourselves, the ensemble will work through the power of Time Latency Adjustment. However, since the 2000s, low orbital satellite constellations have become feasible within a few years due to the low cost or miniaturization of rockets and satellites, and it is highly likely that remote simultaneous performances at low latency will be possible without the use of Time Latency Adjustment.

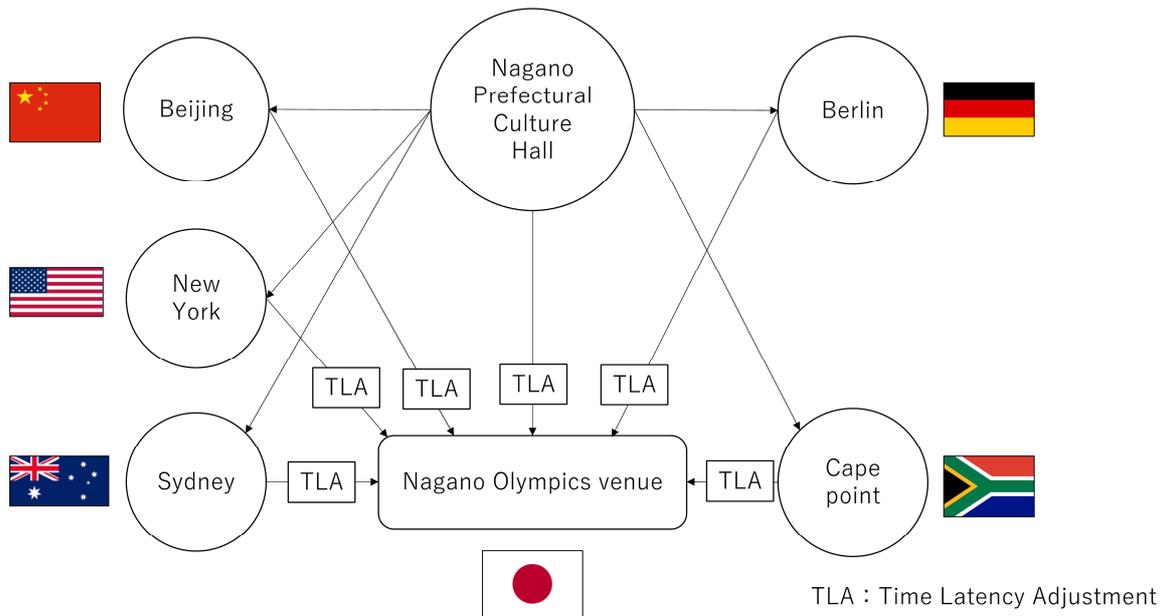


Figure 2. The World Grand Prix Choir System for the Nagano Olympics connecting the five continents.

2.1. Traditional Delay Rate

In 2020, due to the impact of COVID-19, many performers used video conferencing and other tools to perform in ensembles, and the author was no exception in the following experiments as well.

2.2. Experiments on the Latency Speed of Video Conferencing Tools

In the experimental environment, two PCs were connected to the same access point if the experiment was conducted wirelessly, or the PCs were connected to the same router with a LAN cable if the experiment was conducted wired, and the three leading video conferencing tools, Zoom, Hangout, and

Skype were used. [3]

Table 1. Latency and distance conversion of video conferencing tools.

		Zoom	Hangout	Skype
Delay time	Wired	140ms	100ms	117ms
	Wireless	161ms	133ms	157ms
Distance	Wired	47.6m	34m	39.8m
	Wireless	54.7m	45.22m	53.3m

A delay of about 100ms or more was observed using any application. This translates into a distance of more than 30 m, even in a wired environment with low delay, which makes it difficult to perform music with this much delay, and the reality is that most of the video recordings currently available to the public are edited afterward. (See Figure 3)

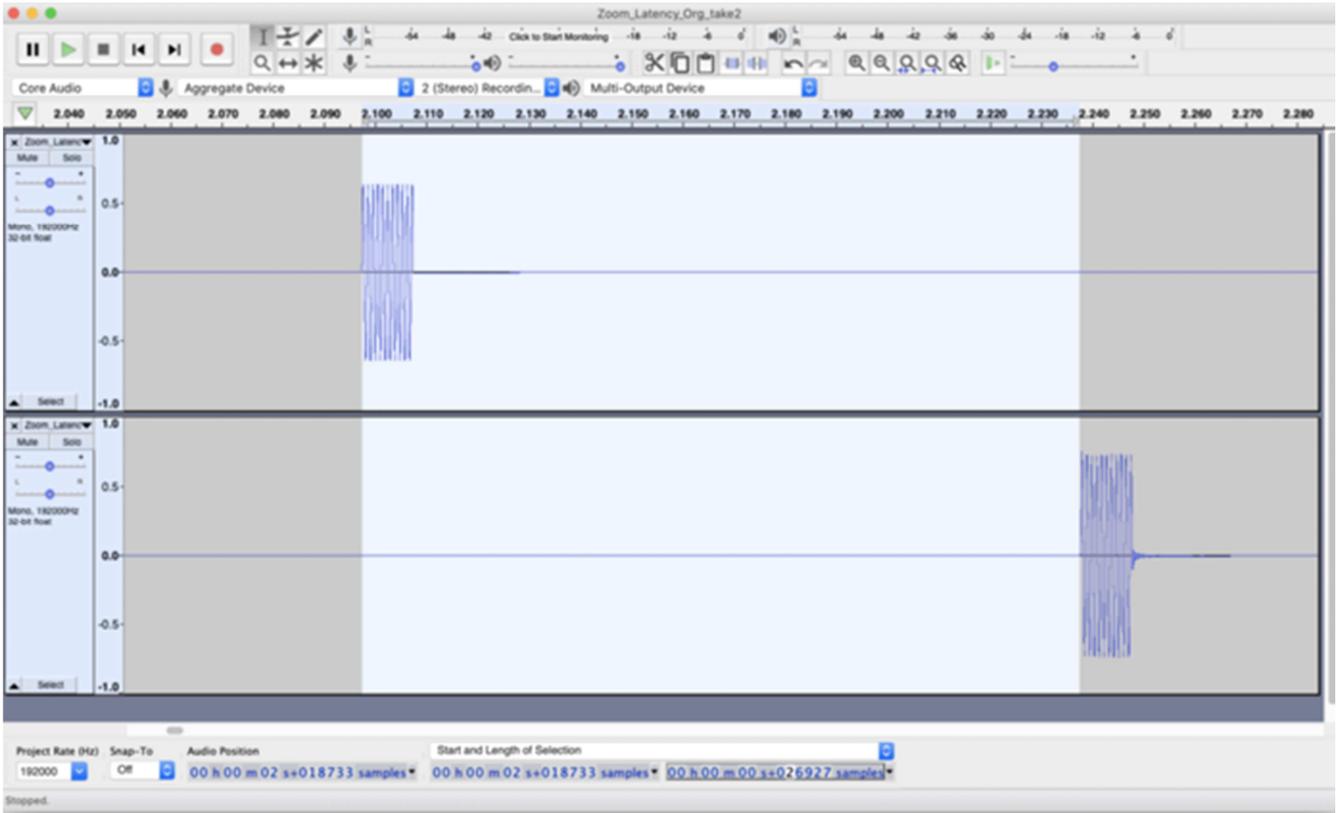


Figure 3. Latency of video conferencing tools. [4].

2.3. Future Delay Speed

However, low-latency remote simultaneous performance is possible by using fifth-generation communication technology services that are designed to work with the IoT on the ground. One of the experiments was conducted using an application developed by YAMAHA called "S Y N C R O O M".

Table 2. Latency and distance conversion of SYNCROOM.

	Wireless	Wired
Delay time	30-70ms	15-25ms
Distance	12,2-23,8m	5-8,5m

This application was found to be capable of simultaneous performance from up to five locations, with a latency of less than 15 to 25 ms, compared to 100 ms with conventional video conferencing tools. This is equivalent to the distance of 5 to 8.5 meters, which is equivalent to the distance of a performance in a concert hall. As a result of the experiments, it was verified that the delay time and the distance were reduced and that simultaneous remote performance was possible. The key to realizing this project, however, is to build a stable communication environment, because the communication speed is not always stable over the radio, even for dedicated applications. On the other hand, there were glimpses of a new form of music. Simultaneous remote performance with a delay of 20ms or less is possible, which means that there is no longer a need to use a studio for all performers to work together on arrangements. Recording

from remote locations, such as in a foreign country, is also possible, and the music industry is becoming more and more globalized.

In the case of a concert, the placement of each instrument is usually determined by the characteristics of the individual instruments, but because this system is good enough without having to calculate them, there will be no need for more specialized techniques to transmit music to the world, and the difference between professionals and amateurs will disappear more and more. Above all, the use of a satellite constellation shows that the communication environment can replace the air. When delivering music and emotional experiences to our eardrums, we will be able to freely control the speed, distance, and direction of sound transmission, which has not been possible until now, and we will be able to experience an emotional experience of another dimension.

3. Global Space Orchestra

In the near future, these technologies will enable music to leave the earth and go into space with mankind. The Global Space Orchestra will make full use of these low-orbit satellite constellations to conduct simultaneous remote, global-scale performances. Composers and conductors will be sent into space to conduct Earth's performances, and the Global Space Orchestra will serve as a form of musical entertainment that connects space and Earth and will open up a new field of space music. With world peace as its concept, this grand project, which uses music to bring harmony to humanity and

perform simultaneously on a planetary scale, will eventually connect the entire solar system with a satellite constellation that will allow simultaneous remote performances on a larger scale, just as it connects the Earth to the Moon or the Earth to the Moon and Mars.

3.1. Space Perspective

The first spacecraft to be developed by Space Perspective will fly in the stratosphere 30 km above the Earth for about two hours in a six-hour flight plan. Since the balloon-type spacecraft can maintain its gravity, this should be the first step, followed by the International Space Station, the space hotel, the lunar orbit platform gateway, the moon, and Mars.

3.2. Delay Time When Connected to the Moon or Mars

If we were to make a communication connection between the Moon and Earth, and between Mars and Earth, using the speed of light as the limit, with current technology, there would be a delay time of 1.26 seconds each way on the Moon, and up to 20 minutes each way on Mars. [5][6]

This is a big challenge in the conventional concept of music form, but in the first place, the performance by an orchestra with only air vibration without any electrical system, the instruments are arranged after considering the influence of their special characteristics, volume and range on the transmission speed, and also the auditory balance between the performers and the communication with the conductor, too. In addition, the auditory balance between the performers and the communication with the conductor were also taken into consideration before the current arrangement was made. [7]

In other words, when human beings leave the earth and travel and migrate between planets daily, composers of the future will use the same concept to construct music by calculating not only the characteristics of each instrument, but also the delay speed and solar system cycle of each planet. This is a return to the laws of nature in today's music, and when combined with today's digital and highly virtual music production style, it will evolve the form of music. [8]

In addition, since the time and date of performance will be limited, musical expression using the universe will undoubtedly turn into a rarer form of artistic expression.

4. Schumann Resonance and Master Pitch

We should also reconsider the master tuning that is currently employed in the performance of music on such a global and planetary scale. All matter in the world has a unique frequency, and the earth is no exception. This has already been confirmed by a German scientist's discovery of the "Schumann resonance". Briefly, the Schumann Resonance is named after the average period of traffic between the Earth's surface and the ionosphere, where electrons are generated by the rotation of the Earth's magnetic field at the North and South poles.

The primary observation was 7.83 Hertz, the second observation was 14.1 Hertz, and the tertiary observation was 20.3 Hertz. (See Figure 4)

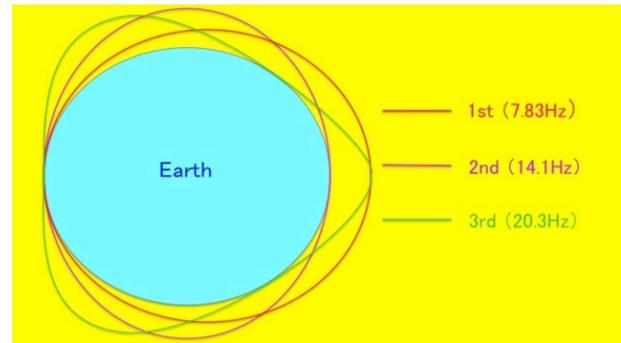


Figure 4. Schumann resonance observation average.

Needless to say, harmony is important in music. Harmony is the harmony of the individual frequencies, and our senses are able to perceive it with all five senses. But what if we could harmonize the frequencies of this planet when music is played on a planetary scale?

The current master pitch defined by the International Organization for Standardization is 440 Hz. In the history of Western music, 435Hz was the prevailing frequency until 1955, and there are many theories as to why the current 440Hz was chosen, but it is certainly not from a natural scientific point of view. It is easy to calculate the master pitch based on the Schumann resonance, which can be calculated by the following formula

$$f_{r}^{12} = 2f \quad (1)$$

The numbers you get with this formula include 421Hz, 432Hz, 445Hz. These numbers are interesting due to the fact that great musicians like Mozart and Karajan had already adopted them, and that's why they preferred those pitches sensibly or musically. However, we would like to discuss this issue at another time.

5. Results

In this verification, it must be said that simultaneous remote performance is difficult to achieve without a wired environment. But in the past, even that wasn't possible, even with an environment. In 2020, Starlink service will be launched in the United States, and 5G will be gradually launched in many countries. With this in mind, the idea of a Global Space Orchestra using space technology is a very exciting one. The Global Space Orchestra is a testament to the market's ability to anticipate trends in this new music format.

The Global Space Orchestra can be used as a platform for scientific experimentation. Including the Schumann resonance and other scientific experiments in this project will increase the significance of the project and broaden the fields in which it can contribute to humanity.

6. Discussion

The communication environment still needs to be discussed and verified in terms of speed and stability. One of the most important aspects of a performance is the sense of presence. This is the quality of the performance that is enhanced by the chemical reaction that is created between the performer and the audience when the performer feels a sense of presence, and this is the real joy of art and a major element that must not be lacking. [13]

From the experimental methods used in this paper and the literature cited, it can be said that these points are largely missing. However, the author believes that these issues can be overcome by adding VR, AR, and MR in addition to space technology and 5G communication environment, while similar studies are almost non-existent. [14]

In selecting a master pitch with reference to the Schumann resonance, it is necessary to examine the communication speed in each country in considerable detail, including weather conditions, land environment, voltage, and connection time, and this must be continued for the time being as the technology spreads. There are data reports that the average value has been increasing in recent years, and we will continue this research while simultaneously determining the causal correlation with recent global warming and abnormal weather. [15]

7. Conclusions

Space has always been an unknown and longed for by mankind. But now that space travel will soon start, space hotels will be built, and the International Space Station will be released to civilian use, space will be a part of our lives. This means that everything we use on Earth will be needed in space. It is the evolution of mankind to deal with zero-gravity and other technologies in space.

The Global Space Orchestra will add a new page to the history of music by using space to open up a new future.

We can expect to see more of this research in the future.

Acknowledgements

I would like to thank Yoshiaki Maeba and Mika for their help in developing the experiment.

I would like to take this opportunity to thank ASTRAX Inc for their always helpful advice on the space industry.

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