出國報告（出國類別：開會）

事故後輻射防護措施研討會

服務機關：台灣電力公司

姓名職稱：放射試驗室　張益民經理

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派赴國家：日本

出國期間：103/11/25-103/11/28

報告日期：104/01/08

目錄

壹、出國目的

世界核能發電協會東京中心(WANO-TC)與巴黎中心(WANO-PC)為使各會員於福島事故後進行輻射防護措施經驗交流，特別於日本東京舉行「事故後輻射防護措施研討會(Post-accident Measures for Radiation Protection)」，邀請各會員派員就輻射防護相關之運轉、維護、工程、人員訓練及緊急計畫等工作，進行經驗交流與知識分享。會中講題著重於福島事故後各電廠輻射防護改善措施、救援物資補給、輻射偵測度量、偵測設備更新及緊急計畫演習等，會中亦就游離輻射防護法規各項限值進行討論，進一步就應否修正搶救人員之曝露劑量限值進行意見交換。

台電公司受邀出席二員，一位以學者專家身分發表「核能事故緊急輻射監測暨展示網在廠外環境輻射偵測上之應用(The Emergent Radiation Monitoring and Demonstration Networks Applied in Environmental Surveillance during the Post-accident)」45分鐘專題演講，另一位以一般與會人員身分發表「福島事故後台電公司於輻射防護工作之強化措施與準備(Enhanced Measures and Preparations of Radiation Protection in TPC after Fukushima Accident)」20分鐘一般報告。

貳、出國過程

日期	地點	工作紀要
103/11/25	台北→日本東京	往程
103/11/26-27	日本東京 WANO-TC	出席研討會
103/11/28	日本東京→台北	返程

參、出國心得

一、會議摘要

本項會議由世界核能發電協會(WANO)東京中心和巴黎中心共同舉辦，計有：台灣、日本、中國、印度及巴基斯坦(以上屬東京中心會員)，法國、西班牙、英國、義大利、瑞典、芬蘭及比利時(以上屬巴黎中心會員)等國之核能發電業者及研究機構派員參加。會議研討主題共有四項:

(一)福島事故期間輻射防護行動準則(包含輻射工作人員曝露和一般公眾曝露)

(二)輻射防護工作面臨之挑戰

(三)福島事故輻射防護工作啟示

(四)其他電廠於處理類似事故擬採行之輻射防護措施

會中邀請與會學者專家進行6篇專題報告(每篇45-60分鐘)及一般會員代表進行6篇一般性報告(每篇20分鐘)，以各國自身經驗為題闡述輻射防護相關經驗，接受與會其他會員代表提問，並進行意見交流。會議各項演講主題請參見附件一。

二、會議內容與心得

(一)、 (張益民部分)

1. 簡報內容摘要：

2011年日本福島核能事故後，本公司放射試驗室為尋求能於嚴峻核能事故及高度輻射污染情境下，順利執行高輻射劑量環境偵測作業，並快速掌握輻射污染和事故發展趨勢，乃結合原能會核研所核能儀器的研發能力，國內發達的無線通訊環境與技術，規畫了一套機動型多功能輻射劑量即時偵測網，命名為「核子緊急事故環境輻射監測暨展示網」(Emergent Radiation Monitoring and Demonstration Networks)，這套作業網絡不但可強化核子事故環境輻射偵測能力，更可透過網際網路，整合既有的輻射偵測資訊，並結合衛星定位和Google 地圖，建立事故時輻射偵測資訊電腦螢幕上的即時展示能力。

核子事故環境輻射監測暨展示網，由塑膠閃爍偵檢器、 碘化鈉閃爍偵檢器、氣象資訊系統，搭配衛星定位儀(GPS)、攝影機等偵測設備組成，經嵌入式工業

電腦整合各方數據後，利用3G網路即時傳送資料至網路伺服器。使用網際網路將偵測資訊網頁展示在「核子事故輻射監測中心」螢幕上，可做為評估核子事故趨勢發展及後續民眾劑量評估之參考。

職本次代表公司赴日本東京參加世界核能發電協會東京中心(WANO-TC)與巴黎中心(WANO-PC)合辦的「事故後輻射防護措施研討會」，即是以此作業網路在緊急事故時在環境輻射偵測上的應用為主題，發表本公司在緊急應變作業的發展狀況與使用心得。

2. OECD/NEA 輻射防護強化措施摘要：

(1). 法規要求架構改變 (Changes to the regulatory framework)：

(a). 人員防護可獲得資源被要求增加(包含廠內工作人員、新進及廠外支援人員等個人防護設備)。

(b). 發生重大事故時，應分析輻射防護需要的人力和物質資源。

(c). 當其他國家援助未達時，應有設備存放規劃(如開設廠內、外後勤中心)。

(d). 以國際經驗及福島事故為基礎，重新評估緊急工作人員(Emergency workers)輻射劑量限值。

(2). 民眾防護強化措施 (Enhancements for public protection)：

(a). 重新檢視緊急管理及復原措施的處理方式，使事故情況得到較佳準備。

(b). 考慮長期庇護(long-term sheltering)和可能的替代方案，及將更多資源聚焦於復原計畫及準備的必要性。

(c). 有關民眾防護計畫及準備活動人員的需求在福島事故後已被加強，但清潔(clean-up)和復原活動相關人員部分仍是挑戰。

(3). 核能業者正在發展及實施的員工防護強化措施(Enhancements for worker protection being developed and implemented by the nuclear power industry)：

(a). 英、美國電廠正進行：針對發生重大且可能持續一段時間的緊急事故時，員工及其他支援人員遭遇外傷、精神、壓力及家庭因素等困擾管理問題的相關研究計畫。

(b). 西班牙電廠正考慮施行增加措施，維持發生電廠全黑事件時，主控制室(main control room)、次控制室(secondary control room)及廠內緊急應變中心的可居

住性(habitability)。

(4). 廠區及廠外輻射監測能力強化措施(Enhancements to onsite and offsite radiological monitoring) ：

(a). 檢視現有輻射監測設備作業能力(capacity)，並考慮指定不同組織(如電廠和主管機關)肩付輻射即時監測(real-time monitoring)的責任。

(b). 檢視現有設施效性(effectiveness)和效率(efficiency)，並確認強化其措施。

(c). 採取行動強化事故期間廠內及廠外輻射外釋監測及外釋射源項 (source terms)測定能力，做為採取廠外防護措施時的建議依據。

(d). 以輻射監測數據為基礎，利用射源項反推(inverse source term)輻射劑量的估算方法正被考慮和分析中。

3. 福島事故發生狀況、輻射防護對應措施與記取教訓之檢討：

(1). 日本福島核能一廠由於廠區喪失電力，輻射監測站無法作業、監測資料無法傳輸，只好由偵測車載送工作人員的作業方式，執行廠區及廠界輻射度量(包括輻射劑量率、風速等)。

(2). 主控制室門因為氫爆炸破壞無法氣密，導致放射性物質侵入造成污染，工作人員因而遭受大量輻射曝露。緊急排氣系統又因喪失電力無法運作，控制室內的值班人員必須戴著呼吸面罩才能工作。

(3). 輻射曝露劑量超過限值 (Exposure exceeding dose limit)：

(a).緊急工作人員(emergency workers) 輻射曝露劑量超過緊急劑量限值 250 mSv：

☞ 狀況說明：

- 共有 6 名主控制室內的機電儀修人員輻射曝露劑量超過 250 mSv。
- 體內曝露劑量大於體外曝露劑量。
- 這些工作人員經過日本國立輻射科學研究所(National Institute of Radiological Science)特約醫師醫療檢查後未發現健康問題。

Unit: mSv

Employees	Internal	External	Total effective dose
A	590	88.08	678.08
B	540	105.56	645.56
C	241.8	110.27	352.08
D	259.7	49.23	308.93
E	433.1	42.40	475.50
F	327.9	31.39	359.29

☞ 發生原因：

- 事故快速擴大，無法即時穿戴配有活性碳濾罐的專用呼吸面罩(respirators)。
- 事故延遲被迫食用主控制室(遭污染)的食物及飲水。
- 呼吸面罩使用不當。

☞ 採取對策：避免在惡劣情況下攝入(intake)放射性物質。

- 供應充足的個人防護設備(包括呼吸面罩、濾罐及防護衣物) 。
- 限制區內禁止飲食。
- 提醒及教導呼吸面罩及防護設備使用方法。

(b). 女性僱員曝露劑量超過限值 ：

☞ 狀況說明：

- 地震後仍有 19 位女性僱員工作。
- 有 2 位女性僱員(employees)曝露劑量超過 5 mSv/季； 2 位女性僱員(非輻射工作人員)超過一般民眾劑量限值 1 mSv/年。
- 體內劑量大於體外劑量。
- 經過醫療檢查均未發現健康問題(no health effects) 。

Unit:mSv

Employees	Internal	External	Total effective dose	Remarks
G	13.6	3.95	17.55	
H	6.71	0.78	7.49	
I	2.81	0.61	3.42	Non-radiation worker
J	2.59	0.78	3.37	Non-radiation worker

☞ 發生原因：

- 2 位女性僱員在廠外執行消防車燃料裝填和在免震建築物工作。
- 她們使用適當的個人防護裝備(穿戴配有活性碳濾罐的呼吸面罩)，僅輕微攝入放射性物質。

☞ 採取措施：降低免震建築物內放射性物質濃度。

- 在入口處設立管制區防止放射性物質進入。
- 將地板更換為抗放射性物質磁磚。
- 設置局部空氣排氣裝置(local air-exhaust ventilators) 。

(c). 體外曝露管理：

☞ 狀況說明：

- 輻射(劑量)管理系統失效。
- APD(alarm pocket dosimeter)無法獲得充分供應：約 5000 枚 APD 和電池充電器無法使用。

☞ 採取措施：

- 員工登記：利用手寫登記方式辨認身分。
- 事故發生後體外劑量管理：利用 320 枚 APD(免震建築 50、廠房 270)，執行體外劑量管理，因為 APD 數量不足，每個工作團隊使用 1 枚 APD 代表成員曝露劑量。

☞ 事故後陸續改善措施：

- 4/1,2011 提供緊急工作人員使用的 APD 已可充分供應。
- 2011 年 11 月東電人員開始使用玻璃劑量計(體外劑量計讀) 。
- 免震建築員工使用條碼機(Barcode reader)執行人員登記(2011 年 4 月) 。
- 使用新劑量管理系統(2011 年 11 月) 。
- 入口處設置控制區(Control building)開始啟用(6/30,2013) 。

(d). 體內曝露管理：

☞ 狀況說明：

- 福島一、二廠所有全身計測(WBC)設備因海嘯、輻射污染和環境背景過高而無法使用。

☞ 採取措施：：

- 由日本原子力開發機構(JAEA)提供 WBC。移動型 WBC 用於低背景地區；利用 JAEA 的 WBC 執行放射性核種能譜分析。
- 使用 KK 電廠 WBC 及修復福島二廠 WBC：優先檢查女性員工和體外劑量超過 100 mSv 的男員工。
- 體內劑量評估作業暫延。

☞ 事故後陸續改善措施：

- 在 Hirono 足球場安裝 11 部 WBC(靠近 J-Village) 。
- 緊急應變人員每月執行 WBC 一次。

☞ 記取教訓：

- 個人防護設備應充足準備；包含：

① 防護衣物、各種不同型式呼吸面罩(配活性碳濾罐)、鉛衣。

② 個人劑量計(主動型 EPD)、WBC。

③ 輻射偵測設備

- 劑量管理系統應安置在特定的安全區域且建立完整作業程序；包含：

① 備援劑量管理系統。

② 體內劑量評估方法及作業程序。

- 提供緊急控制室的免震建築之改善，包含：

① 污染員工和無污染員工通路分離。

② 防止放射性物質穿透門設計。

③ 地板和牆面採用易除污建材。

④ 維持廁所功能/提供休息空間。

- 建立緊急通路控制中心：

① 在鄰近電廠處尋找可以運送物質與設備地點。

② 定期對運送隊伍人員實施輻射防護教育訓練。

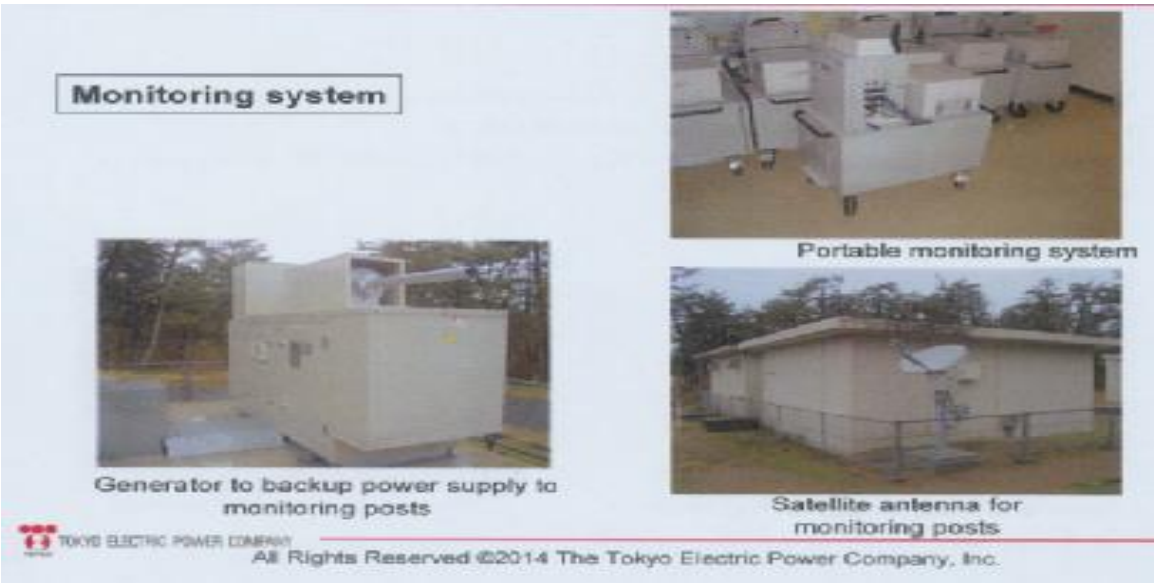
③ 建立建置控制中心的方法及步驟(包含位置、操作步驟、必要緊急設備之提供等) 。

- 提供輻射防護教育訓練：對 NPP 一般職員提供操作手提偵測器、輻射防護知識的基本訓練，儲備輻射防護人員。

(e). 對柏崎-刈羽 KK 電廠的經驗回饋：

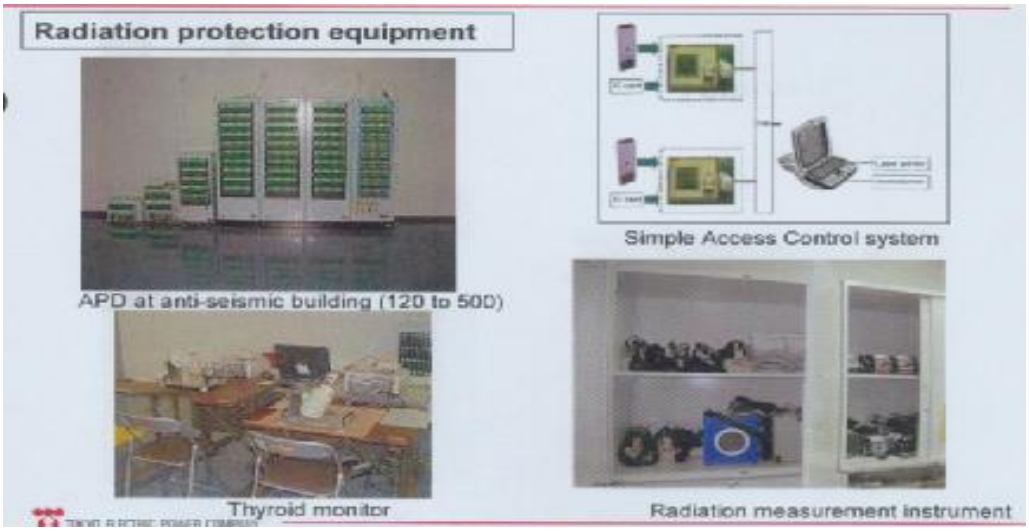
☞ 輻射監測系統(Monitoring system)：

- 增加監測站備用電源供應
- 發展手提式監測系統(portable monitoring system)
- 監測站增加衛星傳輸能力



☞ 輻射防護設備：

- 抗震建築內放置 APD 120 至 500 枚
- 發展簡易型通路管制系統(管制人員進出)
- 建置甲狀腺監測偵檢器(Thyroid minitor)
- 建置各式輻射度量設備並存放於安全設施內(如抗震建築內)



☞ 緊急通路管制中心：

- 選定柏崎市能源局和品川(Shinagawa)的動力系統辦公室做為緊急通路管制中心
- 指派東電總部和 KK 電廠人員為緊急通路管制中心職員

☞ 教育訓練：

- 緊急應變室防止污染訓練
- 工作人員輻射度量訓練
- 在緊急應變室內設置污染管制區(screening and changing area)訓練

4. 參加本次研討會之感想：

(1)、 職等有幸代表台電參加 WANO-TC 和 WANO-PC 共同舉辦福島核能事故後有關輻射防護方面各國採取改善措施的研討會，並分別在研討會中介紹：❶本公司在核電廠輻射防護和緊急應變準備及演習作業，❷核能事故緊急輻射監測暨展示網在廠外環境輻射偵測上的應用。

由於職對 WANO 各成員電廠在輻射防護方面的發展所知有限，在發表題目的研擬上頗費心神，尤其是選定國內首創且由本公司自行發展的緊急事故廠外輻射偵測網及機動偵測儀做為發表題目，深恐與會議主題脫節。然後聽取歐盟(OECD)和南亞各會員電廠(印度和巴基斯坦)介紹他們在福島事故後的改善措施後，才發現在國內本公司引以自豪的機動偵測網構想其實在歐盟電廠已經是核能法規的重點要求事項，只是各成員電廠因自己理念和需求不同，而呈現不同面貌。

推究其因乃為各核能電廠均有感於固定或例行性的輻射監測站通常仰賴市電，而當核能電廠發生類似福島事故時，因電力喪失而無法提供電源，這些測站往往無法持續執行事故時的輻射劑量度量，從而使緊急應變人員處於高輻曝露環境和不知輻射對自身可能造成何種傷害的心理恐慌下，工作能力與信心備受打擊。 因此，各式延長輻射監測能力的構想或機動輻射監測設備被研究發展或建置出來。

當本公司「緊急事故輻射監測暨展示網在廠外輻射偵測之應用」(The Emergent Radiation Monitoring and Demonstration Networks Applied in Environmental Surveillance during the Post-accident)發表時，由於各成員電廠大多擁有類似的監測設施(購自市面上現成商品，如德商 Gamma Tracer 自動偵測儀)，因此討論相對熱烈，整理各會員代表討論大致如下：

a. 首次看到能集合自動偵測、即時傳輸、網頁揭露和螢幕展示的機動偵測網路感到相當驚艷

b. 同時具有能度量輻射劑量率和外釋放射性核種的手提式機動偵測儀，對事故發展瞭解幫助甚大；

c. 對於本公司能善用國內既有資源，自行研發一套最適合自己需要的核能事

故緊急輻射監測網感到佩服；

d. 能根據核能事故不同的發展階段(事故初期、中期及復原期)，結合本公司和國內其他單位(原能會輻射偵測中心)既有的輻射監測網，搭配機動偵測儀的彈性佈置，建構一套核能緊急事故的戰略計畫，讓緊急事故輻射監測能力得到更好的發揮；

e. 利用機動偵測儀(mobile radiation monitoring box)做為偵測工具，使空中、海上及地面輻射偵測能同時納入緊急事故輻射監測網的構思甚具創意；

f. 使用 3G 做為數據傳輸的通信網路，若 3G 基地台因天然災害如地震、海嘯而斷訊時，如何因應或補救？(答復：事故時可以通知中華電信公司開設機動(車載)基地台因應，另本公司正研究利用 VHF 通訊網做為備援通訊管道的可行性)。

g. 利用 Google Earth 將偵測結果製成輻射監測地圖(detection map)並以 螢幕即時展示在牆面的構想，極方便於即時監督和決策指揮。

h. 職雖因語言能力較弱，無法如歐洲電廠或南亞的印度和巴基斯坦電廠代表般自在地以英語交流，但因發表的論文議題較具創意的關係，也得到來自其他電廠的尊敬和友誼和獲得一些來自友廠相關領域的經驗回饋，算是除了完成代表公司赴日本 WANO-TC 發表論文的任務外的另一項收獲。

(2). 關於本次會議東電公司代表報告福島事故記取教訓中，用於 KK 電廠經驗回饋的輻射監測系統部分，職有些許不同看法：

a. 建置大型柴油或汽油發電機做為輻射監測站的備用電源：當發生嚴重核能事故，尤其是地震或海嘯所引發的複合型核災，發電機需要的柴油或汽油如何補充的困擾，似乎未在東電公司內部被深入檢討；反觀歐洲部分電廠多採用長效型鋰電池(有效期 2 年)或太陽能或風力做為備用電源，應該更具備援或持續的實際意義。

b. 手提式(portable)輻射監測設備不符合快速移動、方便使用的目標： 觀察東電公司提供圖片，所謂手提式(portable)輻射監測儀不小，遇緊急事故必須機動佈置時，因體積大、重量重偵測車能承載數量少，不易快速佈放，加上不是採用防水設計，遇暴雨時，恐有漏水故障的疑慮。

(二)、 (邱心怡部分)

本次會議主題係因應福島事故而生，日本方面由日本核能安全協會(JANSI) Akihide Kugo 博士和東京電力公司(TEPCO) Atsutoshi Makihira 先生進行專題報告。Kugo 博士報告中提及經濟合作暨發展組織核能署(OECD-NEA)目前致力於輻射防護工作之重點為：核能安全法規之架構變革、強化公眾輻射防護、加強工作人員於嚴重核子事故之安全防護及加強電廠事故發生後廠內及廠外輻射偵測等。

OECD-NEA 建議於電廠鄰近地點規劃合適物資存放場所及後勤指揮中心，與目前台電公司於各廠規劃興建之免震動建築(Emergency Response Center，REC)概念極其相似。英國及美國正著手進行重大且持續性嚴重事故之工作人員及搶救人員所承受身心壓力研究；西班牙則考慮於電廠增添必要物資，讓處於全黑狀態下之電廠能維持主控制室及次要控制室之適居性，目前台電公司亦於福島事故後推動類似之準備工作。

OECD-NEA 亦建議加強電廠廠內及廠外之輻射監測能力，朝向即時(real-time)及提升現有偵測設備技術方向發展，同時以輻射監測數據為基礎，配合由射源項(source term)推導之方式發展輻射劑量估算模式，此二部分恰為台電公司現在推展中之工作。故而本次台電公司出席代表於會中就廠外環境即時輻射偵測網之軟硬體提升及介面整合工作進行簡報，獲得與會代表廣泛討論與回響，為此行一大收獲。

此外，各會員代表咸認應以福島事故等嚴重核子事故之經驗作為基礎，重新對於緊急工作人員(Emergency Workers)之輻射劑量限值予以討論及再評估，惟各會員代表均表示除非 WHO、ICRP、NCRP 等醫學、流行病學相關研究組織、刊物有進一步學術文獻發表，提供供足之學理佐證，有關提高緊急工作人員法令劑量限度之建議，難有明確定見。

東京電力公司 Makihira 先生於福島事故後奉派馳援福島電廠之輻射防護工作，擔任經理一職，會中 Makihira 先生向大家簡報福島電廠事故經過、人員輻射曝露情況、搶救期間輻射防護應變措施及事故後至今之改善措施(應用於柏崎刈羽核電廠)等，由於與會代表對於日本於福島災後之復原能力及改善措施十分好

奇，期盼能聆聽到輻射防護工作的新想法，可惜或許日本現正處於全國停止核電運轉的狀態，又或是因為東電人員忙於福島善後工作，於此番報告中未見輻射防護工作新作為，略屬可惜。

與會其他國家亦於會中進行輻射防護工作相關報告，諸如巴基斯坦，介紹福島後緊急應變管理組織之提升；印度，介紹該國緊急計畫區(EPZ)半徑增加為 16 公里；芬蘭，介紹福島後核能機組的安全強化工作、輻防裝備備援準備及加強廠內廠外輻射監測網絡；瑞典，介紹該國輻防準備等等；來自中國福清電廠的會員代表，除介紹該公司於福島後的輻防準備外，亦介紹了福清電廠興建及試運轉工作現況，中國於核電建設推展之快速及模組化，令人印象深刻。

本次會議，WANO 巴黎中心亦有一位資深訪查員(reviewer)分享近年來訪視各電廠緊急計畫的心得，報告中建議應增加各電廠演習之無預警演練、演習劇本採多機組事故、演習中應演練事故長時間發生下人員之交接班、外援人力待命進廠、安排非上班時間演練及邀請外援單位(例如醫療人員、消防隊)一起參與演習等等。這些項目正是福島事故後，行政院原子能委員會要求台電公司於各電廠年度緊急計畫演習增加的演習項目，本次會議台電公司人員適巧於簡報中撥放了 1 段 8 分鐘 103 年核安 20 號演習英語版短片，分享台灣電廠緊急計畫之準備，恰呼應了 WANO 訪查員的建議，實屬巧合。

兩天會議中，邀請 Dr. Bernard Le Guen 擔任導師(Mentor)，Dr. Bernard 擔任法國電力公司(Electricité de France，EDF)輻射防護及工業安全部門副總經理，同時也是一位專長於醫學生物和職業醫學的醫生，於巴黎醫科大學教授輻射防護相關課程，更為國際輻射防護協會(International Radiation Protection Association，IRPA)的資深成員。Dr. Bernard 於會中巧妙的引導與會人員進行討論，回顧並省思福島事故於核能安全及輻射防護工作的影響，同時亦準備了一部法國電力公司人員對核能電廠事故處理的簡介影片，生動活潑，讓與會人員瞭解該公司是以整個團隊 LA FARN(la Force d'action rapide du nucléaire，LA FARN)共同備戰應對的方式來執行危機處理和救援任務，這也足以解釋核能發電為何可以在法國國內電力供應佔有舉足輕重的地位，乃因信心源自持續的努力和不鬆懈。

肆、建議事項

1. 日本福島電廠事故後，世界各國核能發電業者在提升機組安全可靠度、輻射防護偵測、核能安全暨輻射防護相關法令檢討修正及緊急救援疏散工作上，均投入大量人力、物力及時間進行長期且持續性研究改善，且核能安全風險溝通之意識逐漸受到國際重視，緊急計畫演習與平時的整備工作，均為不可或缺之一環，台電公司應持續派員參加相關會議並參與討論，汲取經驗，從而發展出適合我國需求的輻防作為與應變方案。台電公司現階段推展之工作，如緊急事故環境輻射監測網之研究發展，與歐盟各國的研議之新法令建議發展的方向一致，值得持續精進推廣。
2. 英文科學報告或論文的撰寫語法有一定規則，例如必須使用第三人稱、被動語氣，對於不熟悉報告撰寫方法的人而言，亟需公司提供管道學習。建議本公司網路學院或各訓練中心尋找此方面專家，針對各種原文報告、簡報或論文的情境，整合出參考範本並提供教學，讓所有需要的員工有成長的機會。

附件一 會議議程

Programme

Wednesday, 26th November 2014

09:00-09:15 **Safety and Logistics**

Mr. Harish Kalsi, Programme Manager OE, WANO-TC

09:15-09:30 **Welcome to the Workshop**

Mr.Sang-Young Moh, Deputy Director, WANO-TC

09:30-09:45 **Introduction to the Workshop – Goals and Topics**

Dr. Bernard Le Guen, Radiation Protection and Industrial Safety VP, EDF DPN

09:45-10:30 **Introducing each other**

10:30-10:45 **Coffee and refreshments**

10:45-11:00 **This is WANO**

Ms. Ayako Tokunaga, Programme Manager Communication, WANO-TC

11:00-12:00 **Current topics of Radiation Exposure Rulemaking**

Dr. Akihide Kugo, Director JANSI

12:00-13:30 **Buffet Lunch**

13:30-14:15 **Radiation Protection Actions at Fukushima Daiichi Accident**

Mr. Atsutoshi Makihira, Manager Nuclear Safety Oversight Office, TEPCO

14:15-14:30 **Coffee and refreshments**

14:30-15:30 **Post-accident Measures for Radiation Protection in EDF NPP**

Dr. Bernard Le Guen, Radiation Protection and Industrial Safety VP, EDF DPN

15:30-16:15 **Post-accident Measures for Radiation Protection of CNNP**

Mr. Li-Guang Fan, Section Head, CNNC Nuclear Power Operations Management Co., Ltd.

16:15-16:30 **Convenience break**

16:30-17:15 **Preparation in Response to Emergency**

Mr. Zhong-Min Yan, Peer Reviewer, WANO-PC

17:15-17:30 **Logistics**

Mr. Harish Kalsi, Programme Manager, WANO-TC

Thursday, 27th November 2014

09:00-09:15 **Golden Nuggets of the Previous day**

Dr. Bernard Le Guen, Radiation Protection and Industrial Safety VP, EDF DPN

09:15-09:35 **Radiation Protection Measures taken at KANUPP after Accident at Fukushima**

Mr. Asad Afzal, Karachi Nuclear Power Plant, PAEC

09:35-09:55 **Safety Improvements at Loviisa NPP before and after Fukushima Accident**

Dr. Marko Marjamäki, Design Engineer, Fortum Power and Heat Oy, Finland

09:55-10:15 **Post Accident Measures for Radiation Protection at PFBR**

Mr. Praveenkumar Emmadisetti, Scientific Officer/D, PFBR Kalpakkam Nuclear Power Station, BHAVINI

10:15-10:30 **Coffee and refreshments**

10:30-10:50 **Enhanced Measures and Preparations of Radiation Protection in TPC after Fukushima Accident**

Ms. Hsin-Yi Chiu, RP Engineer, DONG, TPC

10:50-11:20 **Ongoing Work to Enhance Post-accident Radiation Protection at Swedish Nuclear Power Plants-RPFA Working Group**

Ms. Nastaran Farahi, Radiological Specialist, Forsmark NPP, Sweden

11:20-11:40 Post-Fukushima Improvement on Emergency Preparedness in FQNP

Mr. Hong Huang, RP Manager, Fuqing NPP, CNNC

11:40-13:15 Buffet Lunch

13:15-13:30 Group Photo

Managed by Mr. Harish Kalsi

13:30-14:20 The Emergent Radiation Monitoring and Demonstration Networks Applied in Environmrntal Surveillance during the Post-accident

Mr. Yih-Min Chang, Radiation Laboratory Manager, TPC

14:20-15:45 Group-work

15:45-16:00 Coffee and refreshments

16:00-16:45 Group-Work Results(Open Discussion)

Dr. Bernard Le Guen, Radiation Protection and Industrial Safety VP, EDF DPN

16:45-17:00 Mentor's Final Conclusions

Dr. Bernard Le Guen, Radiation Protection and Industrial Safety VP, EDF DPN

17:00-17:10 Closing of the Workshop

Mr.Sang-Young Moh, Deputy Director, WANO-TC

17:10-17:20 Feedback/Logistics

Mr. Harish Kalsi, Programme Manager OE, WANO-TC

附件二 台電人員簡報資料

(一) 張益民/放射試驗室

「核能事故緊急輻射監測暨展示網在廠外環境輻射偵測上之應用」(The Emergent Radiation Monitoring and Demonstration Networks Applied in Environmental Surveillance during the Post-accident)

(二) 邱心怡/核能發電處

「福島事故後台電公司於輻射防護工作之強化措施與準備」(Enhanced Measures and Preparations of Radiation Protection in TPC after Fukushima Accident)

The Emergent Radiation Monitoring and Demonstration Networks Applied in Environmental Surveillance during the Post-accident

Yih-Min, Chang
Taiwan Power Company, Radiation Laboratory
November 26th 2014

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Contents

- Introduction
- Radiation surveillance work in different stage during the accident
- Specification of mobile radiation monitor
- Emergent radiation monitoring process
- Superiority of Emergent Radiation Monitoring & Demonstration Network
- Exercises of nuclear emergency response trill
- Summary

2

Introduction

- Fukushima Daiichi nuclear accidents, occurred after natural disasters in 2011, told us something important：

❶ Serious nuclear accidents ,such as lose of core coolant, even core meltdown accident could happen especially after a series of grave earthquake and/or huge tsunami.

❷ The people was easily panic-stricken since serious environmental contamination causing from massive radioactive materials release by gaseous and liquid pathways.

3

Introduction

❸ Utilizing the model to predict the public dose developing in the early stage of the accident could be distorted because of insufficient source terms or wrong parameters used.

❹ Revealing the real environmental monitoring data instantly to demonstrate the status of the accident could be the most effective way to pacify the public.

4

Introduction

- Dozens of nuclear power units are located on both sides of Taiwan strait. Any radiation release from emergency events could cause public panic owing to short distance and high population density.
- The environmental radiation monitoring work as an important part of the emergency plan for NPP is undertaken by the radiation monitoring and dose assessment center (RMDAC) while a nuclear accident occurs in Taiwan.

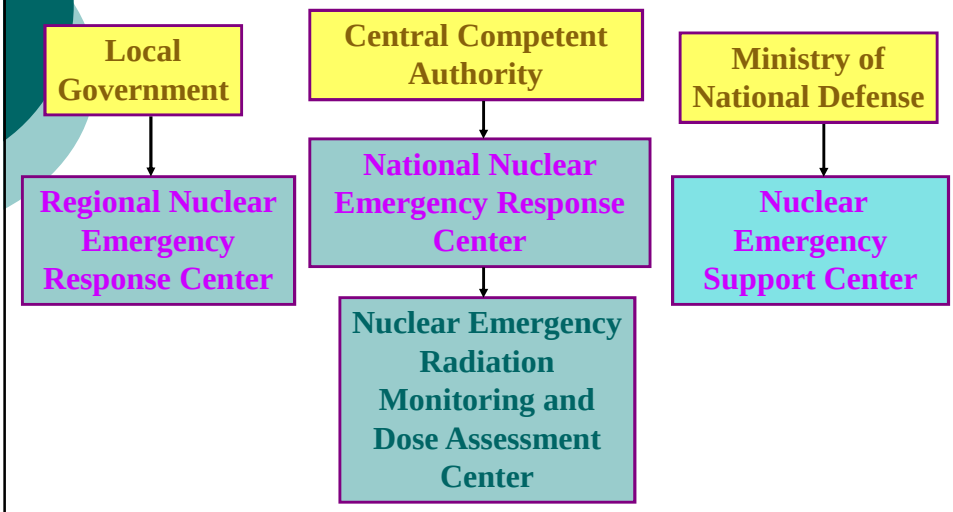
5

Introduction

- Radiation surveillance work could not manually carry out for a long time practically due to high exposure during the post-accident.
- A radiation monitoring network with automatic data collection, real-time transfer, wireless communication and internet integration and screen display shall plays an effective and helpful role of environment monitoring tasks while the accident occurs.

6

Nuclear Emergency Response Organization



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Responsibility of Nuclear Emergency Radiation Monitoring and Dose Assessment

- The Nuclear Emergency Radiation Monitoring and Dose Assessment Center shall:

  (1) carry out radiation measurements for personnel, vehicles, and the environment,

  (2) assess the degree and affected area of the accident, evaluate public radiation dose, and propose protective actions,

  (3) provide sufficient information and technology to the various levels of emergency response centers, and

  (4) implement any other measure as assigned by the National Nuclear Emergency Response Center.

8

Introduction

- TPC Radiation Laboratory being the key member of the radiation monitoring and dose assessment center is in charge of establishing and maintaining the radiation monitoring equipment using for emergency events and actually implementing the radiation surveillance task during the post-accident.

9

Introduction

- The radiation monitoring work during the emergency period in Taiwan used to be executed by human action.
  - ➢ According to instructions from RMDAC, workers reached to the specific spot and used portable instruments (such as survey meters, air sampler etc.) to measure the dose rate and collect air particulate samples.
  - ➢ Radiation data were passed back to RMDAC by a radio (walky-talky) or mobile phone then.

10

Introduction

- Connecting detector manufacture capacity , 3G mobile phone technology and communication environment in Taiwan, many kinds of the mobile environmental radiation monitors and an emergent radiation monitoring and demonstration (ERMD) network are developed by RL/TPC to strengthen the ability of environment surveillance during the accident.

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Introduction

- ERMD network joining with the mobile radiation detectors accomplish an automatically data collecting, real-time data transmitting, wireless communicating, internet integrating and screen displaying operation patterns.
- It shall be effective and helpful for the environment monitoring tasks while the accident occurs.

12

Introduction

- ERMD network also merges the monitoring data collected by the routine radiation monitoring stations coming from AEC/ROC and RL/TPC.
- By way of the internet and Google earth, the network could easily demonstrate the real-time data on the screen.

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Radiation surveillance work in different stage during the accident

- According to the analysis and planning report of the public protective measures within the EPZ, environmental radiation surveillance during the accident is executed by different ways with different stages.
- Basically there are divided three stages during the accident, those are early stage, middle stage and recovery stage.

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Radiation surveillance work in early stage during the accident

- Since radioactive release is still limited in the containment in early stage, environmental radiation surveillance is mainly executed by routine radiation monitoring stations established and operated by TPC/RL and AEC/ROC respectively.

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Radiation surveillance work in early stage during the accident

- There are 3 routine networks for environmental monitoring purpose within the EPZ：

❶HPIC network located around the boundary of the NPP(5 stations operated by TPC).

❷Environmental monitoring network installed in high populated area near the NPP(5 stations run by AEC/ROC).

❸EPZ radiation monitoring network located among 5-8 km region within EPZ especially for the downwind area (7-9 stations operated by TPC).

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Radiation surveillance work in early stage during the accident

- Those data collecting from 3 routine radiation monitoring networks are polled together by ERMD network.
- Through the monitoring data are wholly disclosed on the screen, the status of the early stage during the accident can be easily handled.
- It is really helpful for decision making and action taking.

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Radiation surveillance work in early stage during the accident

- Considering the radiation dose rate distribution, reactor damage information and wind direction, the follow-up detection plan is done by RMDA center.
- At least 10 mobile environmental radiation monitors(MERM) in early stage are temporally installed on the planned spots.

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Radiation surveillance work in early stage during the accident

- MERM can automatically detect the radiation dose rate for 2 days and transmit the data every minute back to the server installed in RMDAC.
- Integrating the data coming from the routine radiation monitoring networks and MERM, a radiation dose rate map projected on the screen can be obtained.

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Radiation surveillance work in middle stage during the accident

- Radiation release quickly increases in the middle stage during the accident, additional MERM (more than 40) being dispatched to the critical area within the EPZ will be necessary.
- In the meantime environmental samples are taken in the highly contaminated region and analyzed by gamma spectroscopy to realize the scope and status of the accident.

20

Radiation surveillance work in middle stage during the accident

- Depending on the status of the accident, specific detection plans, such as patrol detection on the road/by the sea/in the air, will be possible to conduct.
- By means of the automatically detection, 3G wireless communication and built-in GPS of the MERM, the patrol detection plans can be easily carried out.

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Radiation surveillance work in recovery stage during the accident

- Reactor damages are progressively controlled and radiation release is gradually decrease in the recovery stage during the accident, hence dispatching large number MERM to execute surveillance work is not necessary any more.
- Radioactive determination in the samples especially taken from the highly contaminated area is the major task in addition to routine radiation monitoring work.

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Specification of mobile radiation monitor

- Basically MERM is composed of radiation detector, GPS and industrial PC.
- Two kinds of detectors installed in different mobile radiation monitoring system are NaI(Tl) detector and plastic scintillation counter.
- NaI(Tl) detector is used to collect the gamma spectrum at the contaminated spot and the plastic scintillation counter is used to detect the dose rate in the environment.

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Specification of mobile radiation monitor

- If necessary, weather instruments, long-lived lithium battery and camera could be installed in MERM.
- All data collected by various sensors are integrated by an embed industrial PC and real-time transmitted to the server by way of a 3G communication network.

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Specification of mobile radiation monitor

- Radiation monitoring information taking from the server is processed by a specific program linking with Google Earth and demonstrated on the screen installed on the wall in RMDAC to follow up the progress of the nuclear accident.
- That provides a reference to take actions for shelter or evacuation of the residents, even taking iodine tablets.

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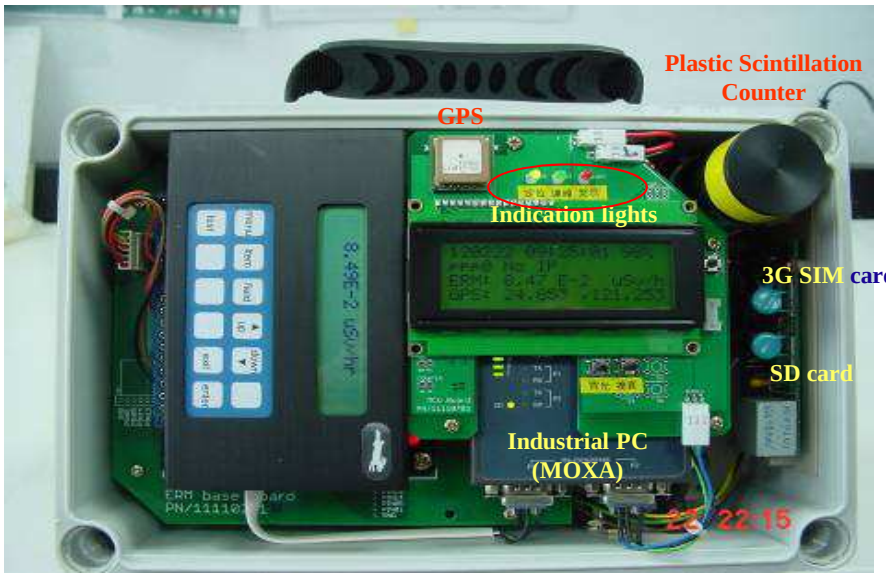
Mobile radiation monitor can integrate different data collecting from various sensors.

26
26

Mobile Radiation/Weather Monitoring Cart 27

3G Smart phone is used to analyzing gamma spectrum and data transmitting.

Portable Radiation/Nuclide Analyzing Box (NaI(Tl)) detection box

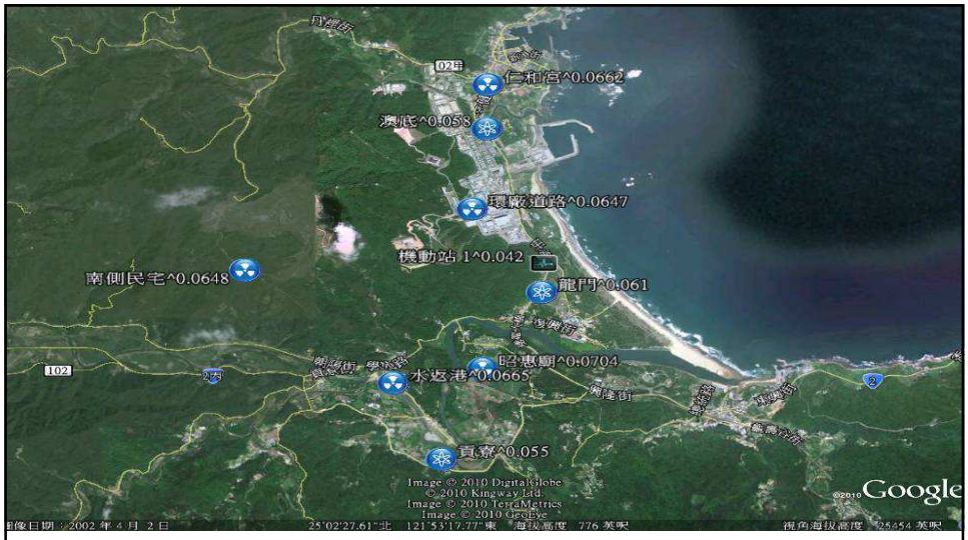


Mobile Environmental Radiation Monitoring Box

Emergent radiation monitoring process

1. Using internet network and a specific program linking with Google Earth, routine radiation monitoring data capturing from RL/TPC and RMC/AEC are revealed instantly on the screen in RMDAC to realize the contamination status in early stage during the accident.

30



A map shows dose rate data collecting from 10 stationary routine spots around Lung-men NPP

31

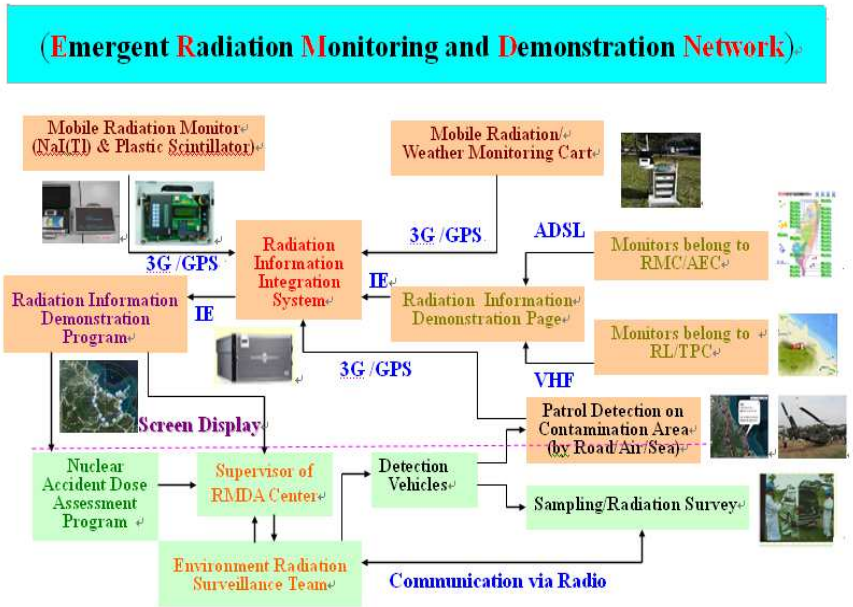
Emergent radiation monitoring process

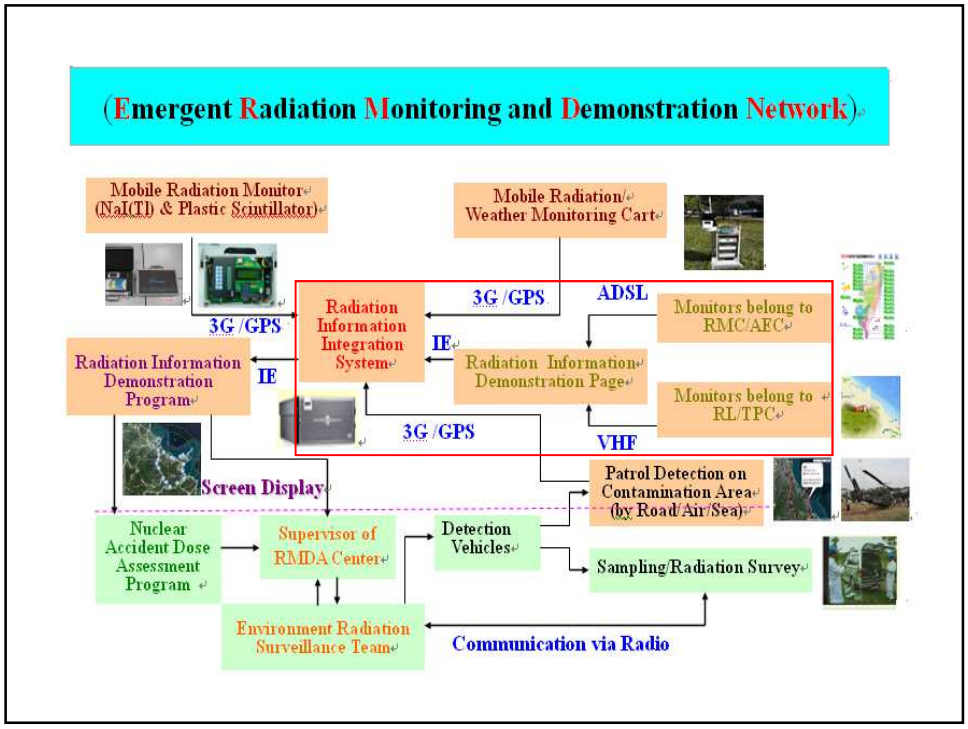
2. The staff being in charge of environmental surveillance reach the scheduled detection spots and hang the mobile radiation monitor box on the hook , then immediately return the center.
3. Data collected by various sensors automatically transmit to the server located on RMDAC by way of 3G communication network.

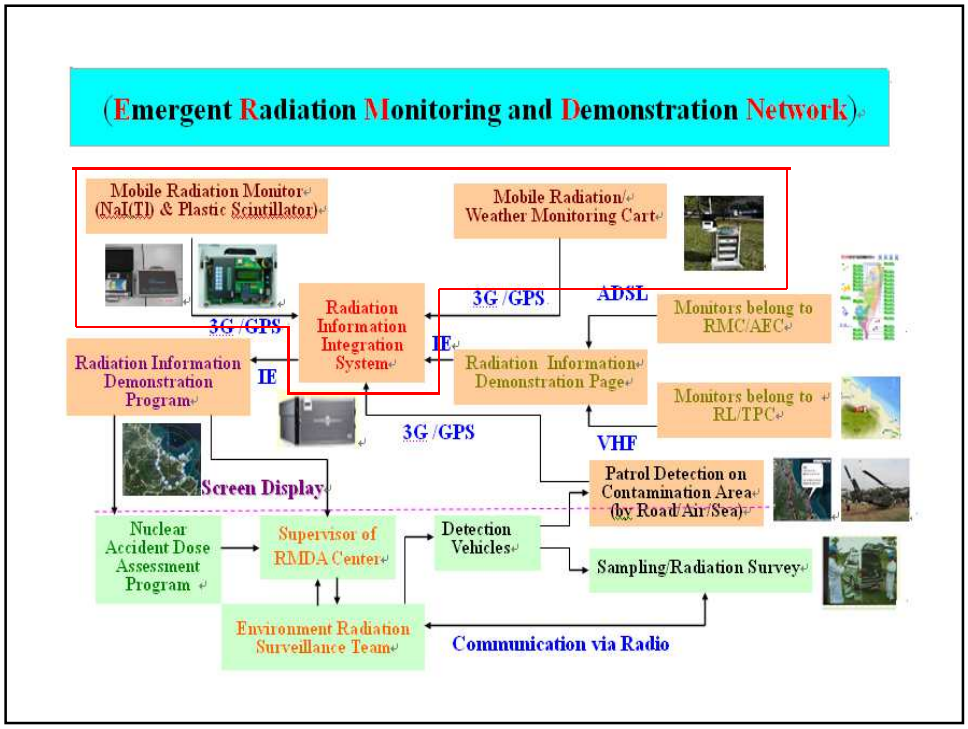
32

Specific spot for deposition in the nuclear accident

Mobile radiation monitor box is hanged on the hook of the pole




(Emergent Radiation Monitoring and Demonstration Network)
Mobile Radiation Monitor (NaI(Tl) & Plastic Scintillator)
Mobile Radiation/ Weather Monitoring Cart
3G /GPS
Radiation Information Integration System
3G /GPS
ADSL
Monitors belong to RMC/AEC
IE
Radiation Information Demonstration Program
IE
Radiation Information Demonstration Page
Monitors belong to RL/TPC
3G /GPS
VHF
Screen Display
Patrol Detection on Contamination Area (by Road/Air/Sea)
Nuclear Accident Dose Assessment Program
Supervisor of RMDA Center
Detection Vehicles
Sampling/Radiation Survey
Environment Radiation Surveillance Team
Communication via Radio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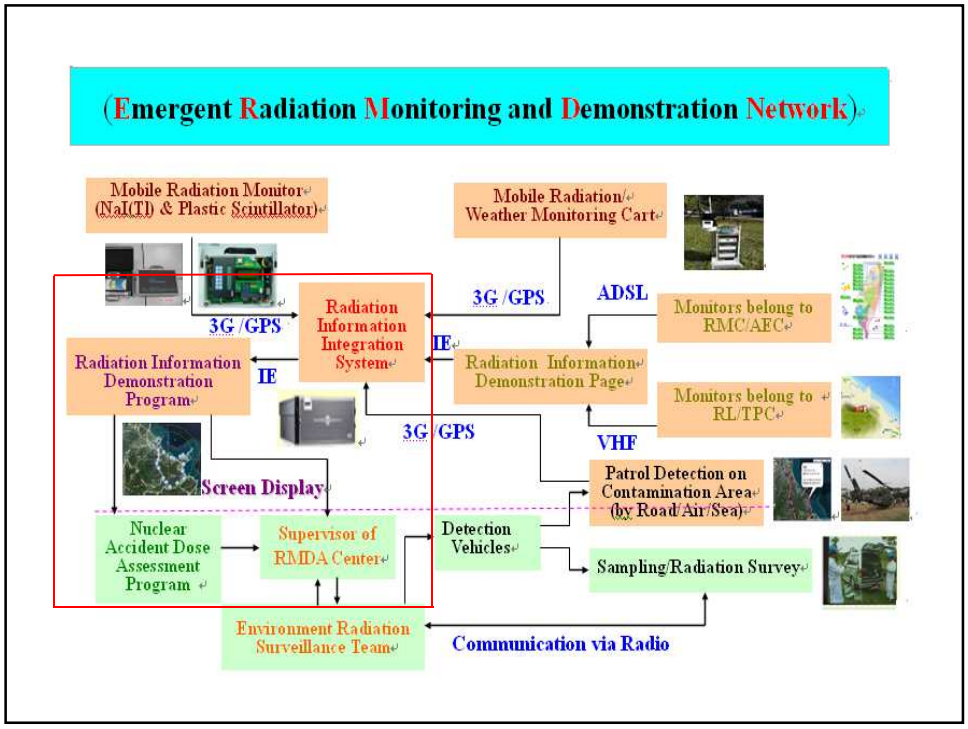
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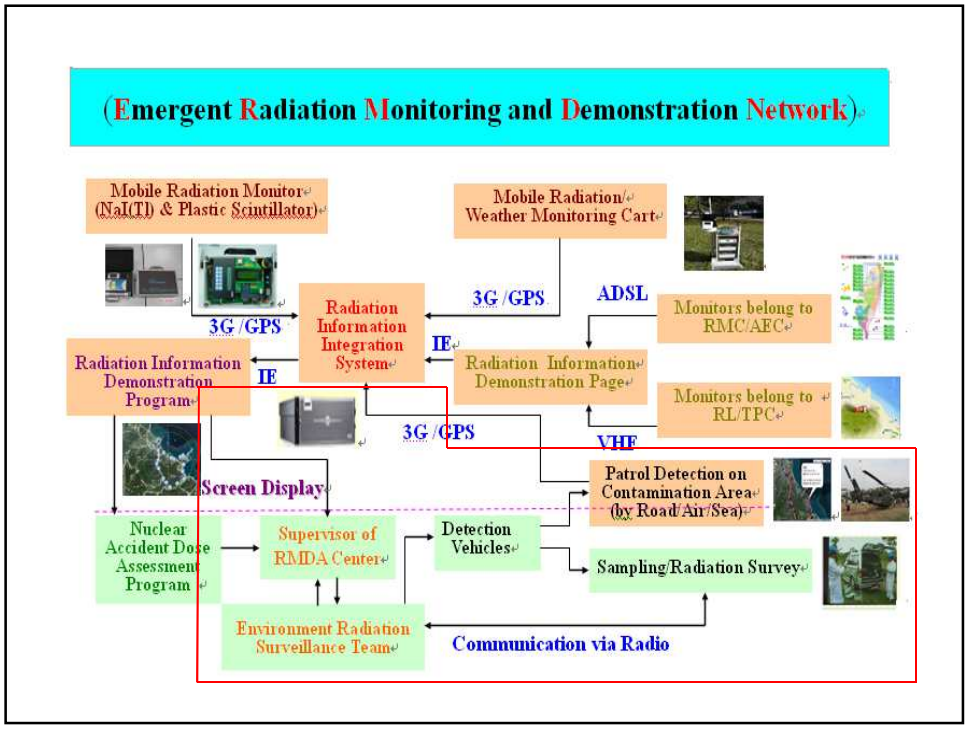
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Superiority of Emergent Radiation Monitoring & Demonstration Network

- Emergent radiation monitoring network integrating radiation detection, GPS position, weather measurement, 3G communication, Google Earth and photography has constituted a complete radiation monitoring system.
- Using numerous data taking from stationary and mobile radiation monitoring stations can easily form a radiation dose rate map .

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Superiority of Emergent Radiation Monitoring & Demonstration Network

- It is possible to execute a long-term and real-time monitoring task by way of assembling a long-lived lithium battery.
- It is not necessary to consider staff contamination and material supply because dose rate is measured automatically by the mobile radiation monitoring devices.

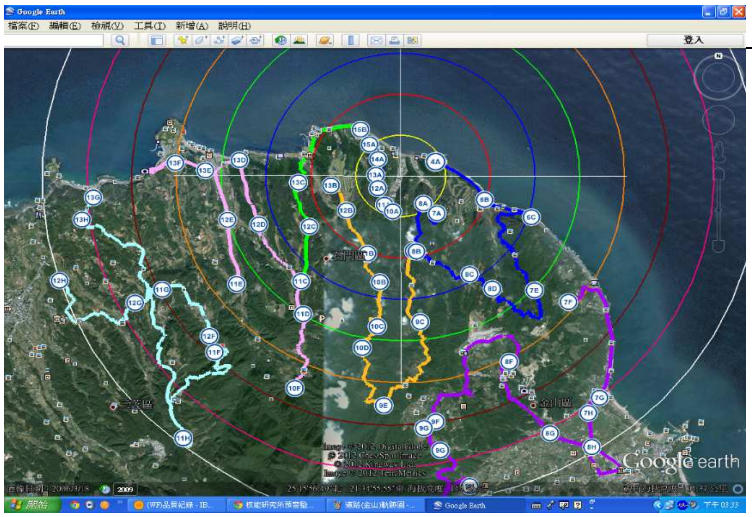
40

Superiority of Emergent Radiation Monitoring & Demonstration Network

- Using GPS and 3G communication, data correction have been improved.
- Via internet network, web page and screen display, radiation information can easily and conveniently demonstrate on the screen in RMDA center. It is useful for realizing the tendency of the accident and making decision by the supervisor of RMDA center.

41

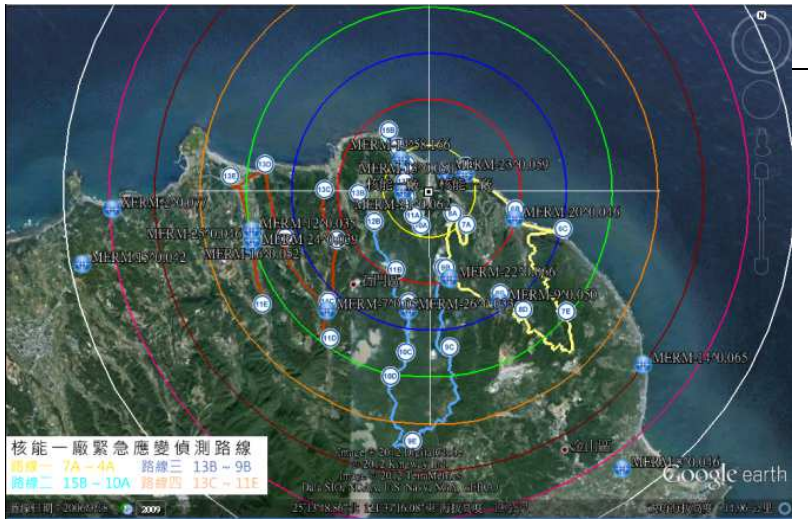
Exercises of nuclear emergency response trill



The surveillance routes and scheduled detection spots within 8 km from Chin-san NPP

42

Exercises of nuclear emergency response trill

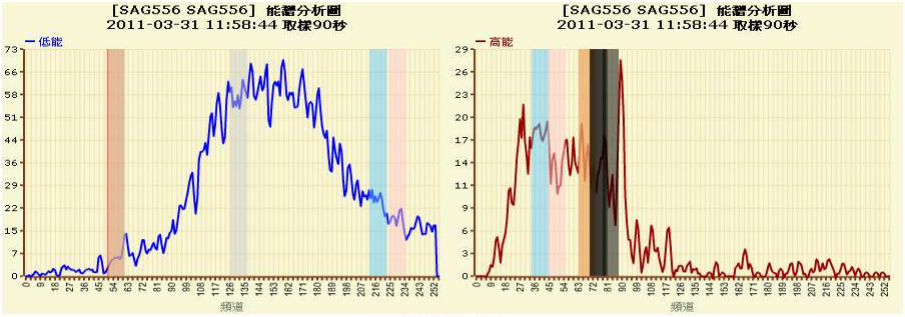


Radiation dose rate map collecting from the mobile radiation monitors (no. 18 Nuclear Safety Drill,2012) 43

- **The upper figure shows radiation and weather information collecting from a mobile radiation/weather monitoring cart.**
- **The lower chart represents the dose rate trend with the measuring time.**

- **The upper figure shows radiation information collecting from a portable radiation/nuclide analyzing box.**
- **The lower chart represents the dose rate trend with the measuring time.**

45



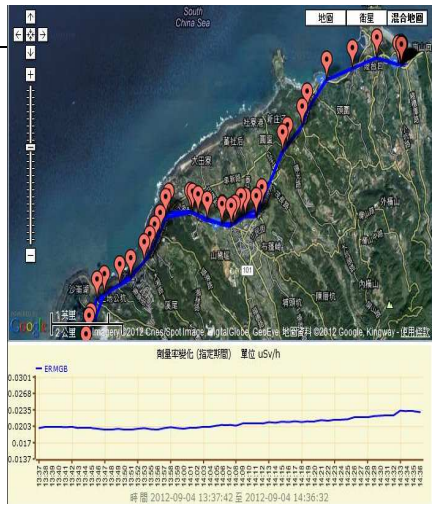
選定取樣核種

核種	半衰期	能量 Kev	劑量率	低能	低能LROI	低能HROI	高能	高能LROI	高能HROI
BA133-33	10.5 Yr.	33	0.0391	0.4	50	61	0		
CS137-35	30 Yr.	35	0.0391	1	51	62	0		
CO57-122	271 Day	122	0.0391	5.3	126	137	0.1		
CS137-662	30 Yr.	662	0.0391	1.3	212	223	1.6	34	45
EU152-779	13.6 Yr.	779	0.0391	0.3	224	235	1.3	44	55
BI214-1120	1.6K Yr.	1120	0.0391	0			1.2	63	74
SC46-1121	83.8 Day	1121	0.0391	0			1.2	63	74
I135-1260	6.6 hr.	1260	0.0391	0			1.3	70	80
NA22-1275	950 Day	1275	0.0391	0			1.4	70	81

The gamma spectrum collecting from a portable radiation/nuclide analyzing box (NaI(Tl)) at the spot

Exercises of nuclear emergency response trill

A vehicle supported by the special forces carries the MERM to execute the patrol detection on the road.

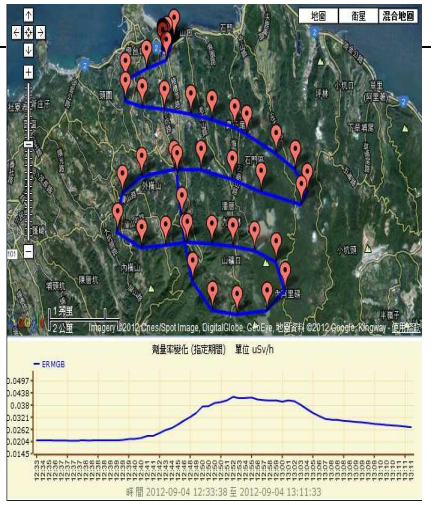


The trail of patrol detection on the road.

47

Exercises of nuclear emergency response trill

A military helicopter carries the MERM to execute the patrol detection in the air.



The trail of patrol detection in the air.

48

Exercises of nuclear emergency response trill

A coastal guard boat carries the MERM to execute the patrol detection by the sea.

The trail of patrol detection by the sea.

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Summary

- Emergent radiation monitoring network integrating automatic detection, multiple information, real-time transmit, GPS position, GSM communication and website display function constitutes a complete radiation monitoring system during the accident.

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Summary

- Through a large number mobile radiation monitors detect simultaneously, a radiation dose rate map can be obtained.
- It is really useful to reveal the radiation monitoring information instantly projected on the screen in RMDA center for judging the tendency of the accident development and taking actions for the public.

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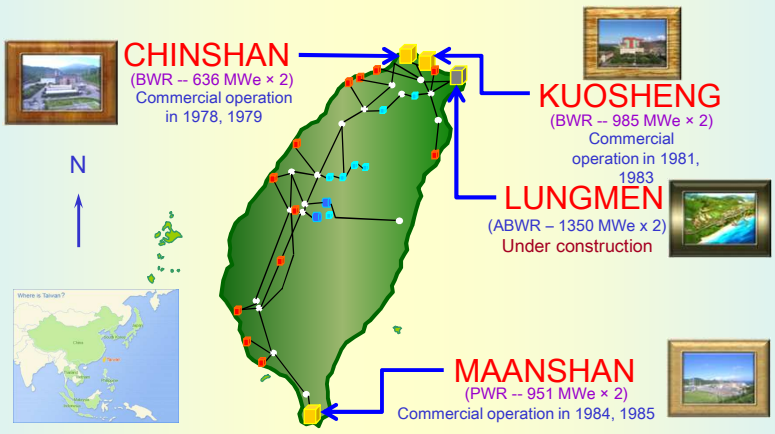
Enhanced Measures and Preparations of Radiation Protection in TPC after Fukushima Accident

Hsin-Yi Chiu, RP Engineer
Taiwan Power Company

November 27th 2014

The Location of NPPs



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The Enhanced Measures of Radiation Protection

Assumption:

nearby roads prevent to NPP, loss of offsite power(it needs several days to recover), station blackout, loss of coolant accident, the failure of containment, worst to general emergency accident(GEA).

Main Ideas:

It provides each NPP's self-preparation on radiation protection needs of emergency saving at least 7 days.

3

The Enhanced Measures of Radiation Protection

Guideline:

1. The Radiation Protection(RP) and Dose Management of field workers

- Internal RP is achieved by Whole Body Counting, Working Environment Radiation Monitoring and provides necessary individual RP equipment when airborne.
- Shortening exposure-time is more important than Shielding protection.
- Dose management is based on EPD, but TLD is still official dose record.
- Prevent to unnecessary dose, the dose-rate monitoring should not be taken when the site is under high radiation.

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The Enhanced Measures of Radiation Protection

2. Monitoring the high radiation area on site
- draw the emergency work path in advance.
- remove the high radiation barrier or decontaminating it in advance.

3. Reducing contaminated spread
- radiation dust, radiation liquid, radiation nuclide concentration

The Enhanced Measures of Radiation Protection

Organization:

1. On-site
- TSC, OSC, HPC(Health Physics Center)

2. Radiation Laboratory
- Off-site Environment Radiation Monitoring
- EPD and TLD emergency Recording
- support RP manpower, RP equipment

3. Headquarter(Nuclear emergency response center)
- report to central government, decision analysis and call-out for rescue.

The Preparation of TPC on Radiation Protection

Set Supporting Plan:

- Manpower, build up RP database including experts and field workers.
- List Daily Work Items in the damaged plant in advance.
- Estimate the needs of RP manpower support, and adjust to routine workers in other unplagued NPPs.

The Preparation of TPC on Radiation Protection

The RP Equipment and miscellaneous for field workers and rescuers:

- Check and List each NPP's RP equipment and misc. in Storage.
- Set the plan for damaged plant.
- Estimate the needs of RP equipment and misc. and adjust those in other unplagued NPPs.

The Preparation of TPC on Radiation Protection

Estimate the habitability of field workers and rescuers:

- Make sure the temporary living area.
- with individual air condition, with HEPA and HECA, if none, provide the close-cycle air filtration system.
- with drinking water filtration system.
- Daily Essentials storage.

The Preparation of TPC on Radiation Protection

Renew on-site emergency RP plan:

- Estimate each NPP's emergency plan is suitable for the condition under general emergency accident(GEA).
- Estimate the alternative RP strategy (ex. Potassium Iodine, breathing mask, activated carbon filter, etc.)
- Estimate the impact and strategy of emergency accident under existing legislation.

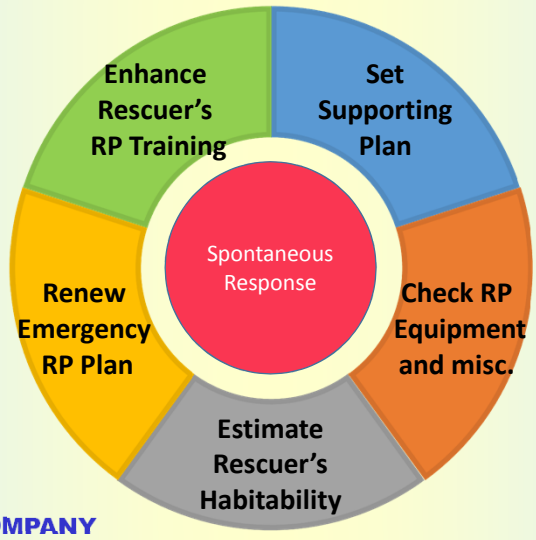
The Preparation of TPC on Radiation Protection

Enhance the RP training course for Rescuers:

ex: military soldiers, firefighters, medical practitioners

- individual RP equipment training, walk down on site.
- especially focus on RP philosophy, self-protection, the Inform of environmental radiation risk on-site.
- invite rescuers to join the annual drill
- each NPP should take the responsibility for RP Training and interact with rescuers.
- 2014 Nuclear Emergency Exercise in Taiwan(VIDEO)

We set plans and keep going on.....



感謝聆聽

Thanks for your attention!

ご清聴ありがとうございました

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