

出國報告（出國類別：其他）

# 出席國際度量衡大會第 24 屆大會 報告

服務機關：經濟部標準檢驗局

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派赴國家：法國

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## 摘 要

第 24 屆國際度量衡大會(CGPM)於 100 年 10 月 17 日至 21 日在法國巴黎之世界動物衛生組織總部舉行，本次會議計約有 37 個正會員，11 個仲會員共 137 人與會，會議重點包括 CIPM 主席工作報告、討論提案並通過重要決議及諮詢委員會報告。

重要報告及決議為國際度量衡局(BIPM)未來以環境變遷、能源依賴、食品安全及醫療衛生等議題為發展重點，其工作計畫最優先為是公斤的重新定義，其次是維持時標的運作、發展高能量光子輻射劑量標準設備及擴展有機化學及莫耳質量領域；會議建議以國際地面參考系統作為衛星地位的唯一國際參考系統，建議政府間任何有關碳交易的制度能承諾其相關的量測活動須追溯至 SI，與國際照明委員會簽署合作協定以確保與光及光輻射等相關量測可追溯至 SI，與國際組織世界氣象組織簽署 CIPM MRA，可確保氣候變遷的挑戰將採用計量的實務。

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## 壹、目的

米制公約 (Metre Convention) 為計量標準領域之政府間協定，1875年5月20日17個國家在法國巴黎簽署簽署後正式生效，1960年將其建立的單位制度重新命名為國際單位制(International System of Units, 簡稱SI)；在米制公約下產生三個國際組織以監督和維持米制標準；國際度量衡大會 (General Conference on Weights and Measures, 簡稱CGPM) 是最高的權力機構，每4年召開1次大會，由各會員國的政府派代表參加，主要係聽取國際度量衡委員會的工作報告，並討論國際單位制之改進及推展等事項，及審查會員國最新研究發展出來的量測標準。目前米制公約共有55個會員國 (Member States) 及25個仲會員 (Associate States)。

國際度量衡大會選出18位代表組成國際度量衡委員會(International Committee for Weights and Measures, 簡稱CIPM)，國際度量衡委員會每年集會1次，負責監督國際度量衡局(International Bureau of Weights and Measures, 簡稱BIPM) 的業務，並執行米制公約及CGPM的決議事項，此外，它並成立10個不同領域的諮詢委員會，提供各項量測技術諮詢。

另外，亦藉由推動國際度量衡委員會相互認可協定 (CIPM MRA)，使簽署MRA之國家計量機構(National Metrology Institutes, 簡稱NMIs)，承認彼此國家量測標準之等同程度及所核發校正證書的效力。目前CIPM MRA共有來自50個會員國、34個仲會員國及經濟體，及3個國際組織的87個NMI代表簽署。我國於91年加入國際度量衡大會成為仲會員，並簽署CIPM MRA，該相互認可協定同時列名的包括量測技術發展中心、核能研究所及中華電信研究所等3個NMI執行單位。

國際度量衡局的局址設在法國巴黎近郊塞佛爾，位於巴黎近郊的Sevres市，是一個永久性的科技實驗室，成立的宗旨是在確保計量科學的發展及國際度量衡標準的一致性。對於與法國政府有外交關係且願意支付予國際度量衡局年費之國家，可申請成為會員國。

出席此次會議目的在於瞭解到國際度量衡大會運作、國際度量衡委員會的工

作報告、國際度量衡局未來工作計畫與重點及諮詢委員會的工作報告，可藉由參加此一會議，瞭解國際間有關計量標準發展情形與未來趨勢，並藉與各會員國代表交流，以建立合作關係。

## 貳、過程

### 一、會議概述

第 24 屆 CGPM 於 100 年 10 月 17 日至 21 日在法國巴黎之世界動物衛生組織總部舉行，會期五天，本次會議計約有 37 個正會員，11 個仲會員共 137 人與會，相關國際組織與機構 OIML 及 ILAC 等亦派代表與會。我團除經濟部標準檢驗局趙靖平簡任技正外，尚有工業技術研究院量測技術發展中心段主任家瑞及及國家度量衡標準實驗室彭組長國勝一行共 3 人。會議重點包括 CIPM 主席 **Barry Inglis** 工作報告、討論提案並通過重要決議及諮詢委員會報告。

### 二、CIPM主席工作報告

- (一)BIPM 的主要使命是達成全球量測的一致性，為加強 BIPM 快速回應國際社會需求的能力，有關環境變化、能源依賴、食品安全以及醫療衛生等議題均仰賴精確的量測，此為 BIPM 現行的發展重點。
- (二)BIPM 的工作計畫中，最優先是公斤的重新定義，將持續發展瓦特天平以促使能應用物理常數取代實物公斤原器；其次是維持時標(time scales)的運作、發展高能量光子輻射劑量標準設備以滿足癌症治療儀器之追溯需求、擴展有機化學及莫耳質量領域，以符合臨床醫學、藥物及食品安全的需求。
- (三)目前聯合國工業發展組織(UNIDO)在 BIPM 的建議下，資助一些計畫以協助開發中國家預備成為 CGPM 的仲會員，並簽署 CIPM MRA；國際組織世界氣象組織(WMO)於 2010 年 4 月 1 日簽署 CIPM MRA，此可確保氣候變遷的挑戰將採用計量的實務。
- (四)BIPM 和 WMO 合辦研討會，結論為藉由衛星遙測或地面監測進行氣候變遷和地球資源平衡的量測，該量測必須追溯至 SI，以確保能獲得持續且高品質的長期資料。而氣象單位必須持續確認其量測需求並與 NMIs

溝通。

- (五)鑑於奈米科技應用廣泛，如何確保安全且負責任的引用這項新技術，未來 BIMP 將在這方面繼續努力。
- (六)國際法定度量衡局 (BIML) 與 BIPM 之間的合作，不排除未來 BIML 遷址至 BIPM 合署辦公或進一步合併，唯仍有待雙方進一步溝通。
- (七)BIPM 目前以 ISO 17025 維持其量測服務之品質系統，在 2010 年已重新修訂品質手冊，並將進一步將其校正與量測服務的量測不確定度公布在網站。
- (八)BIPM 與國際實驗室認證聯盟 (ILAC) 的合作，共同採用”校正與量測能力”的共通定義，取代以往”最佳量測能力”之定義，以避免引用混淆。

### 三、重要決議

本次會議重要決議如次：

- (一)為建立新的策略方向，授權由 CIPM 主席召集成立特別工作小組，重新檢視 BIPM 的使命、目標、財務穩定性及管理機制等，於 2012 年向 CIPM、米制公約會員國及 NMIs 提出檢視結果，CIPM 並據以於形成行動方案，在下屆大會提出報告。
- (二)鑑於米制公約會員國已增長至 55 國，且大部分國家均設立 NMI，為使 BIPM 與各國 NMI 在計量研究活動上須產生互補性，並加強彼此間關係形成更好的綜效 (synergy)；決議將由 CIPM 審視與各會員國間的協議，並與 NMIs 直接對話與討論及與政府代表非正式會議後，提出建議方案送交下屆大會決議。
- (三)有關接受經濟體成為仲會員，CGPM 的認定條件係(1)必須為一領域實體 (Territorial Entity)(2)該領域實體必須擁有自己的 NMI(3)該領域實體參與 BIPM 的活動必須對強化世界量測體系有所助益。因此，政府間國際組織 (Intergovernmental organization ,IGO) 非屬領域實體；唯加勒比海共同體 (CARICOM) 係採用認定條件前加入，仍接受為一仲會員，並請 CIPM 對 IGO 參與 BIPM 活動研究妥善方式，於下屆大會時提出。
- (四)決議目前的仲會員於 2013 年當年起計，逐年增加其年費並於五年內持續增加至成為正會員應付年費的 90%，且符合 2010 年 CIPM 會議之評估

仲會員可否成為正會員的條件，即(1)仲會員的 NMI 參與簽署 CIPM MRA(2)比對結果於關鍵比對資料庫(KCDB)網頁登錄與公布 (3)有一項或多項量測能量(CMC) 登錄 KCDB 上者，則仲會員可申請成為正會員。若仲會員目前支付年費已達成為正會員之額度者，則上述逐年增加費用之決議將不適用。

- (五)促請 NMIs 增加員額參與 BIPM 專案中有利雙方的計畫，請各會員國、國際組織、民間組織或基金會以經費支持 BIPM 相關活動。決議 2013 年之支持經費為 11,577,000 歐元，2014 年為 11,693,000 歐元，2015 年為 11,810,000 歐元。
- (六)已積欠會員會費達六年以上之米制公約會員國，必須在 12 個月內與 CIPM 訂定重新付款協議，若屆時未完成者將自動除名，CIPM 將代表 CGPM 以書面方式經由法國外交部轉知各該欠費會員國及各米制公約會員國。
- (七)為回應各國政府對碳交易的重視，若干 NMI 亦投入支持“碳經濟”的相關研究及活動，BIPM 於 2013 至 2016 的量測議題將著重在氣候變遷及全球暖化。建議政府間任何有關碳交易的制度能承諾其相關的量測活動須追溯至 SI，NMIs 持續發展量測系統使生質燃料製程及碳封存 (Carbon sequestration)的監控能追溯至 SI 並以國際等同的方式辦理。
- (八)有關測時與測距之全球衛星定位系統數量逐年增加，採用共同的參考系統(Reference System)在定位的一致性及系統相容性上將有利於使用者，建議採用現已存在的國際地面參考系統 (International Terrestrial Reference System, ITRS)作為所有計量應用上的唯一國際參考系統。
- (九)鑒於光頻標準已有重大進展，NMIs 業已投入雙邊比對，國際比對能力則尚待建立；建議 NMIs 投入資源於光頻標準的發展及比對，BIPM 將以專案方式協調整合參與的 NMIs，建立光頻標準的比對能力。
- (十)請 CIPM 持續努力於以物理常數重新定義 SI 基本單位的工作，盡可能以更容易讓使用者瞭解的方式描述，同時亦能符合科學的嚴謹性及明確性；請 CIPM、諮詢委員會、BIPM、OIML 及各 NMI 能透過各項活動促使大眾知曉。

#### 四、諮詢委員會工作報告

##### (一) 長度諮詢委員會 (CCL)

1. 依據CIPM的建議，CCL於2009年成立新的工作小組架構，包括(1)策略小組：主要為觀察CCL新架構的運作、長度的長期研發活動及提出CCL的長期計畫(2)MRA小組：主要為協調關鍵比對相關事宜(3)奈米小組(4)與時間及頻率諮詢委員會(CCTF)成立的聯合工作小組。
2. 已完成的第一輪的關鍵比對及RMO關鍵比對，目前正進行第二輪的關鍵比對包括塊規及角度塊規。
3. 有關奈米計量先期研究方面，正進行中的部分為線寬，完成的部分為階高、線刻度、1維及2維光柵線距。此先期研究成果將發布在關鍵比對資料庫作為CCL的輔助比對結果。

##### (二) 質量諮詢委員會 (CCM)

1. CCM的工作重點為全球量測標準的提升、關鍵比對/CIPM-MRA、公斤的重新定義、亞佛加厥常數不確定度的改善。
2. 關鍵比對由工作小組進行，並由CCM負責協調工作。
3. 有關公斤的重新定義，為獲得理想之不確定度，至少仍須進行三項獨立實驗，包括瓦特天平及亞佛加厥協調計畫等工作；由不同實驗所獲得的常數在百分之九十五的信心水準下須具一致性。

##### (三) 電磁諮詢委員會 (CEM)

1. 監督及協調關鍵比對為CEM的核心業務，過去四年在電磁領域約進行90個關鍵和輔助比對。對BIPM電量部門監督和建議的重要活動為瓦特天平的進展(此部分須與質量部門合作)。
2. 於2009年，有15個NMI表達有意願與BIPM進行約瑟芬電壓(Josephson voltage)比對；14個NMI希望於2012年開始與BIPM進行量化霍爾電阻(quantum Hall resistance)比對。
3. 目前BIPM進行中的電量關鍵比對包括1.018 V及10 V約瑟芬電壓標準、



1.018 V及10 V積納電壓標準、量化霍爾電阻標準、1歐姆及10歐姆之電阻標準和10 pF及100 pF之電容標準，這些比對將使NMI能展現其量測能力。

#### (四) 溫度諮詢委員會 (CCT)

1. CIPM於2010年會議接受CCT提出的三項建議包括(1)CCT的使命(2)克耳文(kelvin)的重新定義(3)氣候及氣象觀察之量測。
2. 有關溫度基本單位克耳文的重新定義，過去三年在決定溫度的物理常數即波茲曼常數(Boltzmann constant)K上有卓越進展，唯K值量測仍需約兩年的實驗，使其量測不確定度小於目前的值。
3. 目前進行中的關鍵比對包括(1)濕度標準的比對-露及霜點溫度(2)潮濕氣體的露點溫標(攝氏30至90度)比對。

#### (五) 光學及輻射諮詢委員會 (CCPR)

1. 照明產業的挑戰為使用新的節能光源，新的視覺模型及新的光量測設備以降低照明的電能消耗量從現在的20%至一個可接受的水準。
2. 2007年國際照明委員會(International Commission on Illumination, CIE)與BIPM簽署合作協定以確保與光及光輻射等相關量測可追溯至SI，同時確保量測程序的認可及接受性。

#### (六) 游離輻射諮詢委員會 (CCRI)

1. 游離輻射主要應用於醫學診斷及治療、核能安全等，目前有關(1)物理放射性核種量測、(2)x-rays、gamma-rays及帶電粒子(3)中子計量(Neutron metrology)為重要工作並進行199個相關比對。
2. CCRI的策略方向係成為游離輻射計量的全球中心，此需要透過與機構利害關係者合作及與最終使用者溝通來達成。策略方案內容包括(1)範圍、使命及任務(2)利害關係者(3)2020年願景(4)短中長期行動計畫等，並成為未來CCRI工作報告的參考文件。

#### (七) 物量諮詢委員會 (CCQM) - 化學計量

1. CCQM的工作小組包括有機分析、無機分析、氣體分析、電化學分析、表面分析、生物分析、微生物特別指導小組等。
2. 2008年全球食品的出口達約1兆1千億美金，其中20%至30%的食品損失肇因於微生物損壞，近年來許多NMI均要求建立可靠的微生物量測能力。
3. CCQM與外部組織的合作包括與WHO, WMO, ILAC, JCTLM (IFCC and ILAC) 與EU、APEC、美國、日本的合作著重在食品安全、醫療保健、環境控制/氣候變遷、能源及奈米材料。

#### (八) 聲學、超音波及振動諮詢委員會 (CCAUV)

1. 應用於地震偵測、油探勘及建築物振動管制之低頻振動監測裝置可確保人身安全及保護財產，NMIs有必要提供低頻之校正能量，CCAUV則負責國際低頻振動比對。
2. 目前由NIM (中國大陸) 及 NMISA (南非)開始進行的低頻振動比對，將可確保達0.1Hz低頻振動標準的追溯性及國際等同。
3. 美國聯邦食品藥物管理局資料顯示市售的超音波設備並未完全發揮其功效；若超音波設備未定期與參考標準比對，則醫學診斷或治療的效能將降低。

#### (九) 單位諮詢委員會 (CCU)

1. 傳統SI單位的表示，係以基本單位(m, kg, s, A, K, mol, cd)及導出單位為主，而目前7個基本單位的選擇主要係歷史因素而非邏輯性，Draft Resolution A建議未來以7個參考常數(reference constants)的值來定義基本單位。
2. 本委員會建議仍同時維持基本單位和導出單位的表示，以保留傳統用語的歷史連結；同時改變7個基本單位的次序為s, m, kg, A, K, mol, cd，使次序上前一個單位的定義不會包括後一個單位。

#### (十) 時間及頻率諮詢委員會 (CCTF)

1. 已於本屆CGPM建議採用國際大地測量學與地球物理學協會 (International Union of Geodesy and geophysics ,IUGG) 所定義，國際地球自轉和參考系服務(International Earth Rotation and Reference Systems Service,IERS)所實現的國際地面參考系統 (International Terrestrial Reference System,ITRS)作為所有計量應用上的唯一國際參考系統。
2. 目前的時頻比對方法(包括衛星雙向傳時、GPS載波相位傳時技術)等不若光標準準確，隨光鐘的進展，有關”秒”的重新定義可付諸討論。

### 參、心得及建議

#### 一、留意國際度量衡局(BIPM)的發展重點，適時規劃建置相關計量標準

BIPM 未來以氣候變遷(全球暖化)、能源、食品安全及醫療衛生等議題為發展重點，尤其因應全球暖化之節能減碳所產生之碳交易議題，BIPM 希望各國政府承諾相關的量測活動須追溯至 SI。建議可適時留意後續發展狀況並持續蒐集相關資訊，俾便適時規劃相關計畫或建立相關量測能力，例如透過能源計量標準技術發展計畫，投入能源化學計量標準之先期研究時，可參酌 BIPM 或各國相關進展現況，進行溫室氣體原級計量標準系統技術可行性評估，使系統完成後可落實國內溫室氣體的盤查作業。

#### 二、有關以物理常數重新定義質量公斤，宜注意其進度並適時規劃因應

有關以物理常數重新定義質量公斤，為獲得理想之不確定度，至少仍須進行三項獨立實驗，包括瓦特天平及亞佛加厥協調計畫等工作。鑒於我國國家度量衡標準實驗室主要係在建立維持與國際一致的國家最高量測標準，雖屆時公斤原器之追溯仍將維持，唯定義之改變對實現方法及追溯鏈之影響，仍應繼續注意 BIPM 進度並適時規劃因應，以與國際接軌。同時，可適時將重新定義之訊息發布，使科技、產業界及民眾知曉及因應。

#### 三、鼓勵國家度量衡標準實驗室持續參與國際計量標準相關活動，提升國際地位

國際間各度量衡標準實驗室藉由參加關鍵比對或參與合作計畫以展現該實驗室之能力；為提升我國家度量衡標準實驗室之能力，可透過每年國家標準實驗室運作計畫，以績效指標持續鼓勵實驗室發表國際期刊論文、參與國際研討會、參與國際計量組織活動及參與國際量測比對，使我國國家標準實驗室之能力為國際所認可。例如本年透過建立及維持國家時間與頻率標準計畫使我國林晃田博士獲選為 APMP 之 TCTF(時間與頻率技術委員會)主席，此為國際間對我國國家時間與頻率標準實驗室能力之肯定與實驗室多年參與國際合作及技術交流之成果，具體提升我國計量標準領域之國際地位。

## 肆、附錄

### 附錄 1、第 24 屆 CGPM 議程表

日期	議題/活動
<u>10/17</u> 10:00~17:30	1. 大會開幕 2. 法國外交部部長致辭 3. CIPM 主席答謝 4. CGPM 主席（巴黎科學學會會長）致辭 5. 各國代表遞交國書（政府授權證明） 6. 提名 CGPM 秘書 7. 完成有投票權之會員代表名冊 8. 確認大會議程 9. CIPM 主席報告（四年來的工作） 10. 其他國際組織報告(OIML, ILAC, WHO, WMO, IFCC, IAEA, CIE)、以及報告加強 NMIs 與 NABs 間之合作的新方案 11. CIPM 報告 12. BIPM 的工作及財務運用 - 2013~2016 的工作計畫 - BIPM 的年度經費 13 BIPM 預算工作小組（Working Group on the Dotation of the BIPM）成員提名
<u>10/18</u> 09:00~13:00	14. CIPM MRA 的應用報告 15. Associate 會員相關事宜報告 - Associate 會員國相關事宜 - 成爲 Associate 經濟體之條款 16. 已積欠會員會費達六年以上之米制公約會員國的除名 17. 重新訂定已逾繳費用之繳款期 18. 討論 BIPM 的特權和豁免權
15:00~17:30	• (預算委員會會議)
18:00~20:00	• 德國駐法大使館舉辦歡迎酒會

<u>10/19</u>	• 參觀 BIPM 實驗室
13:00~18:00	
18:00~20:00	• BIPM 舉辦歡迎酒會
<u>10/20</u>	各個技術委員會報告 (CCL, CCM, CCTF, CCEM, CCT, CCPR, CCRI, CCQM, CCAUV, CCU), 預算工作小組的初步報告
09:30~13:00	
15:00~17:30	• (預算委員會會議)
18:00~20:00	• 荷蘭駐法大使館舉辦歡迎酒會並頒發皇家獎章給 Dr.Kaarls
<u>10/21</u>	• 預算工作小組報告
09:00~13:30	20. 會員提案 21. CIPM 半數成員改選 22. 所有決議的投票表決 23. 其他事項 24. 散會

**RESOLUTIONS ADOPTED BY THE  
24th GENERAL CONFERENCE  
ON WEIGHTS AND MEASURES  
(Paris, 17-21 October 2011)**

**List of the Resolutions:**

1. On the possible future revision of the International System of units, the SI.
2. On the importance of international collaboration so as to place measurements to monitor climate change on an SI traceable basis
3. Dotation of the BIPM for the years 2013 to 2015
4. On the status of Associate State of the General Conference
5. On the acceptance of Economies as Associate of the General Conference
6. On financial arrears of States Parties to the Metre Convention
7. On rescheduling agreements between the International Committee for Weights and Measures and defaulting States Parties to the Metre Convention for the payment of their financial arrears
8. On the revision of the mise en pratique of the metre and the development of new optical frequency standards
9. On the adoption of a common terrestrial reference system
10. On the role, mission, objectives, long-term strategy and governance of the BIPM.

## Resolutions of 24<sup>th</sup> CGPM (2011)

### On the possible future revision of the International System of Units, the SI

#### Resolution 1

The General Conference on Weights and Measures (CGPM), at its 24th meeting, considering

the international consensus on the importance, value, and potential benefits of a redefinition of a number of units of the International System of Units (SI),

that the national metrology institutes (NMIs) as well as the International Bureau of Weights and Measures (BIPM) have rightfully expended significant effort during the last several decades to advance the International System of Units (SI) by extending the frontiers of metrology so that SI base units can be defined in terms of the invariants of nature, the fundamental physical constants or properties of atoms,

that a prominent example of the success of such efforts is the current definition of the SI unit of length, the metre (17th meeting of the CGPM, 1983, Resolution 1), which links it to an exact value of the speed of light in vacuum  $c$ , namely, 299 792 458 metre per second,

that of the seven base units of the SI, only the kilogram is still defined in terms of a material artefact, namely, the international prototype of the kilogram (1st meeting of the CGPM, 1889, 3rd meeting of the CGPM, 1901), and that the definitions of the ampere, mole and candela depend on the kilogram,

that although the international prototype has served science and technology well since it was sanctioned by the CGPM at its 1st meeting in 1889, it has a number of important limitations, one of the most significant being that its mass is not explicitly linked to an invariant of nature and in consequence its long-term stability is not assured,

that the CGPM at its 21st meeting in 1999 adopted Resolution 7 in which it recommended that “national laboratories continue their efforts to refine experiments that link the unit of mass to fundamental or atomic constants with a view to a future redefinition of the kilogram”,

that many advances have been made in recent years in relating the mass of the international prototype to the Planck constant  $h$ , by methods which include watt balances and measurements of the mass of a silicon atom, 24th meeting of the



General Conference on Weights and Measures (2011)

that the uncertainties of all SI electrical units realized directly or indirectly by means of the Josephson and quantum Hall effects together with the SI values of the Josephson and von Klitzing constants  $K_J$  and  $R_K$  could be significantly reduced if the kilogram were redefined so as to be linked to an exact numerical value of  $h$ , and if the ampere were to be redefined so as to be linked to an exact numerical value of the elementary charge  $e$ ,

that the kelvin is currently defined in terms of an intrinsic property of water that, while being an invariant of nature, in practice depends on the purity and isotopic composition of the water used,

that it is possible to redefine the kelvin so that it is linked to an exact numerical value of the Boltzmann constant  $k$ ,

that it is also possible to redefine the mole so that it is linked to an exact numerical value of the Avogadro constant  $N_A$ , and is thus no longer dependent on the definition of the kilogram even when the kilogram is defined so that it is linked to an exact numerical value of  $h$ , thereby emphasizing the distinction between amount of substance and mass,

that the uncertainties of the values of many other important fundamental constants and energy conversion factors would be eliminated or greatly reduced if  $h$ ,  $e$ ,  $k$  and  $N_A$  had exact numerical values when expressed in SI units,

that the General Conference, at its 23rd meeting in 2007, adopted Resolution 12 in which it outlined the work that should be carried out by the NMIs, the BIPM and the International Committee for Weights and Measures (CIPM) together with its Consultative Committees (CCs) so that new definitions of the kilogram, ampere, kelvin, and mole in terms of fundamental constants could be adopted,

that, although this work has progressed well, not all the requirements set out in Resolution 12 adopted by the General Conference at its 23rd meeting in 2007 have been satisfied and so the International Committee for Weights and Measures is not yet ready to make a final proposal,

that, nevertheless, a clear and detailed explanation of what is likely to be proposed can now be presented,

**takes note** of the intention of the International Committee for Weights and Measures to propose a revision of the SI as follows:

the International System of Units, the SI, will be the system of units in which:

- the ground state hyperfine splitting frequency of the caesium 133 atom  $\Delta\nu(^{133}\text{Cs})_{\text{hfs}}$  is exactly 9 192 631 770 hertz,
- the speed of light in vacuum  $c$  is exactly 299 792 458 metre per second,
- the Planck constant  $h$  is exactly  $6.626\ 06\text{X} \times 10^{-34}$  joule second,
- the elementary charge  $e$  is exactly  $1.602\ 17\text{X} \times 10^{-19}$  coulomb,
- the Boltzmann constant  $k$  is exactly  $1.380\ 6\text{X} \times 10^{-23}$  joule per kelvin,
- the Avogadro constant  $N_A$  is exactly  $6.022\ 14\text{X} \times 10^{23}$  reciprocal mole,
- the luminous efficacy  $K_{\text{cd}}$  of monochromatic radiation of frequency  $540 \times 10^{12}$  Hz is exactly 683 lumen per watt,

where

- (i) the hertz, joule, coulomb, lumen, and watt, with unit symbols Hz, J, C, lm, and W, respectively, are related to the units second, metre, kilogram, ampere, kelvin, mole, and candela, with unit symbols s, m, kg, A, K, mol, and cd, respectively, according to  $\text{Hz} = \text{s}^{-1}$ ,  $\text{J} = \text{m}^2 \text{kg s}^{-2}$ ,  $\text{C} = \text{s A}$ ,  $\text{lm} = \text{cd m}^2 \text{m}^{-2} = \text{cd sr}$ , and  $\text{W} = \text{m}^2 \text{kg s}^{-3}$ ,
- (ii) the symbol X in this Draft Resolution represents one or more additional digits to be added to the numerical values of  $h$ ,  $e$ ,  $k$ , and  $N_A$ , using values based on the most recent CODATA adjustment,

from which it follows that the SI will continue to have the present set of seven base units, in particular

the kilogram will continue to be the unit of mass, but its magnitude will be set by fixing the numerical value of the Planck constant to be equal to exactly  $6.626\ 06\text{X} \times 10^{-34}$  when it is expressed in the SI unit  $\text{m}^2 \text{kg s}^{-1}$ , which is equal to J s,

the ampere will continue to be the unit of electric current, but its magnitude will be set by fixing the numerical value of the elementary charge to be equal to exactly  $1.602\ 17\text{X} \times 10^{-19}$  when it is expressed in the SI unit s A, which is equal to C,

the kelvin will continue to be the unit of thermodynamic temperature, but its magnitude will be set by fixing the numerical value of the Boltzmann constant to be equal to exactly  $1.380\ 6\text{X} \times 10^{-23}$  when it is expressed in the SI unit  $\text{m}^2 \text{kg s}^{-2} \text{K}^{-1}$ , which is equal to  $\text{J K}^{-1}$ ,

the mole will continue to be the unit of amount of substance of a specified elementary entity, which may be an atom, molecule, ion, electron, any other particle or a specified group of such particles, but its magnitude will be set by fixing the numerical value of the Avogadro constant to be equal to exactly  $6.022\ 14 \times 10^{23}$  when it is expressed in the SI unit  $\text{mol}^{-1}$ .

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**further notes** that since

the new definitions of the kilogram, ampere, kelvin and mole are intended to be of the explicit-constant type, that is, a definition in which the unit is defined indirectly by specifying explicitly an exact value for a well recognized fundamental constant,

the existing definition of the metre is linked to an exact value of the speed of light in vacuum, which is also a well-recognized fundamental constant,

the existing definition of the second is linked to an exact value of a well defined property of the caesium atom, which is also an invariant of nature,

although the existing definition of the candela is not linked to a fundamental constant, it may be viewed as being linked to an exact value of an invariant of nature,

it would enhance the understandability of the International System if all of its base units were of similar wording,

the International Committee for Weights and Measures will also propose

the reformulation of the existing definitions of the second, metre and candela in completely equivalent forms, which might be the following:

the second, symbol s, is the unit of time; its magnitude is set by fixing the numerical value of the ground state hyperfine splitting frequency of the caesium 133 atom, at rest and at a temperature of 0 K, to be equal to exactly 9 192 631 770 when it is expressed in the SI unit  $\text{s}^{-1}$ , which is equal to Hz,

the metre, symbol m, is the unit of length; its magnitude is set by fixing the numerical value of the speed of light in vacuum to be equal to exactly 299 792 458 when it is expressed in the SI unit  $\text{m s}^{-1}$ ,

the candela, symbol cd, is the unit of luminous intensity in a given direction; its magnitude is set by fixing the numerical value of the luminous efficacy of

monochromatic radiation of frequency  $540 \times 10^{12}$  Hz to be equal to exactly 683 when it is expressed in the SI unit  $\text{m}^{-2} \text{kg}^{-1} \text{s}^3 \text{cd sr}$ , or  $\text{cd sr W}^{-1}$ , which is equal to  $\text{lm W}^{-1}$ .

In this way, the definitions of all seven base units will be seen to follow naturally from the set of seven constants given above.

In consequence, on the date chosen for the implementation of the revision of the SI:

the definition of the kilogram in force since 1889 based upon the mass of the international prototype of the kilogram (1st meeting of the CGPM, 1889, 3rd meeting of the CGPM, 1901) will be abrogated,

the definition of the ampere in force since 1948 (9th meeting of the CGPM, 1948) based upon the definition proposed by the International Committee (CIPM, 1946, Resolution 2) will be abrogated,

the conventional values of the Josephson constant  $K_{J-90}$  and of the von Klitzing constant  $R_{K-90}$  adopted by the International Committee (CIPM, 1988, Recommendations 1 and 2) at the request of the General Conference (18th meeting of the CGPM, 1987, Resolution 6) for the establishment of representations of the volt and the ohm using the Josephson and quantum Hall effects, respectively, will be abrogated,

the definition of the kelvin in force since 1967/68 (13th meeting of the CGPM, 1967/68, Resolution 4) based upon a less explicit, earlier definition (10th meeting of the CGPM, 1954, Resolution 3) will be abrogated,

the definition of the mole in force since 1971 (14th meeting of the CGPM, 1971, Resolution 3) based upon a definition whereby the molar mass of carbon 12 had the exact value  $0.012 \text{ kg mol}^{-1}$  will be abrogated,

the existing definitions of the metre, second and candela in force since they were adopted by the CGPM at its 17th (1983, Resolution 1), 13th (1967/68, Resolution 1) and 16th (1979, Resolution 3) meetings, respectively, will be abrogated.

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**further notes** that on the same date

the mass of the international prototype of the kilogram  $m(K)$  will be 1 kg but with a relative uncertainty equal to that of the recommended value of  $h$  just before redefinition and that subsequently its value will be determined experimentally,

that the magnetic constant (permeability of vacuum)  $\mu_0$  will be  $4\pi \times 10^{-7} \text{ H m}^{-1}$  but with a relative uncertainty equal to that of the recommended value of the fine-structure constant  $\alpha$ , and that subsequently its value will be determined experimentally,

that the thermodynamic temperature of the triple point of water  $T_{\text{TPW}}$  will be 273.16 K but with a relative uncertainty equal to that of the recommended value of  $k$  just before redefinition and that subsequently its value will be determined experimentally,

that the molar mass of carbon 12  $M(^{12}\text{C})$  will be  $0.012 \text{ kg mol}^{-1}$  but with a relative uncertainty equal to that of the recommended value of  $N_{\text{A}}h$  just before redefinition and that subsequently its value will be determined experimentally.

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**encourages**

researchers in national metrology institutes, the BIPM and academic institutions to continue their efforts and make known to the scientific community in general and to CODATA in particular, the outcome of their work relevant to the determination of the constants  $h$ ,  $e$ ,  $k$ , and  $N_{\text{A}}$ , and

the BIPM to continue its work on relating the traceability of the prototypes it maintains to the international prototype of the kilogram, and in developing a pool of reference standards to facilitate the dissemination of the unit of mass when redefined,

**invites**

CODATA to continue to provide adjusted values of the fundamental physical constants based on all relevant information available and to make the results known to the International Committee through its Consultative Committee for Units since these CODATA values and uncertainties will be those used for the revised SI,

the CIPM to make a proposal for the revision of the SI as soon as the recommendations of Resolution 12 of the 23rd meeting of the General Conference are fulfilled, in particular the preparation of mises en pratique for the new definitions of the kilogram, ampere, kelvin and mole,

the CIPM to continue its work towards improved formulations for the definitions of the SI base units in terms of fundamental constants, having as far as possible a

more easily understandable description for users in general, consistent with scientific rigour and clarity,

the CIPM, the Consultative Committees, the BIPM, the OIML and National Metrology Institutes significantly to increase their efforts to initiate awareness campaigns aimed at alerting user communities and the general public to the intention to redefine various units of the SI and to encourage consideration of the practical, technical, and legislative implications of such redefinitions, so that comments and contributions can be solicited from the wider scientific and user communities.

**. On the importance of international collaboration so as to place measurements to monitor climate change on an SI traceable basis**

**Resolution 2**

The General Conference on Weights and Measures (CGPM), at its 24th meeting,

**recalling**

Resolution 4 adopted by the General Conference on Weights and Measures at its 21st meeting in 1999 concerning the need to use SI units in studies of Earth resources, the environment, human wellbeing and related issues,

. Resolution 11 adopted by the General Conference on Weights and Measures at its 23rd meeting in 2007 on the importance of SI traceable measurements to monitor climate change,

**considering**

the expansion in the number of international and national initiatives to address the challenges and implications of climate change for the world,

. the deliberations of the United Nations Intergovernmental Panel on Climate Change and the outcomes on the Copenhagen climate change conference 2009,

. the collaboration between the International Bureau of Weights and Measures (BIPM) and the World Meteorological Organization (WMO),

. the signing by the WMO of the Mutual Recognition Arrangement of National Measurement Standards and of Calibration and Measurement Certificates issued by National Metrology Institutes (CIPM MRA),

. the outcome of the joint BIPM/WMO workshop on “Measurement challenges for global observation systems for climate change monitoring: Traceability, stability and reducing uncertainty”, held on 30 March to 1 April 2010,

the deliberations of the Consultative Committee for Amount of Substance – Metrology in Chemistry (CCQM), the Consultative Committee for Thermometry (CCT), the Consultative Committee for Photometry and Radiometry (CCPR), their Recommendations to the International Committee for Weights and Measures (CIPM) and the interactions between the National Metrology Institutes (NMIs) that are members of these Committees and relevant structures of the WMO, and

the increase in interest from Governments in a global carbon trading and capture framework as well as mitigation initiatives,

**welcomes**

the initiatives of the WMO to work more closely with the BIPM and the NMI community,

the reaction of the BIPM, in its proposed programme of work for the years 2013 to 2016, to address measurement issues related to climate change and global warming, and

the initiatives taken by a number of NMIs to become involved in research and other activities to underpin policies on the “carbon economy”,

**recommends**

relevant bodies take steps to ensure that all measurements used to make observations which may be used for climate studies are made fully traceable to SI units,

that any system agreed between Governments on carbon trading and capture includes a commitment to make relevant measurements traceable to the SI,

that appropriate bodies support the development of techniques which can make possible a set of SI-traceable radiometric standards and instruments to allow such traceability to be established in terrestrial and space-based measurements,

that NMIs continue to develop techniques and measurement systems that would enable biofuel processes and carbon sequestration to be modeled and monitored in an SI traceable and internationally equivalent way,

that Governments and relevant intergovernmental organizations and international bodies commit themselves to adopt an internationally agreed and recognized system of measurement units and standards, and

that the BIPM takes steps to contribute to the coordination of this activity with the full support of the States Parties to the Metre Convention.



## **. Dotation of the BIPM for the years 2013 to 2015**

### Resolution 3

The General Conference on Weights and Measures (CGPM), at its 24th meeting,

**recalling** Article I of the Metre Convention in which States Parties to the Metre Convention undertake to maintain at their common expenses a scientific and permanent International Bureau of Weights and Measures,

**recognizing** that this implies a sustainable long term financial support to ensure the continued fulfillment of its mission, the delivery of its core activities and the responsibilities given to the BIPM in the proposed programme of work for 2013-2015,

#### **considering**

. the increased importance of the work of the International Bureau of Weights and Measures (BIPM) to international trade, industrial innovation, climate change, human health and medicine, food and forensic science in all States Parties to the Metre Convention,

. the recognition of the BIPM as a technically expert intergovernmental organization which reacts to the needs of the States Parties to the Metre Convention,

. the way in which the BIPM continues to adopt best management practice and improve the efficiency of its staff,

the need to replenish the level of the BIPM Capital Investment Fund,

that by sharing the cost of the proposed facilities and funding the BIPM, States Parties to the Metre Convention make substantial savings and increase the efficiency and effectiveness of both their national metrology structures and their international metrology activities,

**thanks** those National Metrology Institutes which have provided voluntary contributions of all kinds to the BIPM,

#### **urges**

National Metrology Institutes to increase the number of staff seconded to the BIPM to work on projects of mutual interest integrated into the programme of work of the BIPM,

States Parties, as well as international organizations, private organizations and foundations also to provide additional voluntary financial support of all kinds to

support specific BIPM mission-related activities,

**decides** that the annual dotation of the BIPM, as defined in Article 6, 1921, of the Regulations annexed to the Metre Convention, will be increased in such a way that, for those States that are Parties to the Metre Convention at the time of the 24th meeting of the CGPM, it shall be:

11 577 000 euros in 2013  
11 693 000 euros in 2014  
11 810 000 euros in 2015.

**. On the status of Associate State of the General Conference**

Resolution 4

The General Conference on Weights and Measures (CGPM), at its 24th meeting,

**recalling**

- . Resolution 3 adopted by the CGPM at its 21st meeting in 1999,
- . Resolution 5 adopted by the CGPM at its 23rd meeting in 2007,

**considering**

- . the growing participation of Associate States of the CGPM in the work carried out under the Metre Convention,
- . the scientific and economic benefits gained by Associate States, in particular from their participation in the Mutual Recognition Arrangement of National Measurement Standards and of Calibration and Measurement Certificates issued by National Metrology Institutes (CIPM MRA) and from some services of the International Bureau of Weights and Measures (BIPM) that the International Committee for Weights and Measures (CIPM) made available to them,
- . the increasing effective costs for the States Parties to the Metre Convention of these benefits for the Associate States,
- . that the status of Associate State could constitute a first step to accede to the Metre Convention,

**noting**

- . the decisions made by the CIPM at its 98th and 99th sessions, adopting the following criteria enabling it to review whether it would be appropriate for an Associate State to become a State Party to the Metre Convention:
  - o Signature of the CIPM MRA by the Associate State's National Metrology Institute,
  - o Publication of comparison results in the key comparison database (KCDB),
  - o Having one or more Calibration and Measurement Capability (CMC) listed in the KCDB,

**decides that**

- . during an initial 5-year period following the accession to the status of Associate of

- the CGPM, Associate States shall pay an annual subscription determined from their contributions to the United Nations Organisation, as for States Parties to the Metre Convention, with a minimum equal to 0.1 % of the annual dotation of the BIPM,
- . this decision will be applicable to current Associate States for the calculation of their subscription starting for the year 2013,
  - . after the above-mentioned initial 5-year period, if the CIPM considers, on the basis of the criteria it adopted, that it would be appropriate for an Associate State to become a State Party to the Metre Convention, the amount of subscription for such an Associate will be progressively and irreversibly increased each year so that it reaches, in five years, an amount equivalent to 90 % of the annual contribution it would pay as a State Party to the Metre Convention,
  - . this progressive and irreversible increase will be applicable starting on the 1st January of the second year following the CIPM decision to encourage an Associate State to become a State Party to the Metre Convention,
  - . the CIPM review of the situation of Associate States in 2011 will be used in application of the present Resolution and that the first increase of the subscriptions will become effective in 2013,
  - . such increase will not apply to Associate States whose annual subscription is already equal to the contribution they would pay as a State Party to the Metre Convention,
  - . as long as an Associate State does not fulfil the above-mentioned criteria to be encouraged to become a State Party to the Metre Convention, it will continue to benefit from the advantages of the Associate Status, as provided for in Resolution 3 adopted by the CGPM at its 21st meeting (1999), and from the BIPM services that the CIPM made available to them, and its subscription will continue to be determined as during the initial 5-year period,

**invites**

all Associate States, whether fulfilling or not the criteria adopted by the CIPM to encourage Associate States to become States Parties to the Metre Convention, to accede to the Metre Convention as such accession can only be beneficial for the strengthening of the world's measurement system.

## **On the acceptance of Economies as Associate of the General Conference**

### Resolution 5

The General Conference on Weights and Measures (CGPM), at its 24th meeting,

#### **considering**

- . Resolution 3 adopted by the CGPM at its 21st meeting (1999), creating the status of Associate of the CGPM open to “States and Economies” as a means of promoting their participation in the world’s measurement system,
- . Resolution 6 adopted by the CGPM at its 23rd meeting (2007), which considered the desirability of setting criteria against which applications from Economies be assessed,

#### **decides that**

- . the status of Associate Economy shall not be automatically acquired, but granted unanimously by the CGPM on a case by case basis,
- . the decision of the CGPM to grant the status of Associate Economy shall be based on the following criteria:
  - o an Associate Economy must be a Territorial Entity,
  - o the Territorial Entity must possess its own Metrology Institute within its territory,
  - o the participation of the Territorial Entity in the activities of the International Bureau of Weights and Measures (BIPM) must be considered beneficial for the strengthening of the world’s measurement system,
- . the annual subscription of such Associate Economies shall be determined by the CGPM,
- . Intergovernmental Organizations are not considered as “Territorial Entities”,
- . CARICOM, the regional Intergovernmental Organization currently Associate Economy of the CGPM, having acceded to the status of Associate Economy of the CGPM prior to the adoption of the abovementioned criteria, may continue to enjoy this status despite its notmeeting the said criteria,

#### **invites**

- . the Member States of CARICOM to accede to the Metre Convention or to become Associate States of the CGPM,

the International Committee for Weights and Measures (CIPM) to consider further appropriate means by which intergovernmental organizations, in particular those from regions without well-developed metrology infrastructure, can be involved in the work of the BIPM and to bring forward proposals to the next meeting of the CGPM on how this can best be achieved.

## **. On financial arrears of States Parties to the Metre Convention**

### Resolution 6

The General Conference on Weights and Measures (CGPM), at its 24th meeting,

#### **considering**

. Article 6 paragraphs 6 to 8 of the Regulations annexed to the Metre Convention reads:

“6. Si un État est demeuré trois années sans effectuer le versement de sa contribution, celle-ci est répartie entre les autres États, au prorata de leurs propres contributions. Les sommes supplémentaires, versées ainsi par les États pour parfaire le montant de la dotation du Bureau, sont considérées comme une avance faite à l'État retardataire, et leur sont remboursées si celui-ci vient à acquitter ses contributions arriérées.

7. Les avantages et prérogatives conférés par l'adhésion à la Convention du Mètre sont suspendus à l'égard des États déficitaires de trois années.

8. Après trois nouvelles années, l'État déficitaire est exclu de la Convention, et le calcul des contributions est rétabli conformément aux dispositions de l'article 20 du présent Règlement.” 1

English translation for easy reference of the authoritative French version:

6. If a State remains three years without paying its contribution, the said contribution is distributed among the other States pro-rata to their own contributions. The supplementary sums thus paid by these States to make up the dotation of the Bureau are considered as advances made to the State in arrears, and are reimbursed to them in the event that it repays its arrears of contributions.

7. The advantages and prerogatives conferred by accession to the Metre Convention are suspended for those States in arrears by three years.

8. After three more years, the State in arrears is excluded from the Convention and the calculation of contributions is re-established in accordance with the provisions of Article 20 of the present Regulations.

. Resolution 8 adopted by the CGPM at its 23rd meeting (2007) defining the decision-making process and a procedure governing the recovery of arrears and exclusion,

. the contributions of States Parties to the Metre Convention in arrears for more than

6 years and advances made by the other States Parties pursuant to Article 6 paragraph 6 of the Regulations annexed to the Metre Convention,

**reaffirming**

the absolute necessity that contributions of States Parties to the Metre Convention be paid timely and consistently to allow the BIPM to fulfil its mission and to avoid financial problems in its day-to-day operation,

**decides**

for States Parties in arrears for more than 6 years to grant a period of 12 months from the date of adoption of the present Resolution to conclude with the International Committee for Weights and Measures (CIPM) a rescheduling agreement,

that if a rescheduling agreement is not concluded within 12 months, those States will automatically be excluded, and the CIPM will inform in writing the French Ministry of Foreign and European Affairs for notification to this effect to those States and to all States Parties to the Metre Convention on behalf of the CGPM, and

that the calculation of contributions is re-established in accordance with the applicable provisions in the most immediate calendar year after exclusion.



**On rescheduling agreements between the International Committee for Weights and Measures and defaulting States Parties to the Metre Convention for the payment of their financial arrears**

Resolution 7

The General Conference on Weights and Measures (CGPM), at its 24th meeting,

**recalling** that

Article 6 paragraphs 6 to 8 of the Rules annexed to the Metre Convention reads:

- “6. Si un État est demeuré trois années sans effectuer le versement de sa contribution, celle-ci est répartie entre les autres États, au prorata de leurs propres contributions. Les sommes supplémentaires, versées ainsi par les États pour parfaire le montant de la dotation du Bureau, sont considérées comme une avance faite à l’État retardataire, et leur sont remboursées si celui-ci vient à acquitter ses contributions arriérées.
7. Les avantages et prérogatives conférés par l’adhésion à la Convention du Mètre sont suspendus à l’égard des États déficitaires de trois années.
8. Après trois nouvelles années, l’État déficitaire est exclu de la Convention, et le calcul des contributions est rétabli conformément aux dispositions de l’article 20 du présent Règlement.” 2

English translation for easy reference of the authoritative French version:

6. If a State remains three years without paying its contribution, the said contribution is distributed among the other States pro-rata to their own contributions. The supplementary sums thus paid by these States to make up the dotation of the Bureau are considered as advances made to the State in arrears, and are reimbursed to them in the event that it repays its arrears of contributions.
7. The advantages and prerogatives conferred by accession to the Metre Convention are suspended for those States in arrears by three years.
8. After three more years, the State in arrears is excluded from the Convention and the calculation of contributions is re-established in accordance with the provisions of Article 20 of the present Regulations.

Resolution 8 adopted by the CGPM at its 23rd meeting (2007) which provides that when a State Party to the Metre Convention has not paid its contributions for six years, the International Committee for Weights and Measures (CIPM) may enter into a rescheduling agreement with the defaulting State for the payment of its

arrears,

**considering**

- . that the entering by the CIPM into rescheduling agreements with defaulting States Parties to the Metre Convention has institutional, financial and budgetary consequences for the BIPM and the other States Parties to the Metre Convention,
- . the need to define the rights and obligations of the States Parties to the Metre Convention having financial arrears for six years and having entered into a rescheduling agreement with the CIPM,

**decides that**

- . when a State Party to the Metre Convention has not paid its contribution for six years, but if the CIPM has entered into a rescheduling agreement with that defaulting State, the arrears shall be settled in accordance with the rescheduling agreement together with the payment of the annual contribution,
- . the defaulting State shall again benefit from the advantages and prerogatives conferred by accession to the Metre Convention after the CIPM has entered into a rescheduling agreement with that defaulting State and on payment of the first settlement pursuant to the rescheduling agreement,
- . the annual contribution of the defaulting State shall no longer be distributed among the other States Parties to the Metre Convention starting from the year following the entry into force of the rescheduling agreement,
- . the advantages and prerogatives conferred by accession to the Metre Convention shall be suspended in the case that the defaulting State breaches the rescheduling agreement and its contribution be distributed among the other States Parties to the Metre Convention by applying the provisions of Article 6 paragraph 6 of the Regulations annexed to the Metre Convention,
- . if the State breaches the rescheduling agreement for more than 12 months, it will be automatically excluded.

## **On the revision of the mise en pratique of the metre and the development of new optical frequency standards**

### **Resolution 8**

The General Conference on Weight and Measures (CGPM), at its 24th meeting, **considering** that

- . there have been rapid and important improvements in the performance of optical frequency standards,
- . national metrology institutes are working on comparison techniques for optical frequency standards over short distances,
- . remote comparison techniques need to be developed at an international level so that optical frequency standards can be compared,

#### **welcomes**

- . the activities of the joint working group of the CCTF and the CCL to review the frequencies of optically-based representations of the second,
- . the additions made by the CIPM in 2009 to the common list of “Recommended values of standard frequencies for applications including the practical realization of the metre and secondary representations of the second”,
- . the establishment of a CCTF working group on Coordination of the Development of Advanced Time and Frequency Transfer Techniques,

#### **recommends that**

- . NMIs commit resources to the development of optical frequency standards and their comparison,
- . the BIPM supports the coordination of an international project with the participation of NMIs, oriented to the study of the techniques which could serve to compare optical frequency standards.

**. On the adoption of a common terrestrial reference system**

Resolution 9

The General Conference on Weights and Measures (CGPM), at its 24th meeting,

**considering**

- . that a significant number of global navigation satellite systems (GNSS) now exist and that in the future there may be more,
- . the proliferation of time and geodesy reference systems in use in these navigation systems, which creates ambiguities for users with regard to the interpretation of navigation and timing solutions, and which renders interoperability between the systems more difficult,
- . the existence of the International Terrestrial Reference System (ITRS),
- . that the adoption of a common reference system would lead to benefits for users regarding unification of navigation and timing solutions and systems interoperability,

**recommends** that the ITRS, as defined by the International Union of Geodesy and Geophysics (IUGG) and realized by the International Earth Rotation and Reference Systems Service (IERS), be adopted as the unique international reference system for terrestrial reference frames for all metrological applications.

## **. On the role, mission, objectives, long-term strategy and governance of the BIPM**

### **Resolution 10**

The General Conference on Weights and Measures (CGPM), at its 24<sup>th</sup> meeting,

#### **considering that**

- . the Metre Convention, which established the Bureau International des Poids et Mesures, was signed in 1875 and last modified in 1921,
- . the Annexed Regulations of the Metre Convention were amended on a number of occasions since then,
- . the role and mission of the BIPM were reconfirmed in Resolution 2 adopted by the CGPM at its 23rd meeting,
- . the governance was last examined by an ad hoc Working Group set up at the 16th meeting of the CGPM, that the conclusions of this ad hoc Working Group were that changes to the Metre Convention at that time were neither necessary nor desirable, and that these conclusions were approved by the CGPM at its 17th meeting in 1983,
- . expectations of financial management and accountability have continued to increase both in national administrations and international organizations,

#### **noting**

- . that contacts between the BIPM and governments of States Parties to the Metre Convention have been reinforced since the 23rd meeting of the CGPM through short reports from the Director of the BIPM and a special meeting of representatives of States Parties to the Metre Convention prior to the 24th meeting of the CGPM,
- . that the BIPM has implemented an accrual basis system of accounting to increase the effectiveness, accountability and transparency of the BIPM financial management,
- . the comments expressed by representatives of States Parties to the Metre Convention at a meeting in May 2011, including the following:
  - o All States strongly support and appreciate the Metre Convention and the work of the BIPM, noting that it is moving forward, for example with the development of the CIPM MRA,

- o There was unanimous support for a new and stronger strategic direction for the BIPM with a clear idea of priorities, developed jointly between States Parties to the Metre Convention, NMIs and the CIPM,
- o There are different opinions about the levels of coordination/cooperation activities and laboratory activities,
- o A key aspect of the new strategy will be consideration of the appropriate roles of the BIPM, Regional Metrology Organizations and NMIs,

**invites**

- . the CIPM to establish an ad hoc Working Group under the Chairmanship of the President of the CIPM, with representation from the CIPM, States Parties to the Metre Convention (with maximum, intermediary and minimum contributions) and NMIs, properly balanced to represent all regions, and the Director of the BIPM, charged with conducting a Review of the role, mission, objectives, long-term financial stability, strategic direction and governance of the BIPM,
- . the ad hoc Working Group to present the findings of this Review to the CIPM, States Parties to the Metre Convention and NMI Directors in October 2012,
- . the CIPM to formulate proposed actions on the basis of the findings of the ad hoc Working Group and implement those within its authority, subject to support from the representatives of States Parties to the Metre Convention and NMI Directors, during the 2013-2014 timeframe,
- . the CIPM to report to the CGPM at its 25th meeting on recommendations from the Review of the ad hoc Working Group, actions consequently taken by the CIPM and proposals for additional actions that require the approval of the CGPM.