Governing the Time of the World

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Recent scholarship in International Relations (IR) is concerned with how political actors conceive of *time* and experience *temporality* and, specifically, how these ontological and epistemological considerations affect political theory and practice (Hutchings 2008; Stevens 2016). Drawing upon diverse empirical and theoretical resources, it emphasises both the political nature of 'time' and the temporalities of politics. This *chronopolitical* sensitivity augments our understanding of international relations as practices whose temporal dimensions are as fundamental to their operations as those revealed by more established critiques of spatiality, materiality and discourse (see also Klinke 2013). This transforms our understanding of time as a mere backdrop to 'history' and other core concerns of IR (Kütting 2001) and provides opportunities to reflect upon the constitutive role of time in IR theory itself (Berenskoetter 2011; Hom and Steele 2010; Hutchings 2007; McIntosh 2015).

One strand of IR scholarship problematises the historical emergence of a hegemonic global time that subsumed within it local and indigenous times to become the time by which global trade and communications are transacted (Hom 2010, 2012). This linear and mechanical time evolved in lock-step with industrialisation and the globalisation of capital and through the internet, in particular, a temporal infrastructure has emerged that supports the greater infrastructures of global exchange across a range of massively distributed yet tightly interdependent sociotechnical systems. This form of time-reckoning is contrasted with the complex *heterotemporality* of actual human lives under conditions of late modernity (Hutchings 2008: 1172-6) but relatively little attention has been directed towards the nature and character of global time itself. Terms like 'Western standard time' have served more as placeholders for critique than objects of empirical analysis in their own right (Hom 2010: 1169). This chapter attends to this analytical deficit by asserting the internal heterogeneity of 'global time' but at the same time describing how the *global governance* of time seeks to render this temporal assemblage unified, meaningful and useful. It asks the simple question: who governs the time of the world? Who and what is responsible for producing the hypermodern, technological *chronos*, the 'always-synchronised time of life, society and world history'? (Stevens 2016: 188) The focus of this chapter is the production of Coordinated Universal Time (UTC), the foundation of global broadcast and civil time since 1961.

The first section of this chapter explains what is being governed and why. A brief historical review establishes the context and development of UTC and shows how the *times of the universe* are translated into the *time of the world* for the purposes of global synchronisation and communication. The second section identifies the *key actors and mechanisms* involved in UTC and therefore in the global governance of time. This includes a range of intergovernmental organisations, non-state actors and expert networks. The third section introduces some issues and problems arising from this form of global governance, particularly those surrounding 'leap seconds'. The chapter concludes by suggesting possible avenues of enquiry for IR and global governance scholars concerned with the political construction and contestation of time and temporality in the contemporary world.

A Brief History of Time

Coordinated Universal Time (UTC) is the basis for worldwide broadcast and civil time. It informs multiple time scales from Global Positioning System (GPS) time and internet time protocols to radio time signals and national speaking clock services. It is the most widely used global time scale and underpins every imaginable human activity relying upon precise time reckoning at the local, national and global levels. The production of UTC demonstrates that global time is not a matter of simply 'reading off' time from the universe but is a process of assembling and negotiating different ways of calculating and thinking about time. This section outlines the essential scientific dynamics of this process; the subsequent section will explore in greater detail the actors responsible for the production of UTC and the global governance of time.

The foundation of UTC is the second, the base unit of time in the International System of Units (SI) and the basis of all modern time-reckoning and measurement. Since at least the 15th century, seconds, minutes and hours have been calculated as divisions of the solar day, itself derived from astronomical observations of the Sun 'rising' or 'setting' relative to fixed terrestrial markers. The precise length of the solar day changes due to geological, astronomical and relativistic factors; units derived from its length have therefore always been somewhat approximate. Nevertheless, the calculation of the *mean solar second* as 1/86,400th of a mean solar day not only persisted into the twentieth century, but in 1935 was adopted by formal international agreement as the fundamental scientific unit of time (Kennelly 1935).

By 1928, the mean solar second was informing Universal Time (UT), a global time scale therefore also derived from the axial rotation of the Earth relative to the Sun. The recognition that the length of the solar day fluctuated led to the development of new time scales that took account of factors like atmospheric drag, the gravitation of the Moon and a slow but discernible deceleration in axial rotation speed.[1] One such was Ephemeris Time (ET), adopted in 1952 by the International Astronomical Union, and calculated not on the length of the solar day but on the duration of the Earth's annual transit around the Sun (i.e. the year). In 1960, the 11th General Conference on Weights and Measures (CGPM), which adjudicates on international metrological issues, further refined this 'ephemeris' second as a fraction of the length of the baseline year 1900. This marked a formal shift from using observed solar time to derive the SI second – and, therefore, global time scales founded on the second – to its definition through Newtonian celestial mechanics and, subsequently, by other techniques that accounted for the effects of relativistic motion. All were calculated with reference to physical and observable objects amenable to visual identification and measurement.

In 1967, the 13th CGPM adopted the *atomic second* as the SI base unit of time. Advances in atomic clock technology presented more precise means of establishing consistently the duration to be known as a 'second'. Global time was tethered for the first time not to the observable passage of astronomical objects but to invisible radioactive events, specifically the frequency of oscillations of the caesium-133 atom (Audoin and Guinot 2000).[2] The new International Atomic Time (TAI) surpassed astronomical time in accuracy but for reasons of continuity with the existing system the specific qualities of the atomic second were chosen to match that of the ephemeris second. However, these two values have since drifted apart, not least due to the persistent slowing of the axial rotation of the Earth. The challenge for the new Coordinated Universal Time (UTC), introduced in 1961, was to harmonise astronomical time (UT) with atomic time (TAI) to produce a time scale (UTC) that could be used by all the disparate communities dependent upon accurate time measurement. Then as now, laboratory-based sciences preferred atomic time—on account of its regularity and reliability—whereas spatially dependent activities like astronomy and navigation required time derived from solar and other forms of astronomical time-reckoning. The very existence of UTC can be read as an attempt to reconcile divergent disciplinary requirements under a unifying temporal rubric.

Various experiments were undertaken throughout the 1960s to implement irregular 'jumps' or 'time steps' of fractions of seconds in TAI to align it with UT and therefore to be harmonised within UTC. Stepped Atomic Time (SAT), for instance, 'ticked' at an identical rate to TAI but interpolated jumps of 200 milliseconds to keep it synchronised with UT. Measures like SAT failed to resolve the situation and global time continued to be reliant on two 'seconds' of slightly different length, one of whose length also varied. Proposals emerged that all UTC and TAI seconds should correspond to the SI definition and that any changes to UT should be via the addition or subtraction of integer (whole) seconds to keep astronomical and atomic time coordinated. On 1 January 1972, this system of 'leap seconds' was inaugurated formally and continues to keep the offset between UT and TAI to an integer value that makes the calculation of UTC more straightforward and respectful of both atomic and solar time scales.[3] Leap seconds have been described as a ‘crude hack’ (Kamp 2011) in the structure of time and are in effect a metrological response to the heterotemporality of technological time-reckoning. One fundamental distinction is between times derived from atomic sources and those from astronomical observation, which, despite their superficial similarity, are quite different qualitatively and quantitatively. The foregoing abridged description does not exhaust this heterotemporality, as many other time scales exist, but three key observations emerge from the brief discussion of UTC alone. First, there is no single global time scale for the unequivocal reckoning of time. This is because of the relativistic nature of time itself: what we think of as objective time cannot simply be ‘read off’ a physical universe in which all time is local if it exists at all (Barbour 1999). The atomic second was mapped to the solar second, not the other way around, and, as the two diverge in quantity, ways must be found to account for and accommodate those changes. This leads to the second point, that global time – in this case, UTC – is a matrix of competing times based on different calculations, techniques, material objects and practical imperatives that must be negotiated and, ultimately, governed. The third observation is that temporal or, perhaps better, *global chronometric governance* is enacted in and through assemblages of actors and institutions. Who or what these are, and how they do it, is the topic of the following section.

Actors and Mechanisms in Global Chronometric Governance

Space precludes an extended discussion of global governance but its central intended meaning in IR is the description and explanation of the multiple activities that result in coordinated political action at the global scale, in the absence of a world government (Rosenau and Czempiel 1992). The emergence of global governance as an analytical lens coincided with globalisation and the end of the Cold War and indicated a concomitant commitment to exploring new ways of ordering in a post-bilateral world (Zumbansen 2012: 84). Historically, however, global governance as political *practice* has a longer heritage than its recent analytical introduction suggests. The global governance of time, for instance, dates to the 1870s and 1880s and to the first international attempts to harmonise and standardise scientific and technological ways and means on a global scale (Mazower 2012). The global governance of time *pre*-dates many other forms of global governance and, indeed, has made many of them possible. These early attempts to govern global time were contested, for reasons of national pride as much as disagreement over technical standards and scientific accuracy. Having failed to convince the British and Americans to adopt the metric system of measurement it developed, France abstained from voting for the adoption of Greenwich Mean Time at the International Meridian Conference (1884). Paris Mean Time would instead persist into the twentieth century, an awkward nine minutes and 21 seconds out of step with the rest of the world (Palmer 2002). The governance of time has always been a key aspect of modernity and continues to be highly political, if not always rendered as such.

Specifically, the study of global governance has four principal concerns: the global nature of contemporary problems and their potential solutions; the agency of non-state and transnational actors; the conception of ‘order’ as a dynamic phenomenon having diverse foundations other than political-legal authority; and, a normative concern with how best to effect positive sociopolitical change (Hofferberth 2015: 601). These four aspects are discernible in the discussion of global chronometric governance. Its essential purpose is to translate the unruly localism of all possible times into one unifying time with which the world can transact its business. It does this through state and non-state actors acting transnationally across borders and continents. The order so derived is contingent principally on domains of scientific knowledge rather than political-legal authority and is informed by normative concerns, the contestation of which will be discussed in a later section.

This section will focus on what Avant *et al.* (2010) call ‘global governors’. These are ‘authorities who exercise power across borders for purposes of affecting policy’, and who ‘create issues, set agendas, establish and implement rules of programmes, and evaluate and/or adjudicate outcomes’ (Avant *et al.* 2010: 2). This attention to agents and agency within global governance structures emphasises the constructed and dynamic nature of global governance, in which ‘[n]othing is ever governed once and for all time’ (Avant *et al.* 2010: 17) but is subject to iterative processes of mediation and negotiation. Whilst this is true of chronometric governance too, the persistence of many of the key actors is striking. For instance, The *Convention du Mètre* (Metre Convention) of 1875 brought into being three intergovernmental organisations to coordinate international metrology and internationalise what was originally the European metric system. Since 1960, they have also been responsible for maintaining the International System of Units (SI). The senior decision-making body is the General Conference on Weights and Measures (CGPM), which meets every four to six years to discuss and adjudicate on significant metrological issues. One instance was mentioned previously, the adoption of the atomic second by the 13th CGPM in 1967. More recently, the 25th CGPM discussed but did not decide on the redefinition of the kilogram, the last remaining SI base unit derived from a physical artefact rather than a physical constant (Karol 2014). The CGPM is advised by an expert panel that meets annually, the International Committee on Weights and Measures (CIPM), which also informs the work of the third organisation, the International Bureau of Weights and Measures (BIPM), of most concern here.

One of BIPM's many roles is to ensure the proper administration of Coordinated Universal Time (UTC), although the technical specifications for doing so are defined by the International Telecommunications Union (ITU), a specialist agency of the United Nations. This requires that the BIPM produces a time scale accurate to within one-tenth of a second (ITU 2002). The ITU fulfils this slightly incongruous role on account of its historical status as the regulator of the shortwave radio networks through which global time scales were disseminated prior to satellites and the internet (Beard 2011). Like the BIPM and its peer organisations, the ITU has its origins in 19th-century international attempts to regulate scientific and technological issues and its earlier incarnation, the International Telegraphy Union, should probably be considered one of the first public international unions (Mazower 2012: 102). It was founded in 1865 and is still the world's premier forum for the global governance of information and communications technologies, even if it no longer enjoys universal support.

BIPM produces UTC from a combination of International Atomic Time (TAI) and Universal Time (UT). As described previously, UT is defined by the rotation of the Earth, based originally on astronomical observations but now calculated on measurements provided by satellites. Since 2003, the principal form of UT has been UT1, produced by the International Earth Rotation and Reference Systems Service (IERS), the various components of which are distributed across the US, Europe and Australia.[4] The IERS Sub-bureau for Rapid Service and Predictions of Earth Orientation Parameters located at the US Naval Observatory (USNO) in Washington, DC, publishes a weekly forecast of the next year's daily values of UT1 in its weekly Bulletin A. These values are derived from data obtained by a variety of large-scale observational techniques, including Very Long Baseline Interferometry (VLBI), GPS satellites, Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR), which requires collaboration with multiple scientific institutions and organisations.[5] IERS also publishes Bulletin C, which provides six months' notice of the introduction of leap seconds. Since leap seconds are principally to keep the offset between TAI and UT1 to an integer value, Bulletin C is the primary document of concern to the BIPM's calculation of UTC.

UT1 gives UTC the 'time' we recognise intuitively, calculated from the rotation of the Earth, but atomic time (TAI) gives it stability. The initial step in calculating TAI is the production of 'free atomic time' (*Échelle atomique libre*, or EAL), which is obtained from over 420 atomic clocks based at 72 time laboratories on every continent except Antarctica.[6] These communicate with each other via a complex array of navigation and communications satellites, a 'time transfer' system managed by BIPM but locally calibrated by various actors, including manufacturers of atomic clock technologies. TAI is calculated by comparing EAL to primary frequency standards calculated by atomic clocks like the NIST-F1 at the US National Institute of Standards and Technology (NIST) laboratory in Boulder, Colorado.[7] This newest generation of atomic clocks is accurate to fractions of a second over geological time scales and continues to improve. If EAL drifts from these standards, a correction is applied at the level of nanoseconds and TAI is produced. The final step in calculating UTC involves the addition of leap seconds from IERS Bulletin C to UTC when necessary. At present, each terrestrial day is about 2.5 milliseconds longer than the last, while atomic time remains constant. This incremental lengthening equates to approximately one second per year, requiring the addition of a leap second every one or two years, always in June or December.

The resulting UTC values are disseminated in BIPM's monthly Circular T, which allows participating laboratories to adjust their local time scales. A curiosity of the system is that it is not possible to know the precise value of UTC at any given time or place: there is no absolute value or physical artefact to which reference might be made. Local values known as UTC(k) can be tracked at particular laboratory sites but UTC is only approximate on account of its compiled nature. Since 2013, the BIPM has released a weekly 'Rapid UTC' solution (UTCr), to enable more frequent steering of local atomic clock times, with an error relative to UTC of less than two nanoseconds. BIPM also publishes TT(BIPM), a realisation of Terrestrial Time defined by the International Astronomical Union (IAU) and used for location-dependent astronomical purposes.

A picture emerges that demonstrates the constructed nature of global time and the complex actor-networks that enable its production. These include intergovernmental organisations, expert groups, national and independent laboratories, international scientific collaborations and equipment manufacturers. Crucially, they also rely on a global material infrastructure that includes satellites and scientific observational facilities, digital texts and memoranda, computer networks and atomic clocks, and the supply chains that support them. The machinery of chronometric governance is a sociotechnical infrastructure that in turn supports the greater undertakings of other large technical systems (Mayer and Acuto 2015). The present description of this infrastructure is necessarily brief but illustrates how extensive and pervasive in space *and time* is this network of chronometric endeavour.

Issues and Problems

The preceding narrative might easily give the impression that chronometric governance is a principally technocratic form of global governance in which intergovernmental organisations like the BIPM and ITU rub along in frictionless harmony with public scientific bodies, research institutions and specialist industries. This would be understandable, although misplaced. After all, the product of their mutually reinforcing activities is precisely that which they intend: a global time scale of utility to diverse practitioners, commerce, communications and which affords all the peoples of the world a firm reference point upon which to found their localised temporal practices, including, most visibly, national time zones and calendars. However, the mention of time zones reminds us that time is always exploitable, on account of its essentially constructed nature. Time zones are marked by abstract longitudinal lines that can be shifted to suit political and economic priorities, which also shift in time and space. North Korea's recent adoption of 'Pyongyang Time' – a snub to historical Japanese imperialism – is but the latest example of political manipulation of time zones (Harding 2015). In 2013, Samoa shifted the International Date Line eastward, bringing the country closer in time to its Australasian major trading partners and reversing a 19th-century decision that had taken it the other way (BBC 2011). In 2007, Venezuelan president Hugo Chavez shunted the national meridian westwards and national time thirty minutes back into a 'fractional time zone', ostensibly seeking 'a more fair distribution of the sunrise' (Reuters 2007). In 1949, Mao Zedong dispensed with the five time zones respected by the ousted nationalist government, unifying China into a single national time that persists today, despite its inconvenience to far-flung western provinces (Hassid and Watson 2014). The de facto adoption by western Uighurs of their own 'Urumqi Time' in resistance to 'Beijing Time', for example, continues not to be recognised by a Party-state concerned more with centralising control over 'national unity' than with respecting claims to provincial and ethnic autonomy (Schiavenza 2013).

States can elect to change national time, or to reject or embrace other measures like daylight-saving time, but they cannot easily opt out of the structures of chronometric governance. Technically, most countries are not signatories to many of the treaty instruments that govern time and other international standards – from the 1875 Metre Convention onwards – but they abide by those standards and implement changes when handed down by intergovernmental organisations like the BIPM and the International Organisation of Legal Metrology (OIML). Nor are the ordinary decisions of the ITU binding on its members unless implemented in national law. It is not legal sanctions that deter states from leaving but the benefits of 'membership' that make them stay (see Prakash and Potoski 2010). It is difficult to imagine any state wanting or being able to leave the system of global chronometric governance, given the imbrication of temporal standards with the sociomateriality of everyday life and national activity. This is not to condone the apparent homogenisation of global time through this system of global governance but it is to note the potency of its integrating logic.

As noted previously, the global temporal assemblage is more heterogeneous than perhaps meets the eye. Time is constructed but it is also contested, as a century-and-a-half of unresolved chronometric issues attests. Interest groups within the expert communities of metrologists and other scientists compete to produce temporal regimes most amenable to their interests. For many years, one such field of contention has been the issue of leap seconds. In 2015, leap seconds are, if not headline news, certainly a matter of public and therefore political concern. Since their formal inception in 1972, twenty-six leap seconds have been intercalated to align atomic time and astronomical time.[8] The most recent leap second was inserted at midnight on 30 June 2015. On that date, the stroke of midnight occurred twice, as clocks rolled over from 23:59:59 to 00:00:00 via 23:59:60, a phantom midnight that only exists on those occasions – about once every eighteen months – a leap second is required (BBC News 2015). There are ongoing discussions over whether to abolish leap seconds. Technically, this will depend on the redefinition (or not) of the word 'day'. Under a host of extant international agreements, a day is defined with reference to the rotation or location of the earth relative to the sun. To abolish leap seconds would require the decoupling of the day from the sun and linking it permanently to atomic time.

Abolitionists argue the link to solar time is no longer necessary on account of GPS and other satellite navigation systems that support location-dependent technologies like navigation and astronomy. They also make a strong case that leap seconds pose a threat to time-dependent technologies like the internet that were not designed to accommodate discontinuous time jumps. Serious disruptions to global communications networks and dependent technologies like banking and air traffic control have yet to occur when leap seconds have been added but the argument is that they might (Kamp 2011). Given the impossibility of re-engineering the internet, for instance, and the relative simplicity of abolishing leap seconds, this is a convincing argument to many. Proponents recognise that atomic and solar time will drift apart – albeit slowly – and argue that money is better spent preparing for occasional, longer time jumps (minutes or more) than on more frequent leap seconds introduced often at very short notice. Opponents argue that location-dependent tasks will require huge investments in software and hardware to allow for the continual divergence of solar and atomic time. Government consultations suggest that some members of the public recognise that leap seconds represent 'a symbolically important link with our past' (OPM Group 2014: 6). At the November 2015 World Radiocommunication Conference in Geneva, the ITU decided to retain leap seconds and therefore continue this link between atomic and solar time (ITU 2015). However, it also committed to further investigation into the feasibility of a new reference time scale, leaving open the possibility that there may be in future a final move towards a fully technological *chronos*.

Conclusion

This contribution to the emerging literature on time and temporality in International Relations introduces the idea that global time, principally Coordinated Universal Time (UTC), is the product of global governors operating in and through sociotechnical assemblages. Global chronometric governance constructs UTC as a useful and unitary global time but this provisional analysis suggests that aspects of the global governance of time are contested. The example given here is of leap seconds but there are other topics that could be explored. The task of IR is to explore the modalities and topologies of global chronometric governance in order to better discern the activities and normative priorities of global governors and the constraints and opportunities provided by the structures of global chronometric governance. This is partly a matter of methods, as many of the actors involved – especially the ITU – operate under conditions approaching diplomatic secrecy and are somewhat opaque to outside observers. Careful empirical work is required to construct models of chronometric governance that can be tested against theories of global governance in IR.

Explorations of this type can also help to extend and strengthen our understanding of the mutually co-constitutive relations between time and politics. It is insufficient to identify the political nature of global time through its status as an object of global governance without also recognising the temporal nature of global politics. World politics is, as Kimberly Hutchings asserts, 'a shifting and unpredictable conjunction of times' (Hutchings 2008: 176), unified only by the analytical lens chosen to examine them. There is no pristine ontological *chronos* but rather a heterotemporal assemblage of times and temporalities that is both the cause and outcome of political behaviours seeking to maximise self-interest and effect social change. Time is not a 'background condition' of global life but is 'socially constructed and therefore amenable to manipulation by human agency' (Porter and Stockdale 2015: 12). As this discussion of UTC aims to have shown, this manipulation extends to the scientific and technocratic construction of global time, derived from modern physics as much as ancient astronomy.

The purpose of the present enquiry is to provide empirical support for the proposed heterotemporality of global time, an inherently political activity about a richly textured political 'object'. If we accept its political nature, how else do we open up this particular 'black box' to scrutiny and critique? What avenues of contestation are available, if indeed such a thing is necessary? What does it mean in the present discussion to cast off from our nearest star and look inwards to the oscillations of an invisible atom? Does it matter if pragmatism trumps philosophy? These are all questions that might be addressed through further exploration of the global governance of time.

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[1] The following account is drawn principally from Nelson *et al.* 2001.

[2] The second is defined in the SI system as 'the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom' (BIPM 2006: 133).

[3] This is summarised by the basic formula, UTC = TAI – leap seconds. The leap seconds ensure that UTC (essentially an atomic time) never differs from solar (or rotational) time (UT1) by more than 0.9 seconds.

[4] http://www.iers.org/IERS/EN/Home/home_node.html.

[5] http://www.usno.navy.mil/USNO/earth-orientation/eo-info/general/input-data/input-data-series-used-in-iers-bulletin-a.

[6] http://www.bipm.org/en/bipm/tai/tai.html.

[7] http://www.nist.gov/pml/div688/grp50/primary-frequency-standards.cfm.

[8] See, http://maia.usno.navy.mil/ser7/tai-utc.dat.

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