Information Session on the WRC-15 agenda item 1.14 – Coordinated Universal Time (UTC)

Tuesday 10th February 2015

Video Transcript

^M00:00:00 [Neil Meaney:] Welcome to this very special and unique event as part of the Asia-Pacific Telecommunity's conference preparatory work for the 2015 World Radiocommunication Conference. As you know, tonight's information session is a unique event which we've not done before in our preparatory group for the APT, heading towards a World Radiocommunication Conference.

 ^M00:00:30 But there's a special reason for this one. We're challenged by a specific agenda item, which we've all come to know as Agenda Item 1.14. it has various running titles, 'The Future of Coordinated Universal Time', 'The Issue of the Occasional Insertion of the Leap Second' and other variations of that. It's an agenda item that has a long history. It's also an issue which goes well beyond the issues and concerns of radio communications, which is what the WRC generally deals with.

^M00:01:05 It's got a lot of history, and we'll hear about the history tonight. But importantly we're looking at aspects that are of relevance and meaning to the Asia-Pacific region itself.

Before we start, I would like to make a number of acknowledgements which has led us to where we are tonight. A number of organisations and individuals have been very generous and assisted us to get to this point in time. And in no particular order I would like to thank the Australian Communications and Media Authority, the Australian Government's Department of Communications, the Asia-Pacific Telecommunity, the International Telecommunications Radiocommunications Bureau, and the administrations in particular of Japan, Korea, China and Australia who have made available for us tonight some of the key experts on the issue of coordinated universal time who will be speaking to us tonight.

^M00:02:09 My name's Neil Meaney, I'm from the Australian Communications and Media Authority, I'll be your host for tonight. The format is essentially we'll hear from each of the key administrations about their experiences in the application of the leap second, their experiences of managing coordinated universal time, and essentially we're looking to find out a lot more information than we perhaps had by the time we came to this session tonight.

^M00:02:39 Importantly what we'll also be doing is having a discussion session at the end of the presentations. This is the opportunity to ask questions of each of the presenters about matters that concern you, and perhaps matters which have not even been touched on tonight, that's a distinct possibility as well. So if you do have questions, we're going to welcome those later in the session.

^M00:03:04 First of all tonight I'd like to welcome to the podium the Chairman of the APG for some opening remarks. But before I invite Dr Jamieson here, I'd like to just let you know about Dr Jamieson's personal attachment to this agenda item. As I said, there's some history behind this, we'll hear about the history tonight. But if we go back to 2012, the early part of 2012, one of the important aspects of UTC, Recommendation ITU-R TF.460 was to be revised and considered by the ITU's Radiocommunication Assembly. This was a challenging time. This was the most profile we've ever had for the issue of UTC and dealing with the leap second insertion.

^M00:03:54 Unfortunately that meeting of the assembly could not come to any conclusions on revising that important recommendation. ^M00:04:03However, it did make one decision, which has brought us to where we are tonight, and that recommendation was that the World Radiocommunication Conference in 2015 considers the future of Universal Coordinated Time. And the person who adjudicated on that decision was the Chairman of the Radiocommunication Assembly at that time, Dr Jamieson. So he's very well attached to it. So with those comments I would like to welcome to the podium the Chairman of the Asia-Pacific Telecommunity, Dr Alan Jamieson. Thank you Alan. ^E00:04:38

^B00:04:53 [Alan Jamieson:] Good evening ladies and gentlemen, and thank you Neil for those comments. Well, I think I should thank you, but I'm not 100 per cent sure, because it sounded as though you were setting me up for something, but never mind. You are right in that the reason we are here tonight in many ways stems from the action that was taken at the Radiocommunication Assembly in 2012. ^M00:05:24

We will hear tonight that the issues related to Coordinated Universal Time, or UTC, and more particularly the issue of the insertion of the leap second, have been debated within the ITU for much longer than the ITU cares to admit, I suspect. It certainly has been a long time. There is a suspicion that some of us have made a career out of this, but I'm not sure if that's really true. ^M00:05:59 And as Neil has said, my personal exposure to the UTC debate was in the lead up to the Radiocommunications Assembly in 2012.

^M00:06:12 The leap second issue, as it became known, was seen as being a very controversial and difficult issue for the Assembly to deal with at that time, and it was expected that it would have to go to a vote. Now, having a vote at a Radiocommunications Assembly is not something that the management team of an Assembly actually looks forward to. It's time consuming, it's difficult, and it has the potential to be divisive. ^M00:06:48

During the course of the Radiocommunications Assembly, it became very clear that only a minority of countries had firm views one way or another on the leap second issue, and that the majority of countries, in fact the vast majority of countries, and I really mean something like 160 countries out of the 190 countries or more of the ITU, were not informed about the issue, and were not really in a position to make a decision. That was hardly the basis, a good basis, for holding a vote.

So as the Chairman of the Assembly I had to look for another solution. And it certainly occurred to me that the very best thing we could do would be not to make a decision at that time. ^M00:07:56 It was possible, given the schedule of meetings and events, that we would not be delaying the application of a change to the recommendation, should we decide to delay it for a period. And so consequently the Radiocommunications Assembly decided that it was too important to rush into a decision in 2012, and that more time, and in particular more study, was required. It was clearly identified that the issues were not merely technical, were not merely engineering, were not merely regulatory, but were scientific. Yes, there were commercial issues, but there are also social issues and cultural issues, which needed to be acknowledged and taken into account.

So the Radiocommunications Assembly referred the matter to the WRC in 2012 with a ^M00:09:08 strong recommendation that it be further debated and a decision taken at WRC-15. With the further study that would take place in the ITU-R study group, the responsible group, Study Group 7, there would be an opportunity for administrations and countries to be much better informed for a decision in 2015. ^M00:09:39

We are now at the point where we are seeing the conclusion of that further study, with a draft CPM report available. And this information is the opportunity for our region, the Asia-Pacific region, to become fully briefed on the status of those studies, and on the implications for our region. ^M00:10:07 I believe the organisers of this event have assembled a very impressive list of experts to provide this briefing from the ITU, from Study Group 7, and from the four administrations that are represented, Japan, Korea, China and Australia. I'm confident that we will learn a great deal this evening, both in terms of the global importance of UTC, but also its relevance to the Asia-Pacific region, when we hear the insights that our four Asia-Pacific members will bring to this evening's session.

Will the subject of the UTC as a WRC conference issue capture the attention of the world's media as it did in 2012? I don't know. Time will tell. But I can tell you it was a strange experience and a somewhat daunting experience to see television cameras in the middle of a Radiocommunications Assembly plenary. But like you, ladies and gentlemen, I look forward to what we will learn this evening, and I am confident that we will be in a much better position to understand the issues, and therefore to make a decision on this very important issue. Thank you for your attention. [ applause ] ^E00:11:58

^B00:12:01 [Neil Meaney:] Thank you very much Alan. We do have some brochures available if you've not seen them at this point in time, but these brochures are very useful. They've got two aspects, one is an idea of how our program is running tonight, and the other aspect is that there are extensive biographies in here, which will give you the background to the careers of some of our very distinguished presenters at tonight's information session. Those brochures are widely available, so you shouldn't be able to not find one within the room at great difficulty.

So to the first of our presentations tonight, and this is looking at the history, well certainly part of the history, we haven't got all night to look at it all, it's so extensive, but we'll certainly examine some of the history of this agenda item and how it came to be an important aspect of the forthcoming World Radiocommunication Conference. And to brief us on that background in history I'd like to welcome to the podium the Deputy Director of the ITU's Radiocommunication Bureau, Mr Mario Maniewicz. ^E00:13:10

^B00:13:33 [ Slide ] ^E00:13:36

^B00:13:42 [Mario Maniewicz:] Well, thank you very much and good evening everybody. So I will make just a brief presentation on the history of the Coordinated Universal Time, why we have an issue with it, and what is the way forward. ^M00:14:01 And then we will have Mr Meens from the Study Group 7 in ITU-R that will go more into the technical details of the issue.

So to start with, some definitions and standards. So the Coordinated Universal Time that is known by its acronym UTC is the legal basis for timekeeping for most countries in the world, and for those that it doesn't have a legal basis, it's a de facto time scale in most of the cases. ^M00:14:31 And UTC has been defined by ITU's Radiocommunication Sector through Recommendation ITU-R TF.460-6 entitled 'Standard Frequency and Time Signal Emissions', which recommends the application of leap seconds to maintain UTC closed to Universal Time 1, which is a time proportional to the rotational angle of the Earth on its axis. This leap second, which is the source of all the discussions and controversy, came into use in 1972. ^M00:15:09

[ Slide ]

^M00:15:11 So a number of years later, administrations expressed concerns about the implementation of the leap second, and a study group question about the future of the UTC time scale was adopted. This was in 2000, and it gave birth to Question ITU-R 236 slash 7, entitled 'The Future of the UTC Time Scale'. It was generated by Study Group 7, which deals with the science services, and more particularly with Working Party 7A that deals with Standard Frequency and Time Signal Services.

The question, the Study Group question, was structured to address the future definition and use of UTC in the ITU-R recommendations. ^M00:15:57 And it was especially requested that it would take into consideration that any major technical change to UTC could have a potentially significant impact on communication networks, navigation systems, time and frequency distribution systems, and indeed all aspects of civil and military time keeping. ^M00:16:16

[ Slide ]

So the main issues to be addressed were what are the requirements for globally accepted time scales for use both in navigation and telecommunication systems, and for civil time keeping, and to determine whether the current leap second procedure satisfies user needs or should an alternative procedure be developed. ^M00:16:38

[ Slide ]

So since 2003 proposals have been made by various administrations to revise Recommendation TF460-6 in order to achieve a continuous time scale. The various discussions and studies that had been taking place that were referred to in the opening notes established that UTC as a continuous atomic time scale should be a matter submitted to the 2012 World Radiocommunication Conference for decision. ^M00:17:17

[ Slide ]

The Conference noted that this sporadic insertion of leap seconds may upset systems and applications that depend on accurate timing. Some organisations involved with space activities, global navigation satellite systems, metrology, telecommunications, network synchronisation and electric power distribution requested a continuous time scale. ^M00:17:42

[ Slide ]

On the other hand, for other specialised systems and for local time of day, however, a time scale reckoned with respect to the rotation of the Earth is needed. ^M00:17:55 Also a change in the reference time scale may have operational and hence economic consequences. ^M00:18:03

[ Slide ]

So this dilemma was the core of the discussions during WRC-12, and there was no decision taken, as we well know. Many participants felt that more information was needed before a decision could be reached, and then the Conference adopted Resolution 653 which reflected the agreement to bring the question to the attention of the relevant outside organisations to request ITU-R Working Party 7A to carry out further studies, and to include this topic as an agenda item for WRC-15. ^M00:18:38

[ Slide ]

To study the feasibility of the introduction a continuous time scale in order to avoid the occasional insertion of leap seconds was the request made to the ITU-R study group, as well as to study the effects of possible implementation of a continuous reference time scale, including technical and operational factors. ^M00:19:01

[ Slide ]

So under Agenda Item 1.14, the WRC-15 will consider the feasibility of achieving a continuous reference time scale. And for that, the options that appear to mind are to remove the leap second procedure in the definition of UTC, either retaining or not the name. To keep UTC as it is today and disseminate a second continuous time scale on an equal basis. Or to keep UTC as it is today, but enable the use of another continuous time scale. ^M00:19:40

So the proposed methods to deal with this issue that you will see throughout the presentations tonight are the Method A, which introduces a continuous reference time scale, and stops the insertion of the leap second, and there are two sub-methods that change or do not change the name, UTC. ^M00:20:02 The Method B, which retains UTC as a currently defined time scale, but introduces a continuous reference atomic time scale to be broadcasted on an equal basis, or we will be broadcasting both. And Method C, which is no change to UTC, either Method C1 to remain as it is, or Method C2 to include in the recommendation for 166 to allow the use of other continuous time scales in addition. And of course any method that would be chosen would suppress Resolution 653 from WRC-12. ^M00:20:44

[ Slide ]

So this is, in a nutshell, the history, the definitions, why we are here today, and what is the proposed methods to deal with this issue. Thank you very much. [ applause ] ^E00:20:59 ^B00:21:07

[Neil Meaney:] Thank you Mr Maniewicz. Now we move to what's behind these studies. We look at some of the implications that might occur as a result of the methods that we've heard about, and how this is going to affect the future, and also what is really behind the studies that have been going on for more than 10 years. It's been a long time, there's been a lot of work, and now we're reaching the culmination of that work at the next World Radiocommunication Conference.

And to present on this subject I'm very pleased to welcome to the information session tonight Mr Vincent Meens, who's the Head of the Frequency Bureau at the CNES French Space Agency, and has also been for quite some years now the Chairman of the relevant study group in the ITU, Study Group 7 that's been dealing with this issue of Coordinated Universal Time. Mr Meens, welcome. [ pause ] ^E00:22:01

^B00:22:21

[Vincent Meens:] Okay, good evening ladies and gentlemen. Let me introduce a little bit of what happened in the ITU, considering Agenda Item 1.14. So as you know, 1.14 is considering the feasibility of achieving a continuous reference time scale, and we have to ask ourself the question of what is time and why do we need a continuous time scale.

[ Slide ]

So basically, time was defined many years ago. I think that if we go back to Stone Age time, which is about 4,600 years ago, then a day was defined as the duration between two solar passes at the meridian. Well, that sounds easy, if we say that, but it's not so easy actually. And the reason for that is that the Earth orbit is not a circle, it's an ellipse.

[ Slide ]

So when you consider the rotation of the Earth, then the Earth rotates in 23 hours and 56 seconds. But it rotates also around the sun, and if you look at the drawings behind me, you'll see that the Earth needs a little bit more to go along its orbit to have the sun passing the meridian, and then you add an extra four minutes, and you've got the 24 hours. So that's when you are on the middle of the ellipse. But things are not, are going wrong if you are at the perihelion, so the shortest location of the Earth compared to the sun.

^M00:24:02 And then because the Earth goes a little bit faster, so it has to go a little bit further around its orbit for the sun to pass along the meridian. And then the duration of the day is not 24 hours, it's 24 hours and one minute. When you've got the longest distance from the sun, then this is the opposite, and the duration of the day is only 23 hours and 59 minutes. So we have a problem. ^M00:24:34

[ Slide ]

Well, the problem actually was solved by defining a mean duration of the day, and the mean duration is about 24 hours. And you can see on this curve here then because of this variation around the orbit of the Earth, you've got some deviation from the mean solar day to the real solar day by something like by 15 minutes sometimes. So when you look at the sun, you say it's midday, no, it's not midday, it's midday plus 15 minutes, or midday minus 15 minutes. So you see already you have something which is inconsistent with the 24 hours. But if you define a clock, it's very difficult to define a clock with a second that will evolve around the year. So normally you try to have a second, that is something which is constant. ^M00:25:27

[ Slide ]

And that's, from this astronomical observation it was possible to define the second, which was the 86,400th part of the day, of the mean solar day.

Well, that was the situation for about 4,600 years, or maybe more, I don't know. But things changed in the middle of the 20th century. ^M00:25:55 Then in 1967 it was decided that we should change the definition of the second, and then because the atomic clocks were becoming, to be robust enough to define the time, it's very precise, we decided to define the time as the duration of a radiation period of the Caesium 133 atom. And at this time, the clock became very, very precise. And that's what we call the SI second. SI means systeme internationale, or international system in English. And those, when the second was defined, it was based on the, I would say the ephemeris second or the astronomical second of 1952. ^M00:26:47 And it was determined by the atomic clocks.

Now, we have a situation of what happened before 1967 and what happened after 1967. So before 1967, the reference got wealthier, and so people had to look at their watch and adjust their watch compared to the observation of the time through astronomical observation. So that was a situation before 1967. And if like me you happen to have a mechanical watch, you have to do that every morning, because it's not precise enough.

Then we have the situation after 1967, and then the clocks became very, very precise. And the Earth was not precise enough. So what we had to do is to try to slow down the Earth rotation, or to speed up the Earth rotation. Well, obviously, that's something which was not easy to do. And I think that nobody was actually able to do that. So we need to find another way to adjust the Earth. ^M00:27:59 And the other way was actually to define UTC, and UTC, what is important in the UTC is the C for the coordination. So we try to coordinate the difference between the atomic time and the ephemeris time by insertion or deletion of leap second. And if we do that, we have UTC, which is more or less close to the ephemeris time by a time which is no more than 0.9 second. Well, this is the definition of the UTC.

But we may ask why do we have this difference? Well, first, we have the fact that the Earth's rotation, the Earth is slowing down because of its interaction with the moon. We have tides that affects the rotation of the Earth, and for instance, 400 million years ago, so that's more than Stone Age, the duration of the year was about 400 days. It's not because the orbit of the Earth was different, it's just because the day was about 22 hours long, and not 24 hours, because since 400 million years the Earth has been slowing down.

But actually we know how the Earth is slowing down, it's not a problem. What is a problem is the irregularities in this value, and because in particular of mantle convection, the redistribution of mass. For instance if you take into account global warming, we have a redistribution of mass, and you can have the ice cap which is melting and the water is coming in other parts of the Earth. So that will affect the rotation of the Earth. If we have an earthquake or a volcanic eruptions and so on, that will also affect the rotation of the Earth.

^M00:29:56 And the problem also that we have, when we choose the ephemeris second of 1952, maybe it was not exactly representative of the real mean second at this time. And actually this is what you are seeing on this curve. You see that very rapidly in the '70s when the leap second was introduced, the difference between the mean solar day and the day measured with atomic clock was about three milliseconds per day. So if you multiply three milliseconds per day by 365, the number of days in a year, so basically you have one second. So you had to add one second every year to adjust UTC with the rotation of the Earth.

And you see that the curve is not going up, sometimes it's going down. And in the year 2000 we're really going down, almost to where it was when the SI second was defined, which is the reason why originally you had one second per year, and then in the year 2000 you had a time when you had seven years without leap second. The last occurrence was 2012, and we will have a new leap second this year in June. So basically now we have a leap second I would say every three years, and from the prediction apparently the next will be, the next leap second after 2015 will be probably in three years as well. So you can see from this curve that this, the evolution of time on Earth is very irregular. So you can't really predict. You can predict some years in advance, but you can't predict for 20, 30 years when you will have a leap second insertion.

^M00:31:56 And by the way you could have also a deletion of the leap second, because you see that the curve here is in the positive area of the graph, but it can be in the negative area as well, and in that case you would need to delete a second, something which has never been done. So I don't know how that will be handled, but next time we have that we may have some surprise. But I don't know when that will happen, if that happens.

So when we looked at these various aspects, we looked first at the technical aspects of this agenda item, and as it was already expressed, today we are living really in the digital world, so time is very important for all the systems we are using. And because of that, all the systems then need very precise time synchronisation. And the problem is that when we have a leap second, since we don't know when we will have a leap second, so the insertion needs to be done manually. And then there is of course a risk of mistake, a risk of problem. And the last problem that occurred was in June 2012, and I'm sure you all remember in this region of the world of the various problem that you had. We were quite lucky in Europe, because everybody was sleeping when that happened. But unfortunately in the Asia-Pacific region that's right in the middle of the day, so that's a problem that we didn't have in Europe.

The other thing is that we looked at a system that actually required UTC as a very good approximation of UT1, and there are some systems like astronomical systems that do require UTC as it stands today, or they required a very precise knowledge of UT1.

[ Slide ]

^M00:34:02 So basically it's important that we need to consider that this system will probably need, if for instance we decide to have a UTC without a leap second, then the system will need to be updated. So it's not 100 per cent advantage on one side, and not on the other side. So there are pros and cons for the technical system that are using UTC.

The other problem that we saw was that today the difference between UTC and UT1 is never more than 0.9 second, and actually the IRS and the BIPM, they decide to insert a leap second when that difference will be about 0.6 second. And when it will go above 0.6 second they decide to insert a leap second. But obviously if you stop inserting a leap second, you will have a difference which will be much more than 0.9 second. So far since 1972 the divergence has been about 25 seconds. And we can expect if we decided to stop the insertion of the leap second, that the IS5U would be in the order of 10 minutes in 300 years. It's difficult to predict, but considering the slowing down of the Earth, 10 minutes is an approximation of what could happen in 300 years. So it's not that important, if you consider 10 minutes compared to the 15 minutes that we have on the time equation, or compared to the time zone, but this is something that we have to consider.

^M00:36:00 The other problem is also that some systems actually, since all the digital systems would prefer to have a continuous time scale, some used actually some existing continuous system time that we call, that are broadcasted by the GENESIS system, for instance, such as the GPS time or the Mbayou? time. These times are continuous. But they are not time scale, they are system time, and if there is for instance maintenance of one of the GNNS system, there could be serious consequences on those systems that are using this system time. So the aim here is also to have a real continuous time scale, and not using system time.

[ Slide ]

And one of the problems that was mentioned during the studies was how we handle the leap second on our digital system. And actually it's very simple. You just take the last second, and you reproduce the last second. So basically the last minute of the month will have two identical seconds. Well, that can be a problem today, especially in financial trade. Like just an example here, we have the time when we have a leap second insertion. So we have the normal last second of the minute, which is 59, and then we go to the next second, which is the leap second. So imagine that during this leap second there is an order which says "I sell". ^M00:37:56 But somebody is saying "Well, no, I do not sell anymore", on the second right after. Well, since the two last seconds are absolutely identical, one people will see is that. So "I do not sell" and then "I sell", which will be exactly the opposite of what is meant. So this is something that happened in the last insertion of the leap second.

And the last item I'd like to talk about is one of the ideas that was mentioned during the process in Study Group 7, was to broadcast two time scales at the same time, the current UTC and a continuous time scale. The problem is that the operational considerations were not really studied, because this is an idea that came quite late in the process. And we have the problem of being sure that we can differentiate between the two time scales, and this is something that still needs to be assessed. So that's one of the methods, but there is still some uncertainty about the possibility of this method.

And finally how to satisfy the agenda item, so that was already mentioned. We have the first method where we just suppress the insertion of the leap second, and either will retain the name UTC or we change the name. The Method B one we have two time scales, one which would be the current UTC, and the other one a continuous time scale with that leap second. And Method C, where actually we have no change to UTC, but we have the possibility to recover through further information that will be transported by UTC. With UTC we could be able to recover to continuous time scale like the international atomic time, or another time scale with a constant of offset with the [ inaudible ]. ^M00:40:04 So that the three methods that are proposed so far in this context for the next conference. And I thank you for your attention. [ applause ] ^E00:40:16

 ^B00:40:29 [Neil Meaney:] Thank you Vincent. Some of us with perhaps misplaced responsibility are looking forward with curiosity to see exactly what does happen on the 30th of June this year when the next leap second is inserted. But I guess that's anybody's guess. We'll see what the result will be. I would also like to take this opportunity to sincerely thank the efforts of the ITU's radiocommunication sector for making Mr Maniewicz and Mr Meens available to us tonight, we greatly appreciate that. And I'd also like to add that it's an incentive for us to hold this information session, was an activity held by the ITU and the International Bureau of Weights and Measurements in 2013, when the ITU BIPM session on UTC was held. We looked at this session and thought "This is so important, this is so useful, we'll find out a lot more about it". But unfortunately as we so well know, it was held in Geneva, and many people from this region just could not attend. But it was the catalyst for us to say "Well, okay, maybe it's time that we did something like this in the Asia-Pacific region". ^E00:41:41

 ^B00:41:50 [Bruce Warrington:] Thank you Neil. And thank you everybody for the opportunity to share some of the experience we've had in Australia. ^M00:41:56 And as Neil says, to hopefully make some of the abstract arguments real, make some of the consequences a bit more obvious for the choice that we're all faced with.

Just by way of introduction, the National Measurement Institute is Australia's standards agency, it keeps the reference clocks for Australia, it's part of our Department of Industry and Science. And for us, adding the leap second in the reference clocks is very simple. It's a case of simply programming the atomic clock itself, and the software that's in the clock makes the change. All the difficulty comes when that time flows to everyone who uses it. And there's a very large number of people across the country and around the world who use that time. And that's the tricky part.

Okay, so we've seen the methods that are proposed, and we have to make a choice, we have to make an informed choice about what will work best for the users of time. And in making that choice we have to consider the advantages, the benefits, but also the efforts, the work required to implement and maintain, and also the risks, the dangers of each of these methods.

[ Slide ]

And it's really important to be aware that there are different benefits, effort and risk for every option, even the status quo. Even doing nothing, keeping the system as it is now involves some benefits, but also some effort, and some risk. And one of the great advantages of having an information session like this is to see some of those as they play out in the Asia-Pacific region.

Let me declare my hand. So Australia has undertaken consultation around the country for people who use time, and we have more of that to do. ^M00:43:58 But at the moment our overall feeling is in favour of Method A. And me personally, I'm strongly in favour of Method A. Just so you can factor that into what I say. I don't speak for Australia, I speak for me.

[ Slide ]

Let me just touch on a couple of the things that Mr Meens said in his presentation which are worth repeating. They're general things about the impact of leap seconds in our region and in our modern life. And one of them is that leap seconds have a special impact in the Asia-Pacific region. So leap seconds happen at midnight in UTC, so that means roughly the longitude of London. And in the Asia-Pacific of course we are in the middle, often at the beginning of a business day. So any impact that maybe takes some time to resolve, may not affect business as much in the middle of the night, but it certainly does here in the Asia-Pacific, so this is one thing we really need to be aware of.

Secondly, here's that same history of leap seconds since they were first introduced in 1972. The blue dots are the ones that happened on December 31st, and the orange dots happened on June the 30th. For us here in the Asia-Pacific it's the following day because of the time zone offset. So this means that all the blue dots happened on New Year's Day, January the 1st, and the orange ones happened on July the 1st. And you will notice that they are not happening as frequently, because the Earth rotation is a little unstable, as you've seen. But there hasn't been an orange dot on a business day, a normal business day for some time. You have to go back almost 20 years to get to a leap second that happened on a full business day.

^M00:45:56 Also a lot has happened in that 20 years. At the beginning in the mid-nineties, that's when computer networks really get going, and so there haven't been that many leap seconds which computer networks have had to deal with. So these are two other things to think about for leap seconds. Just, by the way, the orange dot, 2012, that happened on a Sunday in the Asia-Pacific.

And this point about computers. So why do computers, so computer networks care about time because they need to synchronise when they're exchanging data, and they need to stamp events with a consistent clock. Why do we care about computer networks? Because computer networks control so much of our modern life. They control telecommunications. They control power distribution. We rely on them for navigation. We rely on them in our financial markets and for trading. So if our computer systems have a problem, then we have a problem potentially across big parts of our life.

Now, computer networks do have a system which is designed to synchronise, and that's System Network Time Protocol. It's a standard language for exchanging time information across the network. And it knows about leap seconds, it's designed to include leap second information. And a computer has to take that and use it properly. And all the problem again comes with breakdown of that system. Designed on paper it works fine. In practice, computers can fail to be aware or to process a leap second correctly. Just by way of example, the last leap second we had in 2012, something like 10 per cent of the reference pool of NTP servers got it wrong. Most were fixed up pretty quickly, but some took some time.

Okay. Now here's an example of what that means in Australia. So in 2012 you might be aware that a number of computer networks or networked programs had problems. ^M00:48:02 And some of those were social media sites. So if Yelp or 4Square or Reddit goes down, this is maybe not the end of the world. But what happened in Australia was that Qantas' booking system went down, in the middle of the day, in the early part of the morning, on July the 1st, on a day when people were heading home from travelling around. What that meant was real effect on people. Something like 400 flights were delayed by up to a couple of hours, people were stranded all over the country. Sport is a big deal in Australia, and one of the State of Origin teams was delayed getting to the ground to prepare for their game.

So this is a computer network which could not handle the leap second properly, with a real effect on people's lives. So maybe it's not the end of the world, this particular one, but what the real question for us here is, what other computer networks went down that we didn't hear about, and what might go down at the next leap second, right? And just to make a point here, it really was the leap second that was the problem, so the worldwide booking system, Amadeus, relies on a Linux operating system underneath, and the Linux operating system turned out, or the variant of it that Amadeus was using, turned out to have a small bug in the processing of the leap second. And the consequence of that one bug was all the disruption that happened. Now, Qantas and Amadeus did everything right. They relied on the computer system. They made sensible decisions in preparing for the leap second. But it's such a complex interaction between the computer itself, the operating system, and the software that sits on top of it, and everybody using it, that it's very hard to be sure that you've tested every configuration and that there will not be any bug. ^M00:50:06 And as I say, even if you fix this case, as they have, hopefully Amadeus will work fine through the next leap second, what other computer systems might have a problem the next time round.

Here's one that we're particularly careful about in Australia. We have a very particular potential impact at the next leap second. And let me set it up by explaining that financial markets in Australia are regulated under a set of rules, so if you're operating a financial market you have to follow the rules. And one of those rules is that you have to have synchronised clocks. This is very important for high speed trading, for keeping the same value on multiple markets. And that common clock is UTC. So all financial markets in Australia use UTC. This is the rule that says you have to.

Okay, now, here is the chain. So the leap second occurs just before midnight, UTC. Local time in Sydney, which is where the markets are, is 10 hours in advance, that's our time zone. So that means the leap second will occur just before 10.00 am, local time in Sydney, okay, it happens on July the 1st, which is a trading day. So that's a day the markets are going to open. So what that means is that the leap second will be the last second before the markets open. Anybody who doesn't put the leap second in properly will try and trade, or open, one second too soon. And if people make different choices, if some get it right and some don't, there is risk for confusion in Australia's main equities market. ^M00:51:54 So the work that Australia has to do, that the market operators have to do, that everyone who wants to use the market has to do, is to be sure that they're going to apply the leap second correctly and avoid this particular risk. And all of that effort comes because there is a leap second to be inserted. And it comes because it happens at just about the worst possible time for our markets. Just as an aside, if you change the market rule, we would still have to do the work, actually, because of the way civil time is defined. I'll come back to that a little later on.

Okay, so just to unpack that a little bit, to talk about what the effort and risk is in this case. So the first risk here is that the people who use the accurate time have to know that they need to allow for the leap second. So timekeepers like us know. We get the bulletin from the Earth Rotation Monitoring Service, we know we have to program the clock. But does everybody in the financial markets know they have to process the leap second?

Secondly, even if you know, then you have to make sure you've prepared. So there is work involved in maybe developing or testing software, maybe you have to set up a whole parallel test platform to run, because you're operational at the same time. Even if you ran tests the last time there was a leap second, three years is a long time for a computer network. So a lot changes in the hardware, the software, the functions of the network, which all needs new testing. And the users in the financial markets know about finance, they know about market trading. They aren't necessarily time experts. And so they may not know all the testing that they need to do.

And finally this point again. ^M00:53:54 In practice it may be impossible to be absolutely certain that the testing we've done will guarantee correct processing of the leap second. Every single time over the last 20 years that there's been a leap second, there's been some problem, you've seen some of them. And there are critical dependences that are somewhat out of your control. You have bought equipment from a GPS receiver maker or a computer hardware maker, and you're relying on them to have done their testing.

Okay, let me talk about something else. So a different part of the user community for time in Australia. So astronomy is a strong research interest for Australia, has been for a very long time, both in the radio part of the spectrum and for optical astronomy. And here's a picture of some of Australia's observatories. Australia of course is going to be one of the two sites, two major sites for the square kilometre array.

Astronomers care about time for a couple of different reasons. Firstly they care about it for pointing the antenna in exact, or the telescope, in exactly the right direction, because the telescope sits on the Earth, so you have to know exactly how the Earth is oriented at the time on the clock. Now, the offset between UTC and UT1, universal time, is known very accurately from monitoring of the Earth's rotation, and it's known well in advance for astronomical observations. This is basically a solved problem. What happens if you were to stop leap seconds, so one of the options that does that, is that you would stop limiting that difference to one second. So any software that assumes it's less than one second would need to be changed, and so there is some effort there. That effort needs to be balanced against the effort associated with any other method.

^M00:55:56 The other reason astronomers care about precise time is for understanding long series of data, and there might be many, many years of data where we want to compare observations now to observations at a previous point in time, often very precisely and very accurately. So astronomers need to know the definition of time over that whole sequence to make sure they're making the comparison properly. An example in Australia is timing data from pulsars, radio sources in the sky, which are used to test fundamental theories. Also some of that data gets fed into national mapping.

Okay, so overall the astronomy community, in our understanding, is broadly in favour. There is a range of opinion, as there will be in this room. Some are strongly in favour, many are neutral, and some are strongly opposed. The ones that are strongly opposed are mostly opposed for the reason about losing the link to the sun, and I'll come back to that in a minute. On balance though, overall, in favour of stopping leap seconds.

I couldn't resist putting in a science slide. This is one of those long sequences of observations of pulsars which are used to test fundamental theories, in this case to look for, hopefully ultimately to make measurements of, gravitational waves. And just to make the point, that long sequence goes for 20 years.

Okay, so coming back to this point about the difference between UTC and mean solar time. This is another, this graph is very similar to the one that Mr Meens showed. It shows the slowing down of the Earth over a long time scale relative to a perfect clock. ^M00:58:01 So if you go back not quite as far as Mr Meens went, so maybe 100 years or so BC, the day was about 30 milliseconds shorter, and if you think of it as a clock, it's lost a few hours since then against a perfect clock. And the thing to bear in mind is how much will it continue to lose if we stop adding leap seconds? And the projections are of order minutes. So by the end of this century, 2100, about one to two minutes. And this we have to weigh up against other factors.

Okay, now there are two camps here. Some argue that breaking that link, losing the synchronisation between clock time and solar time, is a very fundamental change, that we've lived our entire history with that link, and if we let it go it's a big change. This quote here is from David Willits, who was at the time UK's Science Minister. And this is a view held in Australia that we ought to preserve this link, it's a big part of our history or our culture, or our society.

Others argue that we cope with much larger differences than a couple of minutes, or even 10 minutes, between these two ways of telling time, clock time and solar time, we deal with that already. So we have time zones which standardise up to an hour away from apparent solar time. In many of those time zones we change by an hour twice a year for daylight saving.

[ Slide ]

Solar time varies by about 15 minutes, the equation of time as you've heard, and so in comparison, one or two minutes may not be significant. So this is a choice we must all make. ^M00:59:55 Do we want to keep that link, or are we content to live with a larger difference for convenience?

I just wanted to share something about time zones in Australia, because it's quite a complicated situation, and it gives some background to this decision about convenience versus difference. So Australia has sometimes three, and sometimes five time zones. It is one of the few places in the world that has a time zone that is a half hour away from UTC, and it has some of our states making a daylight savings change, and some not. You can imagine that with a complicated set up like this, there's quite a complicated history. So people have argued and debated for a long time both what the time zone should be, what the offset should be, and whether or not there should be daylight saving. So states that at the moment don't have daylight saving have tried it, sometimes several times, and stopped. And the offsets here have also changed over history.

[ Slide ]

So here's one example. I just wanted to show you how this is set up in Australia, because it makes another point. One of the arguments about, one of the consequences potentially of changing Coordinated Universal Time, or changing UTC is what is the impact in legislation? So in Australia those time zones area are all defined with respect to UTC. So if you change the definition of UTC, the laws inherit that change without needing anything else. This is probably okay as long as the laws don't assume a close link to solar time, in other words there's no extra work that's required if you change the definition. ^M01:02:00 So the choice to be made here is about convenience versus offset to solar time. And I said that over our history we've made that choice many times.

[ Slide ]

Here for example even from earlier this month is the South Australian Government trying again to have a go at changing the offset. So the business community have said it is confusing to have a half hour offset, it would be much better to be aligned with the eastern coast, or even the western coast of Australia, or other trading partners in Asia. So even today we are ready to contemplate changing by half an hour for convenience, and this needs to be compared to allowing an offset to build up for one or two minutes to preserve that link.

[ Slide ]

Okay. So to come back to our methods. As I've said, we need to evaluate the benefits, the effort required and the risk for each one of these methods, and we need to do it consistently, and hopefully with reference to what some of the real impacts might be. And I hope I've shown you what those might be in Australia, and what might be in your countries, to help you maybe make an informed choice as this process continues towards the final decision. Thank you very much. [ pause ] ^E01:03:42

 ^B01:03:53

[Neil Meaney:] Thank you Dr Warrington. ^M01:03:55 I'm beginning to wonder just how much trouble can one second make, it's a challenging situation. To continue with our regional perspective, I'm pleased to welcome to the podium tonight Dr Yu Dai-Hyuk who's the Head of Centre for Time and Frequency at the Korea Research Institute of Standards and Science, often known as KRISS. And he's going to speak to us tonight about Korea's experiences with UTC and the leap second issue. ^E01:04:27

^B01:04:49

[Dai-Hyuk Yu:] Good evening ladies and gentlemen. It's a great honour for me to present about UTC and leap second issues in South Korea. And I'm working at the Centre for Time and Frequency at the Korea Research Institute of Standards and Science. Our Institute is responsible for maintaining and improving and distributing the units. So one of the important units is the second unit of time. I will start with a conclusion first. There has been no official report about problems caused by the insertion of a leap second in Korea.

[ Slide ]

So I will focus more on the information and concerns about the future in my presentation. And no official report does not mean there was no error. ^M01:06:00 More this means that it's very hard to find out the error, before the error becomes very big. So I will start with my presentation.

First I want to introduce the UTC, and Korea's standard time. UTC is generated by International Bureau of Weights and Measures at Paris. And they use more than 400 atomic clocks over 70 labs. They average the time to get the Free Atomic Scale. By using this method, the Free Atomic Time Scale, Free Atomic Scale is very stable. By stable I mean that the duration of a tick is very stable, but that does not mean the Free Atomic Scale is exact, accurate.

So in order to make a very stable Free Atomic Scale to the international atomic time, which is very accurate to the definition of a SI second, is done by the Primary Frequency Standards. The Primary Frequency Standards is a very accurate clock developed in several labs in the world, and now the best atomic clocks have an uncertainty one or two times 10 to the 16. This means that one second error over 300 million years. And then with the TAI, to coordinate the time to the UT1, we insert a leap second. ^M01:08:00 So in this way UTCs are generated.

Actually, in order to generate the UTC, BIPM needs a data from the clocks all over the world. So that means that's it's a delayed time scale. So now we don't know the UTC, because UTC is not generated now. So only after some time later we know that UTC is something like this, or something like that.

I want to note that lately the TAI is very stable, and is continuous. So we can use this resource if necessary. And then as I told you before that there is no UTC in real time, so every nation should generate their own time scale for the standard time. Also in Korea we generate UTC-KRISS to generate the Korean standard time. We have nine atomic clocks, five Caesium clocks and four Hydrogen Majors, and using the similar method we generate UTC-KRISS, and by adding nine hours we can generate the Korean standard time. And then if we send the clock data and Korean standard time data to the BIPM, after maybe one month later we know that how the difference between UTC and UTC-KRISS. ^M01:09:52 So normally BIPM recommends that each UTC-K is maintained within 100 nanoseconds, plus slash minus 100 nanosecond to UTC.

[ Slide ]

So after the generation of Korean standard time we are broadcasting and disseminating our time. There are many methods, but we have two methods. One is broadcasting of time signal by using a high frequency radio station with a carrier frequency of five megahertz with a five kilowatt. And anyone who has a receiver can accept the time, or synchronise their time to the Korean standard time. And then one important other method is time service through internet, NTP service. So now, as of now, the connection to our server increased to 3,000 requests per second. So in a day, 260 million requests per day.

[ Slide ]

So we want to know the current status of timing synchronisation in a civil area in Korea. So we distributed a questionnaire to 22 TV stations and research institutes, companies and banks. And so 17 responses were analysed. The purpose of this survey was not to make a decision, but to find out the current status of time synchronisation, and opinions on the leap second issues. ^M01:11:58 And then also we want to know if there was a failure experience during the leap second insertion.

So one question was if the user knows about leap second, and most of them answered that they know about the leap second. But usually they maintain the time with some equipment, like a GPS receiver and so on, so that does not mean that they know very well about leap second and possible effect.

And also we want to find out the sources of time synchronisation, and most of them used GPS time for synchronisation, and also the second was the NTP network time service. And one of them, one of 17, answered that the high frequency station maintained by KRISS was used for the time synchronisation. So we think that no problem reported so far can be attributed to the well functioning of GPS and receivers. And some users answer that if there will be some problem in the future, they expect some support by other experts like us or other institutes. And also we asked about opinion on stopping the leap second insertion. ^M01:13:56 and as you can see, of course 17 cannot represent the whole situation in Korea, but anyway, yes, with 29.4 per cent and something like that, but most of them don't care about this issue. So maybe it's due to the fact that there was no official report, no problem so far. And also some of them expect that some other experts will help them to solve their problem.

[ Slide ]

So there are various opinions on the cessation of a leap second, and already these slides are explained by previous slides, so I will skip it.

I want to note more on the NTP server. This is already treated by previous slides, but in more detail. Actually the definition of a possible leap second, positive leap second is that as you can see here, in order to do the, to insert leap second, we need to use the, as you can see here, 23, 59, 60. This kind of time was not known before, for the system clock or the message formats. So actually many of the servers use time text like this. So because they don't have such a kind of a system capable of doing that kind of work. ^M01:15:59 So some computers use two times the same 23, 59, 59.

And then already revealed by the previous slide, that in this case time stamps can reverse causality, and then also the calculated time interval is not correct. But it's very important for high speed financial trading, because time intervals are measured in milliseconds. Also a leap second in the middle of the day in Asian area, of course in Korea also the UTC gero is nine o'clock in the morning, and the stock market opens at that time. And there are the different realisation, for example some system use not the same 59 seconds twice, but use a gero second twice, so this has the same problem.

And then another solution was by varying the frequency. So just before the leap second learns clocks slower than before to make no such kind of causality problem. But an example is the Cougar server, that use this kind of non-linear time adjustment is not for all the civil area, because school time is not transferred to national time standards.

^M01:18:04 We have an NTP time server, as I told you before, the request is 3,000 times per second. And if we insert a leap second, we should deal with two times 3,000. This means 6,000 requests during the leap second insertion, and this may cause us some problem, like already occurred in Australia. And some systems do not recognise advance notice parameter, and do nothing at leap second. So this is more problem nowadays.

And in Korea, our status is that there are pros and cons for the cessation of a leap second, but there are no unanimous agreement in Korea. And also there has been no official report of the problem caused by insertion of the leap second. But we are worrying about the future, so we will continue to study to prevent possible future repetitive occurrence of a catastrophe when the leap second is maintained. Thank you for your attention. [ applause ] ^E01:19:37

^B01:19:42

[Neil Meaney:] Dr Yu Dai-Hyuk, thank you for your presentation. Our next presenter is not only a Professor of the Beijing Satellite Navigation Centre, but he's particularly well known to the Asia-Pacific Preparatory Group for the WRC because he does all of the hard work as our Drafting Group Chairman on Agenda Item 1.14. ^M01:20:03 So we're very well known to Dr Han Chunhao thank you very much, and we can hear about China's experiences. Thank you Dr. [ pause ] ^E01:20:15

^B01:20:57

[ Slide ]

[Chunhao Han:] Good evening ladies and gentlemen. It's my pleasure here to give this brief introduction about the preliminary view on the future of UTC in China.

[ Slide ]

And we know to do anything we should consider the conception, the definitions, and the real [ inaudible ]. And we think it's more important for conception, so I wanted to take some time to deliver some introduction about ancient Chinese time conception. What's time? ^M01:21:54 We think it's a very important concept and also a big question in science, philosophy and religion, just like the [ inaudible ]. ^M01:22:11 So different people, different culture maybe have different time conception. What is time for the ancient Chinese? The answer is simple. Time is a change of the universe.

[ Slide ]

Time is the sunrise and the sunset. Time is the moon waxing and waning. Time is the change of seasons. Time is always determined by the sky. So in Chinese we have a very famous word, [ speaks Chinese ] It's meaning is 'just the right place and right time'. [ speaks Chinese ] is sky, heaven, it's time, place, benefit.

[ Slide ]

And the basic units of time in China, the day, the month and the year. And the other time units are [ speaks Chinese ] two hours, where hours are maybe the bigger, and [ speaks Chinese ], five days, [ speaks Chinese ], seven days, [ speaks Chinese ], 10 days, [ speaks Chinese ], three months, [ speaks Chinese ], 12 years, and the [ speaks Chinese ], 60 years. We [ inaudible ] the long time, ^M01:23:52.

[ Slide ]

^M01:23:57 And we also use some other unit. Five day is [ speaks Chinese ], and 3 hour means [ speaks Chinese ], and the [ speaks Chinese ] means the one season. And the four seasons is a year. So one year has 24 solar terms.

[ Slide ]

And many words from the conception of time. We know in Chinese we use climate, the Chinese is [ speaks Chinese ]. And the time is [ speaks Chinese ]. The climate depends on time.

[ Slide ]

And everything in Chinese is affected by the time, even your fate. It has some relations to your local time of birth. For any person we have [ speaks Chinese ] eight words. Year, month, day, [ speaks Chinese ]. Every unit has two words, so eight words. And maybe we denote it by [ speaks Chinese ] and [ speaks Chinese ], Chinese era.

[ Slide ]

^M01:26:02 You know each year has a fixed, [ speaks Chinese ]. The Chinese era of year 2014 is [ speaks Chinese ] and also a horse year. And this year is [ speaks Chinese ], a sheep year. So the number of the [ speaks Chinese ] is 10. And the number of [ speaks Chinese ] is 12. And the cycle period of Chinese era is 60, where we give some [ inaudible ]. ^M01:26:46.

[ Slide ]

Every year we have an animal. And here the 12 animals for the 12 years.

[ Slide ]

And the scientific meanings of Chinese era, my personal opinions. [ speaks Chinese ] is the interference of the sky, I think in the Asian. And the [ speaks Chinese ], the location or direction of the sun on the Earth. Note, the orbital period of the Jupiter around the sun we know at present is 12 years. And so now the orbital period of the Saturn is almost 30 years. So 60 years equals five periods of the Jupiter also two periods of the Saturn.

[ Slide ]

^M01:27:57 The natural environment of the human being is mainly determined by the Earth, the sun, the moon and the big planets. Different time, different sky. But the conception of Chinese era was formed more than 3,000 years ago, it's amazing. Then if you don't understand the Chinese conceptions about time, you can never say you know the Chinese culture. And the way you say some conception of the ancient people is not scientific, you'd better be careful. In most cases you have not enough knowledge about it.

[ Slide ]

Here is the time conception, ancient Chinese culture, and the modern science. Also in Chinese we have a very famous Asian word [ speaks Chinese ]. [ speaks Chinese ] are nothing. [ speaks Chinese ] is one. And [ speaks Chinese ] two sides, [ speaks Chinese ], two sides, and positive slash negative. And [ speaks Chinese ] four images. And the [ speaks Chinese ], ^M01:29:45 [ inaudible ] trigrams. I think the changes, different changes, different changes for zero to one, two to four, to eight, to 64.

[ Slide ]

^M01:30:02 And also we know in Chinese that [ speaks Chinese ] it means everything have two sides and the five states. All the states have relations, favourable or harmful. Things change their five states one after, or one by one with time and form cycles. The key word of the theories [ speaks Chinese ], is the symbol of theory in China, ancient China, and the [ speaks Chinese ] that also, I think are the 64 changes of states. They should have translated it first into the west. And are change, the key word is the change and the relation.

[ Slide ]

The many theories in science and technology can be well understand with ancient Chinese culture, such as telecommunication and computer science, even relativity and cosmology. This is a map of time. And for relatively we know three ^M01:31:36 [ inaudible ], we know the space-like and the time-like, and the null-like.

[ Slide ]

And here is the theory of ^M01:31:48 [ inaudible ], and the modern cosmology. The Big Bang. The Big Bang. ^M01:31:59 And the theory of ^M01:32:01 [ inaudible ]. 2,000 years ago.

[ Slide ]

Okay. Here I wanted to introduce the time service in ancient China. In ancient China the time measurement they usually observe the change of the solar position on the sky. This is the sundial for an ^M01:32:34 [ inaudible ]. And this is ancient of ^M01:32:42 [ inaudible ]. In the seasons and the year.

[ Slide ]

Time keeping, we know, keep time by some manmade devices such as the hourglass, water clock and something like this. And though we know at present we use atomic clock, but conceptually there is no difference in the functions between atomic clock or a clock ensemble and an hourglass. The only difference is the uncertainty of the ability, the ability of the time maintenance.

[ Slide ]

^M01:33:38 [ inaudible ] time signal by some. And each city had a big building in the centre used for time service with drums and bells. Matin Bells and vesper drums [ speaks Chinese ]. ^M01:34:04 At present we use radio signal, but there is also no conceptual difference between the modern society and the ancient. The difference is also the uncertainty or the precision.

[ Slide ]

And second I won't to talk of the definition and the realisation of UTC, because many experts ^M01:34:32 [ inaudible ] here, I don't want to talk again.

[ Slide ] ^E01:34:41

^B01:34:47

And third, I want to give an introduction about the rules and the functions of UTC. UTC is a critical part of the international infrastructure. UTC is the international standard time scale for all practical timekeeping in the modern world. UTC provides an approximation value of UT1 for users who need the Earth Orientation Parameters. They're called the EOP. And any local time can also be obtained from UTC for the public.

[ Slide ]

Here the difference between UTC, UT1, and TAI.

[ Slide ]

The deficiencies of UTC. The shortcomings or deficiencies of UTC is just because it plays two roles. As the standard time it is not continuous and uniform. ^M01:35:59 And as the Earth Orientation Parameter UT1 it is not accurate enough, I think. Then it is time to give up that UTC plays two roles.

[ Slide ]

Five. Used as time for science and technology. A continuous standard time scale is very useful and convenient. I would ^M01:36:28 [ inaudible ] this. Stopping the insertion of leap seconds in UTC is the best way to realise a continuous time scale. And in science and technology we usually not use UTC, but TT, the ^M01:36:47 [ inaudible ] time for the observation and the parameter motion with the ^M01:36:58 [ inaudible ] time, and for centralising and therefore for ^M01:37:05 [ inaudible ] we use the TDB, ^M01:37:10 [ inaudible ] Dynamical Time. It's a conception of relativity.

[ Slide ]

Used as time for civil daily time. The civil standard time should have some relations with the mean solar time or the Universal Time. The impact of time offset between the UTC and the UT1 is negligible, even without leap seconds. Why? Some experts are also talking about this. Conceptually it's atomic time, but also approximate solar time, even without leap seconds. ^M01:37:59 Why? We were just talking, the second, one second is from the solar time. And they use the EOP for science and technology. And the approximation of UT1, UTC has a wide application ^M01:38:21 [ inaudible ] and the base science. Stopping the insertion of the leap second means that the difference between the UTC and the UT1 will be no longer a limited value. Then some hardware and software need some adaptive modifications. This work will take time and money. Also, there must be EOP services.

[ Slide ]

Preliminary views. A continuous and uniform time scale is the basic goal of the eternal pursuit of science and technology. The irregular insertion of leap seconds in UTC is very inconvenient or troublesome for users that require continuous time scales. The dissemination of two "standard" time scales might bring significant risks of confusion.

[ Slide ]

And the definition of international standard time must keep some relations with the mean solar time, or UT1, ^M01:39:36 [ inaudible ]. The base of civil time is always the sunrise and sunset. A continuous international reference time scale can be achieved by stopping the insertion of leap seconds in UTC, and as the de facto international standard time, UTC should give up the role of the approximate EOP. [ Slide ] ^E01:40:03.

^B01:40:15

As an approximation of UT1, UTC has wide applications in astronomy, geodesy and space science. If stop the leap seconds, hardware and software in some systems need some adaptive modifications, and this work will take time and money. Taking into account the long history and the wide application of UTC, the name and continuity of UTC should keep unchanged. If you change the name many systems or software and lawyer document should have modification. And the GNSS, the Global Navigation Satellite System, should provide the Earth Orientation Parameter service.

[ Slide ]

Thank you for your attention. [ applause ] ^E01:41:14

^B01:41:30

[Neil Meaney:] Dr Hun, thank you very much for that very thought provoking presentation, we do appreciate it. I'm sure that there are many questions in the minds of some of the people with us tonight, and the opportunity to ask those questions is not far away, we'll certainly give you that chance after we hear from our final speaker tonight. And I'm pleased to welcome to the podium Dr Tsukasa Iwama, who's the Research Manager of Space Time Standards Laboratory, Applied Electromagnetic Research Institute with the National Institute of Information, Communications Technology and ICT.

[ Slide ] ^M01:42:06

^M01:42:06 [Tsukasa Iwama: ] My name is Tsukasa Iwama from NICT, Japan. Today I would like to present about Japanese activities and views on Agenda Item 1.14.

[ Slide ]

So this shows how to satisfy the Agenda Item 1.14 from CPM text. There are three major methods. The detail there was already into this from other presenters here. We paid attention about the difference of each method. Method A, introduce a continuous time scale. Method B, a continuous time scale and traditional UTC broadcasting on an equal basis. And Method C, keep the traditional UTC and if necessary, the continuous time scale is additional to this.

[ Slide ]

So in this system we ^M01:43:36 [ inaudible ] about the Method B. So Method B essence, it's ^M01:43:51 [ inaudible ] to be broadcasted on an equal basis. ^M01:43:58 So t means two times curve, broadcasting in parallel. But we think it is very dangerous about this, because whenever you act best on the time, for example they develop that some communication systems or some data collection systems. So at that time, you always need to check the time scale for all systems, and every instrument, you need to check the time scale.

So if some system use a different time scale, at that time you need to combat the time scale. So every time and everything. Then it very complicated things. An examination of two times curve can cause a significant confusion socially.

[ Slide ]

Then Japan cannot agree with this Method B. So next, we consider about Method C. In essence it's like this. We divide Method C into two parts, depending on their needs. ^M01:46:01 So this part is to keep the traditional UTC. ^M01:46:10 [ inaudible ] UTC will remain the only time scale, which is broadcasted in order to avoid any confusion.

So in this part, we agree with the view that only one time scale should broadcasted in order to avoid any confusion. So only one time scale, we agree. But it needs to be discussed later whether this one time scale shall be traditional UTC, or continuous time scale. So we discuss later.

[ Slide ]

Under the method we have another point. So this is availability of the continuous time scale. So in this part, it can be derived from UTC using a difference figure, which is also being broadcasted. This looks like the same definition of TF.460-6, but different point. This continuous time scale is a different time scale, so this part includes the same problem as Method B, so it becomes a continuous reference time scale definition, and causes of significant confusion.

[ Slide ]

^M01:48:03 So about the requirement for the time scale. We consider that the international standard reference time scale should be only one. So as only one time scale, which is better, traditional UTC or continuous time scale?

[ Slide ]

In considering this point we should look back for our contribution to Working Party 7A. So Japan input the Working Party, so this Agenda Item, this problem started in 2000 in Working Party 7A. And for these 15 years, Working Party 7A discussed about the question about the future of UTC programs. And Japan sometimes input their contributions in Working Party 7A. And here we show the input of three contributions each year. ^M01:49:55 [ inaudible ] the contribution, the questionnaire of the leap second, and finally the input of leap second incidents.

[ Slide ]

So the first questionnaire is here. The summary of the CRL questionnaire for the future of UTC input in 2002. Here CRL is presently known as NICT. So this questionnaire survey was circulated at the end of 2001 to major Japanese organisations, companies and to time and frequency users. In total we received 80 replies. And in this questionnaire we have four questions and answers. But this question is the most important question related to Agenda Item 1.14. Question, do you think the determination method of UTC should be changed? Answer, changes, yes, is about 24 per cent . Changes, no, is more than 40 per cent . So it seems the major who are opposed to changing UTC in this time in Japan.

[ Slide ]

^M01:51:57 But after 2006 the leap second insertion, we also conduct the second questionnaire of leap second. So this one is the second questionnaire on possible future change to Coordinated Universal Time in Japan. So this questionnaire survey to the related industry field, broadcasting carriers, telecommunications carriers, time stamping authorities, GPS receiver manufacturers, Geographical Survey Institute, satellite launching enterprise. The question D3. First how about the effect of past leap second adjustment? So these four industry fields answered "none". But time stamp authorities answered "operation stopped". And satellite launching enterprise answered "made some changes to the control programs". And these answered "none" field also probably say the "manual adjustment" in each field. And successfully proceed. ^M01:54:04 And the next question is the effect of future change to UTC, does it have some effect? Each year in this time, timings, future changes, two types. One is stopping the insertion of leap second. And second is leap second changed to the leap hour. This method is also discussed in these timings. About this question answered, four fields answered "none". And broadcasting carriers and telecommunication carriers answered "find the merit in disappearing in an irregular leap second adjustment". They don't need to disappearing, so they find the merit. And GPS receiver manufacturers mainly answered "none in near future". But if introduce a leap hour, this "new adjustment method may involve the possibility of significant problems". And these two felt they "need to adopt some changes to the control programs", because their control programs related with the UT1, so they need to change.

Now, finally, you agree or disagree with the future change? Upper three here agreed. And GPS receiver manufacturers both agree and disagree. In this the disagree case, the same as this, a leap hour has a possibility of another significant problem. So ^M01:56:40 [ inaudible ] it's disagree. Stopping the UTC, agree. Stopping the leap second, agree. And these two felt anyway they need to modify the control program, so then only no answer about this question.

[ Slide ]

And, finally, input report of the leap second incident. This was a report about the disadvantage of the UTC, traditional UTC.

[ Slide ]

So this incident report, we have three major points. First is the computer programs. Many faults occurred universally on the process in the application of Linux such as MySQL, Hadoop, Cassandra and so on. ^M01:57:57 So and also this Linux application trouble also occurred in 2009. And this trouble, kind of trouble, and this kind of trouble different. And nowadays computer speed higher and higher and higher. Probably these programs ^M01:58:31 [ inaudible ] increases, probably. And in this time, in this year, in Japan the system delay caused by the same faults were also officially reported by well-known Social Network System, Groupware and Internet Service Provider. These measure users also reported the system delay caused by insertion of leap second. And many other faults in applications mostly related in the Linux systems or NTP troubles have been reported.

[ Slide ]

Second point is the time stamping services. So all the time stamping authorities were suspended providing the services during the leap second insertion. In Japan this time stamping services started at 2005.

[ Slide ]

^M01:59:53 And after 2005, they experienced three times of leap second insertion. At first leap second insertion they stopped the service about half dates. And second experience they stopped more than three hours.

[ Slide ]

And this time, the cessation of services lasted about two hours on average. But they said it's a limited stopping times, because they need to check the main time stamping streams, and also related some audit systems, related systems need to check every time. So they need two hour limit times.

The third point, this one is saying ^M02:01:18 [ inaudible ] so even though the leap second adjustment was implemented on Sunday this time, so this time on Sunday. But barriers ^M02:01:32 [ inaudible ] systems suspended ^M02:01:33 [ inaudible ]. And in the future, the leap second adjustment carried out on week days may cause wider spread confusion through the country in Japan, because a leap second adjustment occurred at nine o'clock in Japan, and it's the starting time for general businesses. ^M02:02:06 And this year a possible leap second will be introduced at the end of June.

[ Slide ]

So in Japan it will be at nine o'clock on July 1st. And July 1st is a Wednesday.

[ Slide ]

And now we share that Japanese time stamping services already announced they are stopping their services. But some users like ^M02:03:00 [ inaudible ] trading users are opposing the time stamping, stopping the time stamping service.

[ Slide ]

Because that morning nine o'clock is just starting the business time, and July 1st is just a half day of the year that's a very important day for business. So many now discussed about these, a positive leap second insertion is now discussed in Japan.

[ Slide ]

^M02:03:51 So here we show the disadvantage of the traditional UTC. And here we also show the disadvantage of continuous time scale. Disadvantages of continuous time scale measures two points. One is the offset between UT1 and UTC will be higher than the current limit of 0.9 second. Most of network systems and applications will work well. But some applications such as Earth stations of the non-GSO satellite systems, radio astronomy stations will be affected, because it will be necessary to modify these special systems, but it takes time and money. So it has problems about these.

And as a point, a civil time scale would be deviated from UT1 after introduction of continuous time scale. And UT1 minus UTC will be in the order of one minute in the first 100 years. So now TAI and UTC is difference is over 35 seconds. And TAI and UTC is adjusted in 1958, so more than 50 years' time difference, only 35 seconds. ^M02:05:56 So in the first 100 years the time difference in order is one minute, about.

[ Slide ]

So considering disadvantage of both time scales. So which is better, in summary. Traditional UTC disadvantage. Number of incidents of internet services and applications will increase in every time. And computer network are higher and higher but year by year. So it will be increasing next time. And in Asia-Pacific region, leap second adjustment occurs during working hours, morning times. This is a major disadvantage of traditional UTC.

So continuous time scales disadvantages. Most of network systems and applications will work, but some systems related with the UT1 need system modification. It takes time and much money. So it is a very important problem. And a civil time scale would be deviated from UT1. But the apparent solar time can differ already by some plus slash minus 16 minutes, shown by Mr Meens, from the mean solar time. ^M02:08:00 Considering all of these advantages, we think the continuous time scale is better than the traditional UTC.

[ Slide ]

So finally we show the Japanese views. Japanese views are very simple. Japan supports to introduce the new continuous reference time scale by stopping the insertion of leap seconds in UTC. And second, Japan supports the name of UTC to be retained after the introduction of the new continuous reference time scale, because this continuous time scale is continuously started to follow the UTC, so many document, or many customers, same name it, very useful. So already said by the Chinese presenters. So this is all. Thank you for your attention. [applause] ^E02:09:18

 ^B02:09:25

[Neil Meaney:] Dr Iwama thank you very much for your presentation. Our final chore for tonight's session is the opportunity for those of you here tonight to put some questions to our distinguished experts. We've got a collection of people who are profoundly well renowned and recognised within our region, and two distinguished representatives from the ITU Radiocommunications Sector with us tonight. ^M02:09:52 So to achieve this, what I'd like to do is to invite all of our speakers to take up your positions on the stage here, and from there we'll be able to put the questions to the floor, and spend our last 30 minutes or so of the session in answering some of the questions, which I'm sure have been raised by the various views and experiences that we've heard tonight.

^M02:10:12 [ inaudible ] and fit with ancient Chinese culture. That was certainly an enlightening presentation from Dr Han. We thank you for that. And Japan has developed clear views on this issue, and from what we've heard from Dr Iwama they provided substantial input into this process over more than 12 years, thereabouts, into the work on WRC-15 Agenda Item 1.14. So I thank the presenters for those remarkable presentations tonight, it's been very enlightening. And I open it to the floor, if anybody would like to take questions to any of our presenters, please take this opportunity. Do I see any questions? ^E02:10:59 ^B02:11:03 Yes, from the rear.

^E02:11:06 ^B02:11:13

[ Question ] ^M02:11:14 [ inaudible ] ^M02:11:20 and I take the opportunity of thanking you for organising this very interesting session, and also I take the opportunity to get some information. My question is about the relationship between the BIPM and the ITU. One of the, well, I'm working for ^M02:11:37 [ inaudible ] regulator, and of course I'm quite far from these questions. ^M02:11:44 And my question would be why is it not possible that for example the ITU would say that the UTC is defined by the BIPM, and the ITU recognise the BIPM definition, and the ITU does not enter into the question of whether or not to insert the leap second, but keep that, or leave that to the BIPM to decide? Is there any ^M02:12:11 [ inaudible ] or organisational difficulty with such an approach? Thank you.

[Neil Meaney:] ^M02:12:21 Thank you very much for the question, and we shall turn to Mr Meens, he would like to perhaps respond? Thank you.

[Vincent Meens:] Yes, thank you very much. Well, actually, the problem is that the, well, as you say, BIPM would be probably more capable of defining the UTC, and actually the BIPM is maintaining the UTC, that it's jobs, one of its jobs anyway, at least for the sake of ^M02:12:50 [ inaudible ]. But the problem is actually that UTC, as a definition, is defined in the Radio Regulation. And I can't exactly tell you when it was decided that way, but historically speaking, the definition is in the Radio Regulation, and UTC is mentioned in several places in the Radio Regulation, and there is the main definition in Article 1, and you can find the definition of UTC, of the occurrence of UTC many times in the Radio Regulation. And this is the main reason why this is our job in the ITU, that we're concerned with the modification of the definition of UTC. ^M02:13:40 Basically because this is described and the definition, this is defined in Article 1 of the Radio Regulation, and this is where you can find the definition. [ pause ] ^E02:13:54

^B02:13:59

[Neil Meaney] Thank you very much. Do we have further questions?

[Alan Jamieson:] I feel the point that's very, very important to recognise is that the International Radio Regulations has the status of an international treaty. When we modify the Radio Regulations at a World Radio Conference, the actions of that conference have to be ratified by governments. That means the nations of the world sign on to any changes which are incorporated into the Radio Regulations. That gives them a status which is very important in terms of the application of the Regulations, their interpretation, and certainly the way in which any future modifications can be made to them. They're subject to international law and it's an important factor to recognise. Thank you. ^M02:15:06

[Neil Meaney:] Yes, thank you. We have a question from Dr Wi.

[ Question ] Thank you. First I appreciate ACMA to coordinate and organising of these information sessions. My question is, I appreciate and then I got the many information, but there's still a people who are not the expert in this area, like me. What I learnt is maybe we can stop the insertion of the leap seconds. ^M02:15:47 So because the experts says it would be benefit for futures, so okay, it's fine. But my question is back to the year 2012, at that time I had no idea on that issue, only the few experienced, the expert, they knew the issues, and my question is why didn't they, or couldn't they decide at the time? ^M02:16:25 Why they continue these kind of things, because only the experts knows and the expert research, has to research the issues, but why? They have to continue these kind of things more than three years, and then tonight, the normal people, including myself, whether I know the leap seconds or not, but still I can survive. Why we have to continue these kind of discussions more than three years? That's the questions. Thank you.

[Neil Meaney:] It's certainly a leading question. I don't know who would like to respond to that, but it does raise a number of issues. I would like to add that information and education is so important to this process, and that's why we're here tonight, to try and sort of make people more aware of what this entirely means. But it is incredibly complicated, which makes it difficult for the average person to appreciate the implications of either doing nothing or doing something. But I put it to the experts to respond.

[Vincent Meens:] Okay, thank you. First actually, as you say, it could have been decided by experts. ^M02:17:42 And that's actually what we meant to do in the first place. And the idea was just to modify the Recommendation ITU-R TF.460. But within the Working Party 7A we couldn't agree for years on modifying that recommendation. There were some administration that proposed to suppress the insertion of the leap second, and some administration that wanted to keep it. So that recommendation was modified, but it could not, we could not reach an agreement within the Working Party, so we went to the Study Group without agreement with the Working Party, and obviously when you are at the Study Group level, then you need to have full agreement from all the administration that are present in the room to have a recommendation adopted. Since we had a few administration that were not in favour of this modification, it could not be adopted.

So we went to the Radiocommunication Assembly, where we expected that there would be a vote, and then these recommendations could be adopted, or even approved. But then as it was mentioned by Alan at the beginning of the meeting, there was an even balance between the pros and the cons, and the large number of administration that as you say, well, they didn't know exactly what to think about, which is the reason why we're still here. And just to remind you that the question was agreed in 2000, so that's 15 years ago, that's a long time for one second.

[Neil Meaney:] Thank you. To me this raises a follow on question, if I may just pick up on what you've said, Mr Meens, and this can go to either Dr Jamieson, Mr Maniewicz or indeed the other people who are involved in this process. ^M02:19:40 The worst case scenario, what happens if we get to WRC-15 and the conference can't decide. Do we then follow on with another 10 years of study? I know that's a bit depressing, but to one side, is there a contingency factor? What do you expect may happen should we get to that point? And I hope we don't, but if we do. ^M02:20:08

[Alan Jamieson:] I think the first point to make is to go back to 2012, and at the Radiocommunication Assembly, as has been pointed out, there was a stalemate. Now, it's very difficult to resolve a stalemate by a vote in which the vast majority of people are uninformed about the issue. Because what are they going to do? The uninformed will either vote on a whim, which is not a good thing to do, or they will abstain. So you don't get a fair reflect of what people really think about the issue.

Now, by exposing the issue to a WRC, yes, it was further study, and the Study Group was requested to actually consider elements beyond the merely technical and engineering, and they did. And that was an important additional aspect in terms of the background information that was made available. But the other thing that exposing it to a WRC did meant that administrations who don't usually attend the meetings of the very technical and scientific based study group, Study Group 7, had a greater opportunity to become informed about the real core issues. So that's really the thinking that went behind why we should pass it to a WRC. ^M02:21:49 Because the issue would be exposed over a longer period of time, there would be extra study, and administration would become well informed about the basic issues.

To come back to Neil's point, what if the very worst scenario, WRC-15 becomes stalemated in the sense of the pros and the cons, basically neutralising each other in terms of the presentation of the issue? By then the administrations who form the body of the WRC will be much better informed on the issue. So first of all I don't think that stalemate will occur. But if it does, it's much easier to conduct a vote at a WRC than at a Radiocommunications Assembly. There is more time. And conducting a vote there would result in a finding, a decision which is more sustainable than would have been the case at the Radiocommunications Assembly. So I'm optimistic that a good result will be achieve. And on the basis of what we've heard tonight, it seems to me that the extra study has paid off handsomely in the benefits and dividends in terms of our knowledge of the particular issues. Thank you.

[Neil Meaney:] Thank you. Further questions? Yes thank you.

[ Question ] ^M02:23:33 [ inaudible ] from CPT. ^M02:23:38 First thank you for all a very detailed and very useful presentation, that will certainly help in administrations taking a well informed decision. One thing in my view we are seeing is not just in this region, but also in the CPT, is a mixed view. The view about whether there is a problem with the current UTC, there are a mixed view. If we make changes to UTC, whether there be problems with some systems which are designed to operate on the UTC with the leap second. So there are quite a mixed view. So basically we are in a situation in one hand there may be, there is a requirement for continuous time for certain applications. And on the other end there are a number of countries who don't see any difficulties with the current UTc, and they will also like to maintain the time scale link to Earth rotation. So my question is how we can meet the requirement of all time scale users, which is clearly in Resolution 653 there are two important things it recognises. The first one is the need for a continuous time scale. The second point is that there is a requirement for time scale based on a link to Earth rotation. Thank you.

[Neil Meaney:] I offer it to the panel to respond. Dr Warrington, thank you.

[Bruce Warrington:] Okay, let me answer the question as best I understand it. ^M02:25:44 So it is certainly true that there is a range of opinion on this issue, and it is perhaps not giving a completely fair presentation to have on the panel people who are dominantly in the time keeping side of that discussion. We tried to give some background around the parts of the user community who care most about Earth rotation, and I would summarise that as two groups. One who care about it for cultural or social, one might even say philosophical reasons for the alignment to the Earth, because it has always been so. And one group who care about it for technical reasons. And rest assured that latter voice is well represented in the debate, as indeed is the first group.

My personal view, and you know my bias, is that particularly for the technical users who require Earth rotation accurately, it is best to put the work and the risk of implementing a system that delivers that with that community. They understand their needs. They understand the need for precise time, they understand their systems. The problem with the current system from my point of view is that the effort and the risk goes outside the group who care most to people who just want a working system, and don't so much care about rotation. So in answer to question, yes, there are multiple voices, but even when those are taken into account, that's my personal view.

[Neil Meaney:] Thank you very much. If I could just follow on from that. ^M02:27:39 Given that we're in times of austerity, we're still in part of the global financial crisis, does anyone really understand what the costs of what we do now is to the community, and indeed what would the cost be if we don't do anything by continuing to insert the occasional leap second? How do we cost that process? There must be a cost. Dr Jamieson.

[Alan Jamieson:] I guess part of the difficulty in coming to terms to quantify the cost is you're trying to quantify an event which may not happen. To quote the Australian example, when the booking system for Qantas fell over, the cost of that must have been enormous in time, yet how do you anticipate, how do you project and say the next time a leap second is inserted, that a similar crisis is going to hit another airline in another part of the world? Very difficult to do that. But I think the point that Bruce made, that in essence we live in an increasingly digital world, as opposed to an analogue world. So the analogue way of measuring time may have been appropriate for an analogue world. But is it still appropriate for a digital world? And I think that's part of the ^M02:29:21.

I think Bruce made a very interesting point too when he said that the costs in terms of the continuous timing system will align more with those who understand and who are prepared to accept the risk, costs and benefits associated with that. ^M02:29:50 As opposed to those of us who might be on the receiving end of a system in some part of the cloud that we access in our normal personal life and business life, in terms of any difficulties that arise with that. Far more difficult to quantify the process.

[Neil Meaney:] Thank you. Do we have further questions from the floor? Mr Percorni?

[ Question ] Thank you Neil. My name is Peter Percorni from the Australian Maritime Safety Authority, but my comments here are personal comments. I have been grappling with this issue probably for about five years or so, but have had a natural interest in electronics and navigation. And I have come to the same conclusion as Dr Warrington has. I've also been involved in having to do the leap second adjustment at a satellite Earth station for the European Space Agency in Perth, and also that clock at the time became a contributing clock to the Australian UTC for some years.

There's a well-known expression that says "A man with a clock knows the time, but a man with two clocks is not so sure". The International Meridian Conference in Washington held in 1884 makes interesting reading, where they decided where the line of zero longitude was going to be. Some 22 countries I believe was represented, and that was in the days of certain empires. And a vote was taken, and in one case Spain's vote was conditional on the United Kingdom adopting the SI system, or the French metric system as it was known then. ^M02:31:51 And in fact that was when the term 'universal' was chosen, because prior to that there was another choice, which was 'cosmic time'. And the decision was actually taken on the number of ships from the UK Hydrographic Service, the number of ships that were using British plates, British copper plates at the time. If the same decision was taken now, it would probably be through Panama City.

But we've heard a lot about, from the interesting presentations, we've heard a lot about the inconvenience, especially to financial transactions, but also there are real potential safety issues, for aviation and for maritime use. I can give some examples of systems on aircraft and systems on ships that, for example in the automatic identification system application by manufacturer of an incorrect leap second, or inserting a leap second one month before the 30th of June for example, which has occurred, causes the transmission of the alias data burst to be in the wrong time slot, or straddling several time slots. So it's not Earth shattering, but these systems are used for safety of life applications.

So if no decision is taken at WRC-15, there will be a number years, it might be 10 years, it might 20 years, but the experts in the BIPM in the International Earth Rotation Service, predict that we will eventually have to apply a leap second every six months. ^M02:33:46 And society, there will be a point in society where they're just sick and tired of leap second problems causing computer systems to fail.

But I have another question which so far I haven't heard answered by anyone on the web. That is, it's a completely separate issue, but unfortunately it's got the same name, it's called the leap year. And with our current system where we have a leap year and we suppress three leap years in every 400 years, even now we are under-correcting by something like two hours, 53 minutes and 20 seconds, every 400 years. And in 10,000 years the error is going to be three days, roughly.

So if we go back in history, the decree which launched the calendar was in 1582, Britain adopted it in 1752. At some point we will have to realign the Gregorian calendar. But this is never discussed in association with this topic, probably at the risk of causing even more confusion. But it's something that if people argue that we're creating a problem for generations to come, there's already a time bomb in there for generations to come to solve. And there's also another issue that in less than 8,000 years from now we will need five digits to express the year, rather than four. So there are other issues lurking in the computer world that have not been addressed. Thank you.

[Neil Meaney:] Okay, in Australia we often say we take that as a comment, I'm not sure we can actually answer those questions. ^M02:35:40 But it raises in my mind, with the work that we have on Agenda Item 1.14, the disadvantages and advantages of course if we institute suppression of the leap second addition, and time does move by whatever the calculation might be, a half an hour in 500 years, what's the theory about correcting that? Is there a theory about when and how it might get corrected in the future, or do we just let it drift? [ pause ] ^E02:36:13 ^B02:36:25

[Vincent Meens:] Well, speaking about the leap hour or the leap minute, well, actually it was discussed in the course of the ITU, not in the course of 1.14, but it was discussed before. And eventually Working Party 7A decided that it was not the right way to take, especially the leap hour, because it means that, it meant that we would need to add a leap hour, something like in 1,000 years when we don't know whether the ITU will still be here in 1,000 years. ^M02:37:00 So it was a bit difficult to say that "Okay, I modify that recommendation, and the next revision of that recommendation is in 1,000 years". So we didn't want to take that step. So it was actually discussed, but it was not kept. ^M02:37:19

One of the discussion, but it was more an informal discussion within the ITU, was that if we decide for the time to drift, one of the possibility is just to change the time zone, instead of changing UTC. And we do that twice a year. So if we had an extra 30 minutes, or subtract an extra 30 minutes, that's something that can be done quite easily, because we do that twice a year. ^M02:37:48 So that was one of the informal proposal was discussed within Working Party 7A. It's not in 1.14, but it was discussed within the group.

[Neil Meaney:] Thank you very much. I believe we've probably come to the end of our session, time is against us, it's been a very long night, we've learnt a lot of information. I personally have benefitted greatly from the presentations we've seen tonight. And apart from that, the general work of many of the delegates is substantial, and you've probably had a long day.

So with that in mind, we might conclude the session, and I offer our personal thanks to our distinguished presenters for some thought provoking presentations tonight. I thank Dr Yu Dai-Hyuk, Dr Han Chunhao, Dr Tsukasa Iwama, Dr Bruce Warrington, Mr Vincent Meens, Mr Mario Maniewicz and Dr Alan Jamieson for your participation tonight, and I would suggest that we all show our appreciation for their presence tonight. Thank you very much. ^M02:38:54 [ applause ] ^M02:38:56

And thank you for your participation. We acknowledge the contributions from the Australian Communications and Media Authority, the Australian Government Department of Communications and the APT, and of course the ITU's Radiocommunication Bureau. And indeed the administrations of China, Japan, Korea and Australia. Thank you all and have a good evening everyone. Thank you very much. ^M02:39:21

[ REPEAT ]

^M02:39:22 Dr Han Chunhao, Dr Tsukasa Iwama, Dr Bruce Warrington, Mr Vincent Meens, Mr Mario Maniewicz and Dr Alan Jamieson for your participation tonight, and I would suggest that we all show our appreciation for their presence tonight. Thank you very much. ^M02:39:37 [ applause ] ^M02:39:44

And thank you for your participation. We acknowledge the contributions from the Australian Communications and Media Authority, the Australian Government Department of Communications and the APT, and of course the ITU's Radiocommunication Bureau. And indeed the administrations of China, Japan, Korea and Australia. Thank you all and have a good evening everyone. Thank you very much.