Twenty-Eighth Session
10 – 14 June 2019

SAB-28/WP.3
4 June 2019
ENGLISH only

SUMMARY OF THE THIRD MEETING OF THE SCIENTIFIC ADVISORY BOARD TEMPORARY WORKING GROUP ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

1. AGENDA ITEM ONE – Opening of the meeting

1.1 The Scientific Advisory Board's (SAB) Temporary Working Group (TWG) on Investigative Science and Technology held its Third Meeting from 2 to 4 April 2019 in The Hague, the Netherlands, with sessions at OPCW Headquarters (2 and 4 April) and the Netherlands Forensic institute (NFI, 3 April). The meeting was chaired by Dr Veronica Borrett on behalf of the SAB, with Dr Ed van Zalen as Vice-Chairperson.

1.2 Dr Borrett opened the meeting by welcoming the TWG members, invited guest speakers and observers. After outlining the programme of work, she introduced the objectives and terms of reference (TOR) of the Group.[1] Dr Borrett highlighted the SAB's exploration of new and emerging technologies,[2,3] and described how the TWG is studying these with a view toward developing technical advice of relevance to the implementation of the Chemical Weapons Convention (hereinafter "the Convention"). She emphasised that in order for the advice to be beneficial, there is need for

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1 For the terms of reference see Annex 1 of: "Summary of the First Meeting of the Scientific Advisory Board's Temporary Working Group on Investigative Science and Technology" (SAB-27/WP.1, dated 26 February 2018); www.opcw.org/sites/default/files/documents/SAB/en/sab-27-wp01_e_.pdf. A quick reference guide to the questions contained within the terms of reference is available at: www.opcw.org/sites/default/files/documents/SAB/en/TWG_Investigative_Science_Tech_Questions.pdf.

2 (a) "Report of the Scientific Advisory Board on Developments in Science and Technology for the Fourth Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention" (RC-4/DG.1, dated 30 April 2018); www.opcw.org/sites/default/files/documents/CSP/RC-4/en/rc4dg01_e_.pdf. (b) "Report of the Scientific Advisory Board's Workshop on Emerging Technologies" (SAB-26/WP.1, dated 21 July 2017). www.opcw.org/sites/default/files/documents/SAB/en/sab26wp01_SAB.pdf. (c) "Report of the Scientific Advisory Board's Workshop on Chemical Forensics" (SAB-24/WP.1, dated 14 July 2016). www.opcw.org/sites/default/files/documents/SAB/en/sab24wp01_e_.pdf. (d) "Verification Report of the Scientific Advisory Board's Temporary Working Group" (SAB/REP/1/15, dated 11 June 2015). www.opcw.org/sites/default/files/documents/SAB/en/Final_Report_of_SAB_TWG_on_Verification_-_as_presented_to_SAB.pdf.

3 "Innovative Technologies for Chemical Security", J. E. Forman, P. Aas, M. Abdollahi, I. P. Alonso, A. Baulig, R. Becker-Arnold, V. Borrett, F. A. Cariño, C. Curty, D. Gonzalez, Z. Kovarik, R. Martínez-Álvarez, R. Mikulak, E. de Souza Nogueria, P. Ramasami, S. K. Raza, A. E. M. Saeed, K. Takeuchi, C. Tang, F. Trifirò, F. M. van Straten, F. Waqar, V. Zaitsev, M. Saïd Zina, K. Grolmusová, G. Valente, M. Payva, S. Sun, A. Yang, D. van Eerten; *Pure Appl. Chem.*, 2018, *90(10)*, 1527-1557. DOI: 10.1515/pac-2018-0908.

engagement with and between experts from the fields of investigative and forensic sciences, the OPCW Technical Secretariat (hereinafter "the Secretariat"), and the Designated Laboratories (DLs).[4] Dr Borrett provided updates on the intersessional work after the 14-16 November Second Meeting of the TWG[5] (including informal meetings with members of the Secretariat and a briefing to States Parties during the "Science for Diplomats" event at the Fourth Review Conference[6]).

1.3 During the visit to the NFI on 3 April, the TWG and its guests were welcomed by NFI Chief Executive Officer Mr Leo Zaal. Mr Zaal provided an overview of the work of the NFI which is an agency of the Netherlands Ministry of Justice and Security. He explained its role in supporting the Dutch Prosecutor and Police, as well as many national and international organisations in investigations. He also explained the NFI's CBRN forensics capabilities. Mr Zaal emphasised the importance of the work of the TWG and expressed appreciation for its close partnership with NFI. He highlighted capabilities of the NFI and looked forward to the presentations that were to be held throughout the day. Following the opening remarks, Dr van Zalen briefed the TWG on the history of the NFI and its key roles in examinations in criminal cases (NFI is not a crime scene investigating organisation, it provides support), research and development, and acts as a centre of knowledge and expertise. The NFI is a highly interdisciplinary laboratory with expertise across the range of forensic analysis capabilities (chemical, biomedical, physical, and digital).

Executive Summary

1.4 At its Third Meeting, the TWG received briefings on the Secretariat's non-routine activities from current and former chemical weapons inspectors, as well as briefings from invited guests with experience in forensic science, international treaty verification, the collection of evidence and information under adverse circumstances, unmanned systems, and the use of open source intelligence for verification applications. These briefings provided further input for TWG's consideration of the needs of the Secretariat.

1.5 The sub-groups established at the first TWG meeting provided updates on their findings. The TWG intends to hold two additional meetings in 2019 to develop a substantive report on its work, including recommendations, to be finalised before the Group's mandate ends in February 2020.

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4 (a) "Status of Laboratories Designated for Authentic Environmental Sample Analysis" (S/1738/2019, dated 27 March 2019); www.opcw.org/sites/default/files/documents/2019/03/s-1738-2019%28e%29_0.pdf. (b) "Status of Laboratories Designated for the Analysis of Authentic Biomedical Samples" (S/1661/2018, dated 4 September 2018); www.opcw.org/sites/default/files/documents/2018/12/s-1699-2018%28e%29.pdf.

5 "Summary of the Second Meeting of the Scientific Advisory Board Temporary Working Group on Investigative Science and Technology" (SAB-28/WP.2, dated 21 January 2019); www.opcw.org/sites/default/files/documents/2019/01/sab28wp02%28e%29.pdf.

6 Science for Diplomats at the Fourth Review Conference was held on 22 November 2018 along with a briefing on the Third Spiez Convergence workshop; www.opcw.org/sites/default/files/documents/2018/12/20181123-Science_for_Diplomats_at_RC4-Convergence%20and%20solving%20chemcial%20mysteries.pdf (answers to the "chemical mystery" are also available: www.opcw.org/sites/default/files/documents/2018/12/20181123-Science_for_Diplomats_at_RC4-Answers%20to%20Chemical%20Mystery.pdf).

1.6 The TWG further explored the key outcomes of its Second Meeting,[7] in particular the TWG's previous considerations on the benefits of having access to a "forensic advisor" (see sub-paragraph 6.7(b), paragraphs 7.1 to 7.6, and 14.3) and establishing working relationships with forensic science organisations, laboratories, and experts (see sub-paragraph 6.5(a) and paragraph 14.4). Additional presentations and discussions on these topics support developing advice to the Director-General on these considerations.[7]

1.7 The outcomes of panel discussions (see paragraphs 10.7 and 13.11) and the deliberations within TWG subgroups (see paragraphs 14.2 to 14.19) have identified a number of interesting tools, methods and approaches for investigative science. The TWG suggests that findings from the TWG's Third Meeting be considered with a view to formulating advice to the Director-General on the issues of pertinence to the Secretariat when the SAB meets for its Twenty-Eighth Session.

2. AGENDA ITEM TWO – Adoption of the agenda

The TWG adopted the following agenda for its Third Meeting:

1. Opening of the meeting
2. Adoption of the agenda
3. *Tour de table* to introduce Temporary Working Group members, observers, and guest speakers
4. Establishment of a drafting committee
5. Engagement with forensic and other relevant experts
    - (a) Chemical Forensics International Technical Working Group (CFITWG)
    - (b) Visit to the School of Criminal Sciences at the University of Lausanne, Switzerland
    - (c) Wilton Park Conference on attribution of responsibility for the use of chemical weapons
6. Updates from the OPCW Technical Secretariat
    - (a) Verification (VER) and Inspectorate (INS) Divisions
    - (b) Identification and Investigation Team (IIT)
    - (c) Proposals to add chemicals to Schedule 1A of the Annex on Chemicals
    - (d) OPCW Laboratory

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7 See paragraph 1.6 of SAB-28/WP.2 (footnote 4).

7. The role of the Forensic Advisor: the NFI Experience

8. New technical capabilities

    (a) Geospatial WMD verification and crowdsourcing

    (b) Forensic biometrics in conflict zones

    (c) Collecting verifiable photos and videos: eyewitness

    (d) A tech-stack for the collection and maintenance of information and evidence in adverse, challenging, or contested circumstances

    (e) Forensic Big Data analysis

    (f) Generic Integrated Forensic Toolbox for CBRN (GIFT)

9. Unmet technical needs for verification

    (a) OPCW Fact-Finding Mission (FFM)

    (b) OPCW Declarations Assessment Team (DAT)

    (c) UN led missions and investigations in Syria: tools and capabilities

    (d) Verification of treaty compliance and enhancement of the verification of international treaties: perspectives on the DPRK

10. Verification in inaccessible areas

    (a) Lessons learned from remote verification

    (b) Robotics and Artificial Intelligence to support investigations in hazardous environments

    (c) Non-routine missions in non-permissive environments panel discussion

11. International Organisations and their differing mandates: effects on forensic investigations

12. VX incident at KLIA2 International Airport: national experience

13. Unmanned systems

    (a) UAV-based Radiation Monitoring and Mapping

    (b) Utilization of cargo drones for logistics in low resource settings

    (c) Unmanned systems panel discussion

14. Sub-group updates and discussion

15. Next steps and agendas for the Fourth and Fifth Meetings of the Temporary Working Group

16. Drafting and adoption of the report

17. Closure of the meeting

3. AGENDA ITEM THREE – *Tour de table* to introduce Temporary Working Group members, observers, and guest speakers

A *tour de table* was undertaken to introduce the TWG members, observers, and guest speakers. A list of participants appears in Annex 1 of this report.

4. AGENDA ITEM FOUR – Establishment of a drafting committee

The TWG established a committee to draft the report of its Second Meeting.

5. AGENDA ITEM FIVE – Engagement with forensic and other relevant experts

Subitem 5(a): Chemical Forensics International Technical Working Group (CFITWG)

5.1 Dr Carlos Fraga (Technical Coordinator for the CFITWG) provided updates on key CFITWG developments since the second meeting of TWG. Since its inauguration in 2017, the CFITWG holds an annual meeting during the Fall, and a meeting of its Executive Committee once per year at Pacific Northwest National Laboratory (PNNL) in the USA, and this past February an additional meeting (the "Projects Meeting") which was held at TNO in the Netherlands. Dr Fraga summarised the key findings and outcomes from the Projects Meeting and the Executive Committee Meeting. The Projects Meeting discussed the status and findings of six international collaborative projects; and agreements were made on work and programmatic issues that should be addressed for each project in preparation for the annual CFITWG Meeting to be held in August 2019 in San Diego. During the Executive Committee Meeting, a policy statement was drafted that defined the CFITWG mission and how it supports OPCW's efforts to counter the re-emergence of chemical weapons. The Executive Committee finalised the agenda for the CFITWG Meeting, and drafted strategic plans to increase funding opportunities for chemical forensics research collaborations and future exercises - an area of pressing need, whose advancement would benefit the OPCW, especially for non-routine missions.

5.2 In the subsequent discussion, the following points were raised:

(a) The CFITWG, which includes experts in forensics and chemical warfare agent analysis (including those from DLs), aims to expand the science that could be applied to OPCW identification and investigation missions, and therefore complements the mandate of the TWG.

(b) The CFITWG Projects Meeting involved 36 people, representing 23 organisations, from twelve countries. One planned project is to publish a critical review article on chemical forensics which will summarise the field and provide a future strategy for its advancement. Currently, 32 authors have signed up for this project from across regional groupings. More authors are welcome if they wish to contribute; interested parties can approach Dr Fraga.

Subitem 5(b): Visit to the School of Criminal Sciences at the University of Lausanne, Switzerland

5.3 Mr Cheng Tang (SAB Chairperson) briefed the TWG on a visit to the School of Criminal Sciences at the University of Lausanne in February 2019. Members of the TWG accompanied by staff from the OPCW Inspectorate attended. The visit covered two thematic topics: the concept and application of forensic intelligence[8] and collecting intelligence from online forums and web-based content.

5.4 Briefings were received on applications of forensic intelligence for illicit drug profiling (including analysis of wastewater[9] and seized exhibits[10]), explosives leaching from lake dumped munitions,[11] and the profiling of counterfeit watches;[12] all of which included chemical analysis. Forensic intelligence approaches to crime scene

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8 *The Routledge International Handbook of Forensic Intelligence and Criminology*; Q. Rossy, D. Decary-Hetu, O. Delemont, M. Mulone (eds), Routledge, London, 2017. DOI: 10.4324/9781315541945.

9 (a) A. Bannwarth, M. Morelato, L. Bengalia, F. Been, P. Esseiva, O. Delemont, C. Roux; "The use of wastewater analysis in forensic intelligence: drug consumption comparison between Sydney and different European cities", *Forensic Sciences Research*, 2019. DOI: 10.1080/20961790.2018.1500082. (b) F. Been, L. Bijlsma, L. Benaglia, J. Berset, A. Botero-Coy, S. Castiglioni, L. Kraus, F. Zobel, M. Schaub, A. Bucheli, F. Hernandez, O. Delmont, P. Esseiva, C. Ort; "Assessing geographical differences in illicit drug consumption – A comparison of results from epidemiological and wastewater data in Germany and Switzerland", *Drug and Alcohol Dependence*, 2016, *161*, 189-199. DOI: 10.1016/j.drugalcdep.2016.02.002. (c) F. Been, P. Esseiva, O. Delemont; "Analysis of illicit drugs in wastewater – Is there an added value for law enforcement?"; *Forensic Science International*, 2016, *266*, 215-221. DOI: 10.1016/j.forsciint.2016.05.032.

10 (a) J. Broseus, S. Baechler, N. Gentile, P. Esseiva; "Chemical profiling: A tool to decipher the structure and organization of illicit drug markets: An 8-year study in Western Switzerland"; *Forensic Science International*, 2016, *266*, 18-28. DOI: 10.1016/j.forsciint.2016.04.008. (b) S. Megali, N. Liberatore, D. Luciani, R. Viola, G. Cardinali, I. Elmi, A. Poggi, S. Zampolli, E. Biavardi, E. Dalcanale, F. Bonadio, O. Delemont, P. Esseiva, F. Romolo; "Rapid screening and identification of illicit drugs by IR absorption spectroscopy and gas chromatography", *Quantum Sensing and Nanophotonic Devices X*, 2013, *8631*. DOI: 10.1117/12.2003903.

11 (a) N. Estoppey, J. Matheu, E. Gascon Diez, S. Sapin, O. Delemont, P. Esseiva, L. De Alencastro, S. Coudret, P. Folly; "Assessment of passive sampling for the monitoring of explosive residues in surface water", International Symposium for Sea-Dumped Munition and UXO, Berlin (Germany), 2-4 May 2018, *Infoscience EPFL scientific publications;* https://infoscience.epfl.ch/record/255630 (b) N. Estoppey, J. Matheu, E. Gascon Diez, E. Sapin, O. Delemont, P. Esseiva, P. Folly, L. De Alencastro; "Calibration and deployment of POCIS and Chemcatcher for the monitoring of explosives on lake-bottom sediments"; 8th International Passive Sampling Workshop and Symposium (IPSW 2016), Prague, Czech Republic, September 7-10 2016, *Infoscience EPFL scientific publications*; https://infoscience.epfl.ch/record/221327/.

12 S. Hochholdinger, L. Marvin, M. Arnoux, P. Esseiva, O. Delemont; "Elemental analysis for profiling counterfeit watches"; *Forensic Science International*, 2019, *298*, 177-185. DOI: 10.1016/j.forsciint.2019.03.006.

investigation[13] and the use of photographic information for crime scene reconstruction were reviewed.[14] Additional briefings described the collection and interpretation of intelligence from online forums, detecting links across web content,[15] and the analysis of online illicit markets with both digital and physical traces.[16]

5.5 In the subsequent discussion, it was recognised that the approaches to monitoring of wastewater to detect illicit drug use and explosive residues, in particular mass spectrometric techniques, were relevant to the analysis of residues for chemical warfare agents.

Subitem 5(c): Wilton Park Conference on attribution of responsibility for the use of chemical weapons

5.6 Dr Robert Mikulak briefed the TWG on outcomes of a conference on attribution of responsibility for the use of chemical weapons held from 25 to 27 March in Wilton Park, United Kingdom. Discussions were held to assess political, institutional, technical, and resource aspects for attribution and accountability for using chemical weapons.

5.7 Regarding science and technology aspects of attribution, there is a need to integrate technical data with other types of information. Technical information must be reliable and relevant and meet high forensic standards. Less certain information can still be useful for developing investigative leads, as long as its limitations are understood. There is also a need to use new types of information to link injuries to perpetrators.

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13 (a) T. Resnikoff, O. Ribaux, A. Baylon, M. Jendly, Q. Rossy; "The polymorphism of crime scene investigation: An exploratory analysis of the influence of crime and forensic intelligence on decisions made by crime scene examiners", *Forensic Science International*, 2015, *257*, 425-434. DOI: 10.1016/j.forsciint.2015.10.022. (b) O. Ribaux, A. Baylon, E. Lock, O. Delemont, C. Roux, C. Zingg, P. Margot; "Intelligence-led crime scene processing. Part II: Intelligence and crime scene examination", *Forensic Science International*, 2010, volume (1-3)199, 63-71. DOI: 10.1016/j.forsciint.2010.03.011. (c) O. Ribaux, A. Baylon, E. Lock, O. Delemont, C. Roux, C. Zingg, P. Margot; "Intelligence-led crime scene processing. Part I: Forensic intelligence", *Forensic Science International*, 2010*, 95(1-3)*, 10-16. DOI: 10.1016/j.forsciint.2009.10.027.

14 (a) Q. Milliet, M. Jendly, O. Delemont; "An innovative and shared methodology for event reconstruction using images in forensic science"; *Forensic Science International*, 2015, *254*, 172-179. DOI: 10.1016/j.forsciint.2015.07.028. (b) Q. Milliet, O. Delemont, E. Spain, P. Margot; "A methodology to event reconstruction from trace images"; *Science & Justice*, 2015, *55(2)*, 107-117. DOI: 10.1016/j.scijus.2015.02.001. (c) Q. Milliet, O. Delemont, P. Margot; "A forensic science perspective on the role of images in crime investigation and reconstruction"; *Science & Justice*, 2014, *54(6)*, 470-480. DOI: 10.1016/j.scijus.2014.07.001.

15 (a) J. Broseus, D. Rhumorbarbe, M. Morelato, L. Staehli, Q. Rossy; "A geographical analysis of trafficking on a popular darknet market"; *Forensic Science International*, 2017, *277*, 88-102. DOI: 10.1016/j.forsciint.2017.05.021. (b) T. Pineau, A. Schopfer, L. Grossrieder, J. Brosseus, P. Esseiva, Q. Rossy; "The study of doping market: How to produce intelligence from Internet forums"; *Forensic Science International*, 2016, *268*, 103-115. DOI: 10.1016/j.forsciint.2016.09.017.

16 D. Rhumorbarbe, L. Staehli, J. Broseus, Q. Rossy, P. Esseiva; "Buying drugs on a Darknet market: A better deal? Studying the online illicit drug market through the analysis of digital, physical and chemical data"; *Forensic Science International*, *2016*, 267, 173-192. DOI: 10.1016/j.forsciint.2016.08.032.

5.8 In the subsequent discussion, the Daubert standard[17] that is used in the United States was highlighted as an example of a standard intended to ensure scientific results are robust and reliable. This standard allows persons that are qualified as experts based on knowledge, skill, experience, training, or education to offer expert opinion testimony if the following conditions have been met: (a) the expert's scientific, technical, or other specialised knowledge will help the trier of fact to understand the evidence or to determine a fact in issue; (b) the testimony is based on sufficient facts or data; and (c) the testimony is the product of reliable principles and methods and the expert has reliably applied the principles and methods to the facts of the case.

6. AGENDA ITEM SIX – Updates from the OPCW Technical Secretariat

Subitem 6(a): Verification (VER) and Inspectorate (INS) Divisions

6.1 Dr Carolyn Browne (Director of the OPCW Verification Division[18]) and Dr Evandro De Souza Nogueira (Director of the OPCW Inspectorate[19]) informed the TWG about the role of their respective divisions currently and in future, describing their longer term planning and how they are proceeding.

6.2 Dr Browne discussed the interface between the two divisions and their strategic visions and objectives. On-going work in the Verification Division includes updates to the Declarations Handbook[20] and the Handbook on Chemicals,[21] increased digitalisation (which offers new opportunities to make effective use of the data collected by the Secretariat, as well as providing new tools for use by States Parties for submitting declarations), streamlining of inspection reports and associated data collection, and a review of the Article VI verification regime, including the site-selection methodology.[22] Dr Browne highlighted the role of the new ChemTech Centre to provide a platform for capacity building and training that will be highly beneficial for the future of the OPCW.

6.3 Dr Nogueira provided an overview of the structure of the inspectorate and its routine and non-routine activities, including the upcoming operations to verify the final destruction of the remaining chemical weapons stockpile in the United States of America.[23] He noted the critical role of science and technology in the work of the

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17 P. F. Eckstein, S. A. Thumma; "Getting Scientific Evidence Admitted: The Daubert Hearing"; *Litigation*, 1998, *24(2)*, 21-26.

18 OPCW Verification Division; www.opcw.org/about-us/technical-secretariat/divisions/verification.

19 OPCW Inspectorate Division; www.opcw.org/about-us/technical-secretariat/divisions/inspectorate.

20 OPCW *Declarations Handbook*; www.opcw.org/resources/declarations/declarations-handbook.

21 OPCW *Handbook on Chemicals*; www.opcw.org/resources/declarations/handbook-chemicals.

22 "Report on the Performance of the Revised Methodology for the Selection of Other Chemical Production Facilities for Inspection" (S/1715/2019, dated 6 February 2019); www.opcw.org/sites/default/files/documents/2019/02/s-1715-2019%28e%29.pdf.

23 (a) "Decision: Agreed Detailed Plan for Verification of the Destruction of Chemical Weapons at the Blue Grass Chemical Agent-Destruction Pilot Plant Static Detonation Chamber Chemical Weapons Destruction Facility Richmond, Kentucky the United States of America" (EC-90/DEC.2, dated 13 March 2019). (b) "Decision: Facility Agreement Between the Organisation for the Prohibition of Chemical Weapons and the United States of America Regarding on-Site Inspections at the Blue Grass Chemical Agent-Destruction Pilot Plant Static Detonation Chamber Chemical Weapons Destruction

Inspectorate and the need to keep abreast of developments (including those outside the traditional boundaries of chemistry) to ensure inspectors are prepared to function in a technologically evolving operating environment. He stressed the need to ensure that inspectors are trained to the highest possible standard required to carry out their missions.

6.4 Both Directors emphasised the need for effective cross-divisional cooperation and the retention and transfer of specialised experiences and knowledge developed from the implementation of the Convention.

6.5 In the subsequent discussion, the following points were raised:

(a) Given the tenure policy and the potential loss of tacit knowledge,[24] knowledge management and the recruitment of appropriately skilled staff members were seen as a critical priority to ensure the Secretariat remains fit for purpose. For some capabilities, it was recognised that it might be more effective to find outside experts that can be called in as needed rather than try and develop the skills in house.

(b) The SAB has provided many recommendations for the Article VI verification regime that are relevant to the points raised by Dr Browne for its review. The SAB stands ready to provide guidance on standardisation and digitalisation of benefit to the Secretariat.

(c) To gain the most benefit from advice coming from the SAB and the work of the TWG, it was recognised that engagement with the Secretariat is critical. The SAB and TWG can connect the Secretariat with relevant technology development communities to maintain engagement in this area (the SAB had previously made a similar recommendation[25]).

Subitem 6(b): Identification and Investigation Team (IIT)

6.6 Mr Santiago Oñate (OPCW IIT) briefed the TWG on the status of the newly formed IIT and progress in implementation of the decision on addressing the threat from chemical weapons use (C‑SS‑4/DEC.3)[26] taken by the Conference of States Parties (hereinafter "the Conference") in June 2018.[27,28] The IIT will be comprised of

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Facility Richmond, Kentucky the United States of America" (EC-90/DEC.1, dated 13 March 2019). (c) "Overall Progress with Respect to the Destruction of the Remaining Chemical Weapons Stockpiles" (EC-90/DG.13, dated 4 March 2019).

24 "Report on the Impact of the OPCW Policy on Tenure" (EC-89/DG.28, dated 2 October 2018).

25 See sub-paragraph 1.6(b) of SAB-26/WP.1 (footnote 2(b)).

26 "Decision: Addressing the Threat from Chemical Weapons Use" (C‑SS‑4/DEC.3, dated 27 June 2018); www.opcw.org/sites/default/files/documents/CSP/C-SS-4/en/css4dec3_e_.doc.pdf.

27 Fourth Special Session of the Conference of the States Parties, held from 26 to 27 June 2018; www.opcw.org/resources/documents/conference-states-parties/csp-ss-4.

28 "Progress in the Implementation of Decision C-SS-4/DEC.3 on Addressing the Threat from Chemical Weapons Use" (EC-90/DG.14, dated 7 March 2019); www.opcw.org/sites/default/files/documents/2019/03/ec90dg14%28e%29.pdf.

Mr Oñate, two investigators, two analysts, one legal officer, and one information technology expert; recruiting is currently underway.

6.7 In the subsequent discussion, the following points were raised:

(a) Satellite imagery and impurity profiling of chemical samples were discussed as useful tools for the work of the IIT.

(b) It was recognised that a forensic advisor with broad experience in forensic science and international law could be valuable for providing advice to the Director-General, the OPCW, and the work of the IIT. When operating in a contentious environment, such an advisor is preferably an external, independent, unbiased, and impartial expert, who would provide advice on which exhibits should be examined.

(c) In addition to the mandate of C‑SS‑4/DEC.3 to identify the perpetrators the use of chemical weapons in the Syrian Arab Republic, paragraph 20 of the decision allows for a more permanent provision of technical expertise in the event that a State Party requests assistance in identifying those who were perpetrators, organisers, sponsors, or otherwise involved in the use of chemical weapons on its territory in future. The deliberations of the TWG may produce advice most applicable here as it informs the development of new capabilities.

Subitem 6(c): Proposals to add chemicals to Schedule 1A of the Annex on Chemicals

6.8 Dr Jonathan Forman (OPCW Science Policy Adviser and Secretary to the SAB) updated the TWG on the two submissions under Article XV, paragraphs 4 and 5, to add new chemicals and/or families of chemicals to Schedule 1A of the Convention's Annex on Chemicals.

6.9 The first submission was a joint proposal from the United States of America, Canada, and the Netherlands seeking to add two families of chemicals to Schedule 1A, which after evaluation by the Secretariat[29] was recommended for adoption by the Executive Council (hereinafter, the "Council") on 14 January 2019,[30] which triggered the start of a 90-day window (ending on 14 April 2019) where States Parties could object to the decision. An objection was received on 9 April 2019 (after the conclusion of the Third Meeting of the TWG).[31] This objection sends the proposal to the Twenty-Fourth Session of Conference of States Parties (CSP-24, to be held in November 2019), where it will be treated as matter of substance. Should CSP-24 adopt the proposal, the changes would enter into force 180 days later.

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29 "Evaluation of The Proposal Submitted by Canada, the Netherlands, and The United States of America for a Change to the Annex On Chemicals of the Chemical Weapons Convention" (EC-M-62/DG.2, dated 14 December 2018).

30 "Decision: Recommendation for a Change to Schedule 1 of the Annex on Chemicals to the Chemical Weapons Convention" (EC-M-62/DEC.1, dated 14 January 2019); www.opcw.org/sites/default/files/documents/2019/01/ecm62dec01%2B%28e%29.pdf.

31 "Russian Federation: Request for Circulation of a Document" (EC-M-62/NAT.15, dated 9 April 2019).

6.10 An additional set of 5 proposals submitted by the Russian Federation was evaluated by the Secretariat,[32] which was recommended for rejection by the Council on 25 February 2019 (the five proposals were submitted as one decision[33]). The rejection of the decision resulted from the States Parties failing to reach a consensus on the fifth proposal, due to disagreements on whether the chemicals within the proposal were consistent with the guidelines in the Convention for Schedule 1A. This recommendation to reject entered a 90-day window (ending on 26 May 2019) where States Parties could object to the decision. An objection was received on 9 April 2019 (after the conclusion of the Third Meeting of the TWG).[34] This decision will now be treated as matter of substance at CSP-24. Should CSP-24 adopt the proposals, the changes would enter into force 180 days later.

6.11 In the subsequent discussion, the TWG expressed its appreciation of the highest standard of scientific expertise and communication on this topic by the experts from the Secretariat who have been involved in evaluating Schedule change proposals and providing technical briefings to inform States Parties.

Subitem 6(d): OPCW Laboratory

6.12 Dr Marc-Michael Blum (Head, OPCW Laboratory) updated the TWG on the Forty-Fourth[35] and Forty-Fifth Proficiency Tests[36], the Fourth Biomedical Proficiency Test[37], the Third inter-laboratory ricin test,[38] the work of the Validation Group,[39] and new and potential future additions to OCAD.[40]

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32 "Evaluation of the Proposals Submitted by the Russian Federation for a Change to The Annex on Chemicals of the Chemical Weapons Convention" (EC-M-63/DG.2, EC-M-63/DG.2/Corr.1 and EC-M-63/DG.2/Corr.2, dated 29 January 2019).

33 "Draft Decision: Recommendation for a Change to Schedule 1 of the Annex on Chemicals to the Chemical Weapons Convention" (EC-M-63/DEC.1/CRP.1, dated 19 February 2019).

34 "Burundi: Request for Circulation of a Document" (EC-M-63/NAT.4, dated 9 April 2019).

35 "Evaluation of the Results of the Forty-fourth Official OPCW Proficiency Test" (S/1739/2019, dated 27 March 2019); www.opcw.org/sites/default/files/documents/2019/03/s-1739-2019%28e%29.pdf.

36 "Call for Nominations for the Forty-fifth Official OPCW Proficiency Test" (S/1704/2019, dated 10 January 2019); www.opcw.org/sites/default/files/documents/2019/01/s-1704-2019%28e%29.pdf.

37 "Call for Nominations for the Fourth Official OPCW Biomedical Proficiency Test" (S/1699/2018, dated 19 December 2018); www.opcw.org/sites/default/files/documents/2018/12/s-1699-2018%28e%29.pdf.

38 "Call for Nominations for the Third Exercise on the Analysis of Biotoxins" (S/1674/2018, dated 24 September 2018); www.opcw.org/sites/default/files/documents/2018/12/s-1699-2018%28e%29.pdf.

39 (a) "Report of the Forty-Eighth Meeting of the Validation Group for the Updating of the OPCW Central Analytical Database 19 – 20 March 2019" (S/1740/2019, dated 8 April 2018); www.opcw.org/sites/default/files/documents/2019/04/s-1740-2019%28e%29.pdf. (b) "Report of the Forty-Seventh Meeting of the Validation Group for the Updating of the OPCW Central Analytical Database 25 and 26 September 2018" (S/1681/2018, dated 19 October 2018); www.opcw.org/sites/default/files/documents/2018/10/s-1681-2018%28e%29.pdf.

40 (a) "Decision: Lists of Newly Validated Data on Scheduled Chemicals for Inclusion in the OPCW Central Analytical Database" (EC-88/DEC.3, dated 12 July 2018); www.opcw.org/sites/default/files/documents/2018/07/ec88dec03%28e%29.pdf. (b) "Decision: Lists of Newly Validated Data on Non-Scheduled Chemicals Relevant to the Chemical Weapons Convention for Inclusion in the OPCW Central Analytical Database" (EC-88/DEC.4, dated 12 July 2018); www.opcw.org/sites/default/files/documents/2018/07/ec88dec04%28e%29.pdf.

6.13 Turning to the project to upgrade the OPCW Laboratory into a Centre for Chemistry and Technology (ChemTech Centre), Dr Blum updated the TWG on timelines and expressed appreciation for voluntary contributions received since the TWG's Second Meeting. These contributions were received from Slovakia, Japan, France, the European Union, the United Kingdom, Bangladesh and Slovenia.[41] An announcement of intention to contribute has also been received from the United States of America.[42]

6.14 Dr Blum concluded with a discussion on TWG deliberations regarding the OPCW Laboratory and the DLs, pointing out priorities, available resources, and other considerations that impact the capacity to pursue new projects. A project of particular interest to the OPCW Laboratory and some of the DLs is the development of a high-resolution OrbiTrap database.

6.15 In the subsequent discussion, the potential for other laboratories to lead joint research projects, with involvement of the OPCW Laboratory was raised. Opportunities would have to be considered on a case-by-case basis against priorities and available resources of the OPCW Laboratory. In relation to the DLs, as new developments arise, the OPCW Laboratory is in a position to benefit from the existing relationships. Funding of projects through States Parties (for example, the recent EU Council Decision[43]) could also be considered.

7. AGENDA ITEM SEVEN – The role of the Forensic Advisor: the NFI Experience

7.1 Following the request from the Second Meeting of the TWG that the SAB consider developing a recommendation to the Director-General on how OPCW inspection teams could benefit from having a "forensic advisor" within a team and/or available to

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41 (a) OPCW News Item, 28 January 2019, "Slovakia Contributes €30,000 to Future OPCW Centre for Chemistry and Technology", www.opcw.org/media-centre/news/2019/01/slovakia-contributes-eu30000-future-opcw-centre-chemistry-and-technology. (b) OPCW News Item, 27 February 2019, "Japan Contributes €2.4M to Future OPCW Centre for Chemistry and Technology", www.opcw.org/media-centre/news/2019/02/japan-contributes-eu24m-future-opcw-centre-chemistry-and-technology. (c) OPCW News Item, 7 March 2019, "France Contributes €1.2M to Future OPCW Centre for Chemistry and Technology", www.opcw.org/media-centre/news/2019/03/france-contributes-eu12m-future-opcw-centre-chemistry-and-technology. (d) OPCW News Item, 4 April 2019, "European Union Contributes €11.6M to Support OPCW Activities", www.opcw.org/media-centre/news/2019/04/european-union-contributes-eu116m-support-opcw-activities. (e) OPCW News Item, 18 April 2019, "United Kingdom Contributes £1.1M to Support OPCW Activities, including Future Centre for Chemistry and Technology", www.opcw.org/media-centre/news/2019/04/united-kingdom-contributes-ps11m-support-opcw-activities-including-future. (f) OPCW News Item, 25 April 2019, "Bangladesh Contributes $15,000 to Future OPCW Centre for Chemistry and Technology", www.opcw.org/media-centre/news/2019/04/bangladesh-contributes-15000-future-opcw-centre-chemistry-and-technology. (g) OPCW News Item 28 May 2019, "Slovenia Contributes €20,000 to Support OPCW Activities", www.opcw.org/media-centre/news/2019/05/slovenia-contributes-eu20000-support-opcw-activities.

42 "United States of America: Statement by H.E. Ambassador Kenneth D. Ward Permanent Representative of the United States of America to the OPCW at the Ninetieth Session of the Executive Council" (EC-90/NAT.7, dated 12 March 2019); www.opcw.org/sites/default/files/documents/2019/03/ec90nat07%28e%29.pdf.

43 Council Decision (CFSP) 2019/538 of 1 April 2019 in support of activities of the Organisation for the Prohibition of Chemical Weapons (OPCW) in the framework of the implementation of the EU Strategy against Proliferation of Weapons of Mass Destruction; https://eur-lex.europa.eu/eli/dec/2019/538/oj.

advise off-site for planning and carrying out investigative activities to help ensure that they meet international forensic standards, take advantage of modern forensic methods, and tap into the broad range of forensic expertise available",[44] two experienced forensic advisers, Ms Doris Eerhart and Ms Irene O'Sullivan from the NFI, explained the function of a forensic advisor. They described the advantages such a position can bring to facilitate and optimise identification and investigation operations, drawing on NFI experiences of the forensic advisory function.

7.2 The advisor can provide guidance to help take evidence and information from a crime scene to a courtroom. This includes expert advice on the sequence of forensic evidence collection and processing, and ensuring that the maximum amount of evidence is processed and not destroyed accidentally by conducting forensic processing in an inappropriate order. An important aspect of the role is the translation of information, from forensic science (e.g. a hypothesis) to forensic evidence (e.g. to support a hypothesis). The function is highly interdisciplinary and specialised, and best performed by an experienced and trained professional.

7.3 A forensic advisor has a broad background in forensic science and provides independent, impartial advice based on his or her knowledge of the application of forensic science to investigations. The advisor assists, but does not necessarily participate in setting out the forensic investigative strategy for a criminal investigation. The advisor also serves to ensure that experts in the field remain unbiased in their investigations by filtering out unnecessary information. The advisor ensures that the questions presented to the scientists performing analyses are sufficient, appropriate, and clear; and monitors the examination (providing further forensic advice as required).

7.4 Many types of traces can come from a unique sample or type of evidence. Understanding linkages and recognising the traces that would be prudent to analyse (e.g. fingerprints, chemical composition, DNA) will dictate the order of examination to avoid collecting certain traces through a process that destroys, contaminates, or degrades other traces of interest.

7.5 Quality control represents another crucial aspect of forensic work: there is a need to use validated (accredited) methods.[45] The forensic advisor would provide guidance on

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44 See paragraph 1.6 of "Summary of the Second Meeting of the Scientific Advisory Board Temporary Working Group on Investigative Science and Technology" (SAB-28/WP.2, dated 21 January 2019); www.opcw.org/sites/default/files/documents/2019/01/sab28wp02%28e%29.pdf.

45 For example: (a) International Organization for Standardization (ISO) standards 17025 and 17020. (b) ISO/TC 272 Forensic Sciences, https://www.iso.org/committee/4395817.html. (c) ISO 21043-1 – Forensic Sciences - Terms, definitions and framework, https://www.iso.org/standard/69732.html. (d) ISO 21043-2:2018 – Forensic Sciences -Recognition, recording, recovering, transport and storage of items, https://www.iso.org/standard/72041.html. (e) ISO/AWI 21043-3 – Forensic Sciences – Analysis, https://www.iso.org/standard/72040.html. (f) ISO/AWI 21043-4 – Forensic Sciences – Interpretation, https://www.iso.org/standard/72039.html. (g) ISO/AWI 21043-5 - Forensic Sciences – Reporting; https://www.iso.org/standard/73896.html. (h) AS 5388.1 Recognition, recording, recovery, transport and storage of material; AS 5388.2 Analysis and examination of material, AS 5388.3 Interpretation, AS 5388.4 Reporting. (i) See also, *Quality Management in the Forensic Sciences. Expert Evidence*; A. Ross, A. Davey; Thomson Lawbook Co.; 2017.

which standards to follow based on the ultimate use of the forensic results (e.g. whether they will be presented in a courtroom or are for further evidence gathering?).

7.6 In the subsequent discussion, the following points were raised:

(a) Forensic awareness training is very important to allow the full potential of evidence to be realised. The constraints and requirements for bringing evidence into a courtroom must be fully understood in order to provide useful guidance. Such awareness provides the basis for procedures that demonstrate the integrity of samples, processes, and results.

(b) TWG members discussed where a forensic advisor would be best placed within an investigation. It was recognised that an advisor external to the team would be viewed as more independent; however, having an on-site advisor would be highly valuable for immediate needs in the field.

8. AGENDA ITEM EIGHT – New technical capabilities

Subitem 8(a): Geospatial WMD verification and crowdsourcing

8.1 Ms Grace Liu (guest speaker, the James Martin Center for Nonproliferation Studies[46]) presented her work on the use of satellite imagery in weapons of mass destruction (WMD) verification. She discussed how open-source and commercial remote-sensing data have the potential to help identify and monitor sites related to chemical weapons production, storage, or deployment. Ms Liu explained how monitoring construction and infrastructure can provide information about the type and purpose of a facility, and how the level of activity around a site can provide insights for verification. The use of higher frequency image collection to gain insights into levels of activity help reveal aspects of equipment being installed at a site of interest. While there are limitations to the information that can be collected from remote sensors, multiple imaging techniques (such as traditional optical imagery, multispectral and hyperspectral images, and thermal and near-infrared images) can be leveraged to understand better a site, including possible chemical signatures.

8.2 Ms Liu described the use of a crowdsourcing tool, Geo4Nonpro 2.0 (G4N),[47] to engage a "curated" crowd of satellite imagery analysis experts to analyse open-source geographic information of known or suspected WMD. When monitoring industrial sites, there is a critical need to engage appropriate industrial experts to better understand and interpret the imagery. A case study using remote sensing to monitor uranium mining and milling has been published.[48]

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46 Middlebury Institute of International Studies at Monterey, James Martin Center for Nonproliferation Studies, United States of America. For further information see https://www.nonproliferation.org/about-2/.

47 M. Hanham, J. Lewis, C. Dill, G. Liu, J. Rodgers, O. Lepinard, B. Knapp, O. Hallam, B. McIntosh; "Geo4Nonpro 2.0", *CNS Occasional paper #38*, Middlebury Institute of International Studies at Monterey, James Martin Center for Nonproliferation Studies, 2018; https://www.nonproliferation.org/op38-geo4nonpro-2-0/.

48 G. Liu, J. Rodgers, S. Milne, M. Rowland, B. McIntosh, M. Best, O. Lepinard, M. Hanham; "Eyes on U: Opportunities, Challenges, and Limits of Remote Sensing for Monitoring Uranium Mining and Milling", *CNS Occasional paper #44*, Middlebury Institute of International Studies at Monterey, James

8.3 In the subsequent discussion, the following points were raised:

(a) Non-governmental organisations (NGOs), such as the James Martin Center for Nonproliferation Studies, carry out geospatial WMD verification which can be independent from that of government departments which conduct similar work. The analysis can be complemented by further open source information to draw informed conclusions. The geospatial analysis is part of the toolbox for open source intelligence.

(b) The ability to obtain historical satellite image data is valuable for drawing informed conclusions on the activities and facilities being monitored.

(c) Interpretation of images might provide a hypothesis (for further confirmation) rather than a conclusion.

Subitem 8(b): Forensic biometrics in conflict zones

8.4 Dr Didier Meuwly (guest speaker, NFI) briefed the TWG on recognition methods and technologies for human-based and computerised biometrics[49] (metrics related to human characteristics[50]). His presentation began with an introduction to the examination and analysis of biometric traces and reference specimens, examined specific examples using images and video from conflict zones. There are three primary questions the methods are applied to address the origin of the trace (source level inference), the activity that leads to the trace (activity level inference), and the fact that the activity constitutes an offence (offence level inference).

8.5 In a conflict zone, biometric traces might be recovered from both formal (government or military entities) and informal (NGOs and civilian entities) sources, with each source introducing its own challenges for authentification and validation of chain of custody. Biometric traces (fingerprints, for example) can be transient and fragile, their reliability and the preservation of their physical integrity depending highly on initial actions at the scene of an incident. The ability to digitalise these traces provides an opportunity to capture and preserve them. Dr Meuwly noted that while the

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Martin Center for Nonproliferation Studies, 2018; https://www.nonproliferation.org/op-44-eyes-on-u-opportunities-challenges-and-limits-of-remote-sensing-for-monitoring-uranium-mining-and-milling/.

49 M. Tistarelli, E. Grosso, D. Meuwly; "Biometrics in Forensic Science: Challenges, Lessons and New Technologies"; In: V. Cantoni, D. Dimov, M. Tistarelli (eds), *Biometric Authentication. BIOMET 2014. Lecture Notes in Computer Science*, 2014, *8897*. Springer, Cham. DOI: 10.1007/978-3-319-13386-7_12.

50 (a) D. Seckiner, X. Mallett, P. Maynard, D. Meuwly, C. Roux; "Forensic gait analysis - Morphometric assessment from surveillance footage"; *Forensic Sci. Int,* 2019, 296, 57-66. DOI: 10.1016/j.forsciint.2019.01.00. (b) C. G. Zeinstra, D. Meuwly, A. C. Ruifrok, R. N. Veldhuis, L. J. Spreeuwers; "Forensic face recognition as a means to determine strength of evidence: A survey"; *Forensic Sci. Rev.*; 2018, 30(1), 21-32. (c) A. J. Leegwater, D. Meuwly, M. Sjerps, P. Vergeer, I. Alberink; "Performance Study of a Score-based Likelihood Ratio System for Forensic Fingermark Comparison"; J. Forensic Sci.; 2017, 62(3), 626-640. DOI: 10.1111/1556-4029.13339. (d) D. Maltoni, R. Cappelli, D. Meuwly; "Automated Fingerprint Identification Systems: From Fingerprints to Fingermarks"; in: M. Tistarelli, C. Champod C. (eds); *Handbook of Biometrics for Forensic Science. Advances in Computer Vision and Pattern Recognition*, 2017 Springer, Cham. DOI: 10.1007/978-3-319-50673-9_3

environment of a conflict zone may constrain applicability of standardised methods, there are guidelines that can be followed.[51] The presentation provided an overview of the process from recovery of traces, preparation of data, analysis (using machine learning and big data methods), and use. Matching recovered information to a reference can be evaluated using likelihood ratios.[52] Data integrity and the availability of databases containing reference information[53] (which can be constrained by privacy requirements) present challenges to the analysis and interpretation of biometric data. Dr Meuwly discussed examples from the MH17 civil airline accident, Darfur, and the Syrian Arab Republic.

8.6 To use the recovered information forensically requires more than a single image. Multiple images from different perspectives (a redundancy approach) and metadata for the images are needed to gather a more complete picture. For forensic purposes, the data preparation must also adhere to methods and processes that can ultimately translate to a courtroom.

8.7 Dr Meuwly demonstrated a method for forensic biometric analysis that can be used for traces collected in conflict zones. Key to the approach is the use of mobile technology which allows large scale and multiple digitalisation of the physical world, combined with the capability for global data transmission. Digitalisation likewise allows automated approaches to be adopted to help answer questions by mining the data. However, reliability of the data (and any newly developed methods used for recovery and analyses) requires that biased or false results are avoided.

Subitem 8(c): Collecting verifiable photos and videos: eyeWitness

8.8 Ms Wendy Betts (guest speaker, eyeWitness to Atrocities[54]) briefed the TWG on the app eyeWitness, which is designed for collecting verifiable photos and videos. eyeWitness aims to bridge the gap between efforts to document human rights violations and the requirements for justice mechanisms to use this information, by providing an innovative system that addresses the evidentiary challenges facing documenters. eyeWitness technology is based on two pillars. The first is a mobile camera app and software for a smart phone or tablet that allows the documenter to record photographs, videos, and audio. The app uses the device sensors to capture metadata to help verify the authenticity of photo/video/audio recordings. Specifically, it captures data to identify the location, date, and time of the footage. The eyeWitness app has been designed to ensure that the collected media and associated metadata

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51 *Crime scene and physical evidence awareness for non-forensic personnel*, United Nations Publication E.09.IV.5, UNODC, Vienna, Austria, 2009. ISBN 978-92-1-130273-8; https://www.unodc.org/documents/scientific/Crime_scene_awareness__Ebook.pdf.

52 (a) D. Meuwly, D. Ramos, R. Haraksim; "A guideline for the validation of likelihood ratio methods used for forensic evidence evaluation"; *Forensic Science Journal*, 2017, *276*, 142-153. DOI: 10.1016/j.forsciint.2016.03.048. (b) D. Ramos, R. P. Krish, J. Fierrez, D. Meuwly; "From Biometric Scores to Forensic Likelihood Ratios"; in: M. Tistarelli, C. Champod (eds); *Handbook of Biometrics for Forensic Science. Advances in Computer Vision and Pattern Recognition*, 2017, Springer, Cham. DOI: 10.1007/978-3-319-50673-9_14.

53 T. Ali, L. Spreeuwers, R. Veldhuis D. Meuwly; "Biometric evidence evaluation: an empirical assessment of the effect of different training data"; *IET Biometrics*, 2014, *3(4)*, 335-346. DOI: 10.1049/iet-bmt.2014.0009.

54 For additional information on eyeWitness to Atrocities, see https://www.eyewitnessproject.org/.

cannot be altered or manipulated by the user or a third party. The second pillar is a secure server set up by eyeWitness, which in conjunction with transmission protocols, creates a robust chain of custody that can be presented in court.

8.9 Once collected, the images can be annotated and associated with searchable key words, lending themselves to the creation of dossiers that can be retrieved electronically and presented to investigators. The app has been used to collect images that were admitted as evidence in at least one courtroom in a crimes-against-humanity case where the defendants were convicted.

8.10 In the subsequent discussion, the following points were raised:

(a) Apps like eyeWitness might be useful for verification activities involving sampling and analysis. These could be especially advantageous for recording sample collection in the field with full chain of custody.

(b) In future, chemical sensors could be integrated into the system. However, Ms Betts explained that metadata which the app captures with the image is restricted to exclude any data that can only be compared between devices with device-specific calibration.

(c) An image repository could be combined with other information to cross corroborate. Protocols for using open source intelligence and image data for such purposes are being developed by the Human Rights Investigations Lab at the University of California, Berkeley.[55]

(d) The use of apps such as eyeWitness can be valuable for verification purposes; however, simply taking a photo with a camera phone is common behaviour and more instinctive. To use these types of apps outside a formal investigative process may require behavioural change.

Subitem 8(d): A tech-stack for the collection and maintenance of information and evidence in adverse, challenging, or contested circumstances

8.11 Dr Geoff Gordon (guest speaker, Global Legal Action Network (GLAN)[56] and T. M. C. Asser Institute[57]) briefed the TWG on the use of technologies for information and evidence collection, retention and end use, in adverse, challenging, or contested circumstances (a "tech-stack"). The tech-stack enables new means for collection of information and evidence for monitoring, reporting, and fact-finding missions operating under adverse conditions. Dr Gordon discussed a tech-stack currently under construction for applications in conflict zones.[58] The design is guided

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55 For further information on the Human Rights Investigations Lab, see: https://www.law.berkeley.edu/research/human-rights-center/programs/technology/human-rights-investigations-lab-internships/.

56 Global Legal Action Network (GLAN); https://www.glanlaw.org/.

57 T. M. C. Asser Institute, Centre for International and European Law; https://www.asser.nl/.

58 (a) *GLAN and Bellingcat host open source intelligence experts to investigate air-strikes in Yemen*, 4 February 2019, Global Legal Action Network; https://www.glanlaw.org/single-post/2019/02/03/GLAN-and-Bellingcat-run-open-source-intelligence-hackathon-on-air-strikes-in-

by considerations of humanitarian and human rights law, but with a more robust build to account for wider use and other legal and institutional goals. Inputs for requirements of the GLAN/Asser tech-stack have been informed by a number of external stakeholders.

8.12 As presently constructed, the tech-stack (which can be thought of as a type of evidence database) includes eight layers: data collection; data hashing; time stamping; data retention; data verification; data security; case-management functionality; and legal/institutional use. Data are collected via two means: direct upload and artificial intelligence. Content is hashed and time stamped by BlockChain, but retained exclusively on secure servers. Verification entails two different challenges: establishing chain of custody; and verifying any one or several data points by the use of multiple other data points. Verification is closely related to a possible end use, namely data reconstruction.[59] Finally, legal and institutional issues require consideration of context-specific knowledge of rules and/or standards applicable to the handling of information or evidence.

8.13 In the subsequent discussion, the following points were raised:

(a) There are many different organisations looking at technology solutions for the collection and maintenance of data for verification, forensic, and potential legal uses. The tools developed are strengthened by the sharing of experiences and understanding the various user requirements (especially legal constraints). Collaborative development of these tools can also be limited by the sensitivity of sharing data between organisations and States.

(b) The development of a tech-stack must consider fully the ultimate use of the data and ensure it fulfils the legal and evidentiary requirements. It was suggested that if collected under the right set of circumstances, data from a tech-stack may be transferable to an investigator.

Subitem 8(e): Forensic Big Data analysis

8.14 Mr Rolf Ypma (guest speaker, NFI) briefed the TWG on the use of Big Data analysis in forensic applications. He provided examples from the work of the Forensic Big Data Analysis at NFI, explaining how they use data analysis to assist criminal court cases and public safety projects. Mr Ypma provided examples from three areas: (a) cleaning, structuring and visualising data; (b) the application of machine learning techniques for automated recognition of relevant text or images in large datasets; and (c) evidence evaluation.

8.15 In the subsequent discussion, the following points were raised:

(a) Given the rich variety of data that might be looked at for any given investigation, custom solutions for data science are frequently required

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Yemen (b) *New project: Digital evidence, blockchain, and air-strikes in Yemen*, 16 March 2018, Global Legal Action Network; https://www.glanlaw.org/single-post/2018/03/15/New-project-Digital-evidence-blockchain-and-air-strikes-in-Yemen.

59 See for example, https://youtu.be/NuOg7ldgnd8.

(requiring an agile team of data scientists). For commonly encountered data analysis related problems, off-the-shelf software packages often exist, but they may not be applicable for unfamiliar situations or data sets.

(b) For image recognition with techniques like deep learning, training sets are immensely important. The data used to train the AI should be similar to the kind of images that will actually be analysed. These techniques can be used as high confidence screening methods. Text recognition and extraction from images is also possible.

Subitem 8(f): Generic Integrated Forensic Toolbox for CBRN (GIFT)

8.16 Dr van Zalen briefed the TWG on the Generic Integrated Forensic Toolbox for CBRN (GIFT) project that ran from 2014 to 2017.[60] The EU funded Framework Programme 7 project GIFT (Generic Integrated Forensic Toolbox). The deliverables of GIFT focused on developing SOPs, procedures and tools for CBRN crime scene investigation; and the development of methods to decontaminate forensic traces and methods to profile CBRN agents so that one can relate the agents to a possible source. Within GIFT, a web-based toolbox has been developed where the SOPs can be retrieved, measurement data from crime scenes can be stored and the outcomes of the examinations and investigations reported to the Command and Control Center. To support the GIFT capabilities, a CBRN Forensics educational curriculum has been developed.

8.17 As follow up of the GIFT project, a consortium has been formed to prepare a proposal for the 2019 call of the Horizon 2020, EU SU-FCT02 sub-topic 1 Trace Qualifications, which is to be submitted on 22 August 2019. This project proposes to develop technologies for near real-time forensics to relate traces to possible sources at the crime scene. The consortium includes OPCW designated laboratories and forensic laboratories from the Netherlands, Sweden, Finland, Switzerland and Germany, law enforcement agencies from several European countries, and technology suppliers (for development of crime scene sensor technologies). The main focus of the proposal will be to develop crime scene methods to relate narcotics, explosives and chemical warfare agents to a possible source and/or synthesis/purification route. The technologies and methods are intended to allow information to be brought into a Court Room.

8.18 In the subsequent discussion, the following points were raised:

(a) A field exercise of GIFT was recently held in Belgium and a publication is now available.[61]

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60 Generic Integrated Forensic Toolbox for CBRN (GIFT Forensics); https://cordis.europa.eu/project/rcn/192217/factsheet/en (factsheet) and https://cordis.europa.eu/project/rcn/192217/reporting/en (reports).

61 N. Kummer, B. Augustyns, D. Rompaey, K. Meulenaere; "Forensic investigation of incidents involving chemical threat agent: presentation of the operating procedure developed in Belgium for a field-exercise"; *Forensic Science International*, 2019, *in press*. DOI: 10.1016/j.forsciint.2019.03.037.

(b) GIFT deliverables are freely available, with exception of those that are considered the intellectual property of any GIFT partner. Dr van Zalen as coordinator of GIFT can provide further information.

(c) Another Horizon 2020 project is ATTRACT,[62] which is funding 170 projects to take research in the area of sensors and imaging from the laboratory to commercialisation.

(d) The ToxiTriage[63] project is developing complementary technologies to GIFT; a presentation on this project is planned at an upcoming meeting of the TWG.

9. AGENDA ITEM NINE – Unmet technical needs for verification

Subitem 9(a): OPCW Fact-Finding Mission (FFM)

9.1 The TWG received a briefing on the history and ongoing work of the Fact-Finding Mission (FFM).[64] The Head of the FFM discussed the mandate, team composition and training, the mechanism by which FFM deployment is initiated, the procedures followed (including security and logistical considerations), post deployment activities and reporting, and how these activities have evolved over time.

9.2 The aim of the FFM is to gather facts regarding incidents of alleged use of toxic chemicals as a weapon in the Syrian Arab Republic. Deployment objectives include reviewing and analysing all available information pertaining to an incident for fact-finding; collecting statements and testimonies; collecting samples and wherever possible, carrying out medical examinations. Since its inception in 2014, the FFM has issued 15 reports covering 65 incidents; 17 events of likely or confirmed use of chemical weapons have been reported (12 for chlorine, 2 for sulfur mustard, and 3 for sarin).[65] Identification of perpetrators is outside the mandate of the FFM.

9.3 Describing the challenges faced and lessons learned, Mr Cekovic provided perspectives on tools and methods available to the FFM and discussed required expertise.

9.4 In the subsequent discussion, the potential for FFM collected information to transfer to new mechanisms, such as the IIT, was discussed. Any methods and procedures used should ensure the information that is transferred can be considered in the subsequent mechanisms.

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62 ATTRACT, Developing breakthrough technologies for science and society; https://attract-eu.com/.

63 Toxi-Triage, Tools for Detection, Traceability, Triage and Individual Monitoring of Victims; http://toxi-triage.eu/about.

64 "Update of the Activities Carried Out by the OPCW Fact-Finding Mission in Syria"; (S/1677/2019, dated 10 October 2018); www.opcw.org/sites/default/files/documents/2018/10/s-1677-2018%28e%29.pdf.

65 Reports and other documents related to the OPCW Fact-Finding Mission (FFM) are available at: www.opcw.org/fact-finding-mission.

Subitem 9(b): OPCW Declarations Assessment Team (DAT)

9.5 Mr Nihad Alihodzic and Dr Murty Mamidanna (OPCW DAT) discussed on-going work of the Declarations Assessment Team (DAT).[66] Mr Alihodzic provided an overview and updated the TWG on the status of on-going consultations with the Syrian National Authority concerning the completeness of declarations. The DAT has deployed 16 times since its creation in 2014 it has identified a number of unresolved issues concerning the declarations submitted by the Syrian Arab Republic. Consultations with the Syrian Arab Republic have resulted in amendments to its declarations concerning facilities, chemicals and equipment; however, outstanding issues and consultations continue.[67]

9.6 Mr Alihodzic also described challenges the DAT has encountered for interpretation of chemical analysis results due to contamination and masking of traces occurring from the further use (and repurposing) of equipment, decanting, and other activities occurring between a time point of interest and the time point where an analysis had been conducted.

9.7 Following the introduction, Dr Mamidanna discussed a proposal for a detailed retrospective study of the raw data files for gas chromatography/mass spectrometry (GC/MS) results obtained from chemical analysis on samples collected by the DAT. The combined set of results may provide a better understanding of the history of collected samples in the absence of documentation, provide a better scientific basis for understanding the reasons for the presence of certain chemicals in samples collected) from remnants of equipment and across various locations), and inform further discussions and/or follow up activities.

9.8 In the subsequent discussion, it was noted that the types of data analysis tools described in the presentations from Dr Meuwly and Mr Ypma could be useful for the analysis of the raw GC/MS data files.

Subitem 9(c): UN led missions and investigations in Syria: tools and capabilities

9.9 Professor Åke Sellström (guest speaker, Umeå University) discussed tools and capabilities available and desired during his experiences with the 2013 United Nations Secretary General's Mechanism (UNSGM) mission to the Syrian Arab Republic in 2013, and also the OPCW-UN Joint Investigative Mechanism (JIM)[68] in 2016-2017.

9.10 The UNSGM had been activated at the request of the government of the Syrian Arab Republic, following an alleged incident near the city of Aleppo on 19 March 2013.[69] Under UN leadership, staff from the OPCW and the World Health Organization

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66 OPCW Declarations Assessment Team (DAT); www.opcw.org/declaration-assessment-team.

67 "Progress in the Elimination of the Syrian Chemical Weapons Programme" (EC-91/DG.11, dated 25 March 2019); www.opcw.org/sites/default/files/documents/2019/04/ec91dg01%28e%29.pdf.

68 An OPCW-UN Joint Investigative Mechanism Fact Sheet is available at: https://unoda-web.s3-accelerate.amazonaws.com/wp-content/uploads/2016/08/JIM-Fact-Sheet-July2016.pdf

69 O. Holmes, E. Solomon; "Alleged chemical attack kills 25 in northern Syria'', *Reuters*, 19 March 2013; https://www.reuters.com/article/us-syria-crisis-chemical/alleged-chemical-attack-kills-25-in-northern-syria-idUSBRE92I0A220130319.

(WHO) investigated seven cases of alleged use of chemical weapons in the Syrian Arab Republic from April to December 2013.[70]

9.11 The investigators made extensive use of open source material, collected environmental[71] and biomedical[72] samples for off-site analysis, followed the epidemiology of chemical exposures, and used DNA analysis for identification. All these methods and actions were accepted without criticism. The investigators also identified a number of needs;[73] these included standardised symptomology for identifying nerve agents intoxication,[74] simplified methods to assess the content of improvised explosive devices (IEDs), stand-off analysers; satellite communication with remote expertise while in field (reachback capability), unmanned systems for site surveillance and sampling, and metallurgic analysis capabilities, especially for probing the interaction of chemical warfare agents (CWAs) with the lining of munitions.

9.12 The JIM was tasked by the UN Security Council (UNSC) to attribute events where the OPCW reported that CWAs had been used between 2014 and 2017; seven reports were published before the JIMs mandate ended in October 2017.[75]

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70 (a) UN to investigate allegations of the use of chemical weapons in the Syrian Arab Republic Fact Sheet, UNODA, 2017; https://s3.amazonaws.com/unoda-web/wp-content/uploads/2017/07/Syrian-CW-Investigation-Fact-Sheet-Jul2017.pdf. (b) "United Nations Mission to Investigate Allegations of the Use of Chemical Weapons in the Syrian Arab Republic" (A/68/663-S/2013/735, dated 13 December 2013); https://undocs.org/A/68/663.

71 For example, S. Mogl, P. Siegenthaler, B. Schmidt; "Chemical weapons in the Syrian conflict"; Annual Report 2013, Spiez Laboratory, 2013, 26-33; https://www.labor-spiez.ch/pdf/en/dok/jab/88_003_e_laborspiez_jahresbericht_2013_web.pdf.

72 For example, H. John, M. J. van der Schans, M. Koller, H. E. T. Spruit, F. Worek, H. Thiermann, D. Noort; "Fatal sarin poisoning in Syria 2013: forensic verification within an international laboratory network"; *Forensic Toxicology*, 2018, *36(1)*, 61–71. DOI: 10.1007/s11419-017-0376-7.

73 See also: R. Trapp; *Lessons Learned from the OPCW Mission in Syria*, dated 16 December 2015; www.opcw.org/sites/default/files/documents/PDF/Lessons_learned_from_the_OPCW_Mission_in_Syria.pdf.

74 Publications on approaches to take in recognising symptoms, and several reviews on observed symptomology (under specific circumstances) are available, see for example: (a) G. R. Ciottone; "Toxidrome recognition in chemical-weapons attacks"; *N. Engl. J. Med.*; 2018, *378(17),* 1611-1620. DOI: 10.1056/NEJMra1705224. (b) D. S. Reddy, E Colman; "A comparative toxidrome analysis of human organophosphate and nerve agent poisonings using social media"; *Clin. Transl .Sci.*; 2017, *10(3)*, 225–230. DOI: 10.1111/cts.12435. (c) T. J. Keegan, L. M. Carpenter, C. Brooks, T. Langdon, K. M. Venables; "Sarin exposures in a cohort of British military participants in human experimental research at Porton Down 1945-1987"; *Ann. Work. Expo. Health*; 2017, *62(1)*, 17-27. DOI: 10.1093/annweh/wxx084. (d) Y. Rosman, A. Eisenkraft, N. Milk, A. Shiyovich, N. Ophir, S. Shrot, Y. Kreiss, M. Kassireral; "Lessons learned from the Syrian sarin attack: evaluation of a clinical syndrome through social media"; *Ann. Intern. Med.*; 2014, *60*, 644–648. DOI: 10.7326/M13-2799. Additionally, a review of data for long term effects of acute sarin exposure has recently been published: *Systematic Review of Long-Term Neurological Effects Following Acute Exposure to the Organophosphorus Nerve Agent Sarin*, the National Toxicology Program (NTP), 2018, Office of Health Assessment and Translation Division of the National Toxicology Program National Institute of Environmental Health Sciences; https://ntp.niehs.nih.gov/pubhealth/hat/selected/sarin/index.html.

75 (a) First report of the Organisation for the Prohibition of Chemical Weapons United Nations Joint Investigative Mechanism (United Nations Security Council, S/2016/142, dated 12 February 2016); http://undocs.org/S/2016/142; (b) Third report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2016/738, dated 24 August 2016); http://undocs.org/S/2016/738; (c) Fourth report of the

9.13 The 2016 and 2017 JIM investigations used reconstructive evidence. This included modelling of dispersion and toxicity after chemical release; modelling of the impact of munitions on the ground, on buildings and on the forms of shrapnel that should result; forensic corroboration of the authenticity of videos; forensic localisation of events in photos and videos; identification of individuals in photos and videos; satellite imagery to verify the time of an event; radar imagery of flight paths; and chemical profiling to identify molecular signatures. For a number of the methods used, there are no recommended operating procedures and/or standards for interpretation of results.

9.14 After reviewing the methodologies used and discussing their strengths and limitations, Professor Sellström advised that well thought through quality assurance of methods and tools used for an investigation is the best protection against external (and politically motivated) criticism. He advocated for accepting only the use of well-developed and internationally recognised methods. Interpretation of results may, however, constitute another problem area. Professor Sellström concluded with a perspective on the inherent conflict between the effectiveness of an investigation and its intrusive nature, noting that States Parties may place constraints on the level of intrusiveness, and the tools and capabilities available to the inspection team.

9.15 In the subsequent discussion, on-site sample collection and analysis was discussed, with recognition that tools which could allow verifiable remote or third party sample collection, including integrity of the chain of custody, are highly desirable.

9.16 **Subitem 9(d): Verification of treaty compliance and enhancement of the verification of international treaties: perspectives on the DPRK**

9.17 Dr Olli Heinonen (guest speaker, Foundation for Defense of Democracies[76]) briefed the TWG on his experiences in safeguards and verification of declarations[77] from the Democratic People's Republic of Korea (DPRK) by the International Atomic Energy Agency (IAEA).[78] The presentation began with an overview of the safeguards and objectives to ensure that all nuclear material and activities in a territory of a state has been placed under the IAEA safeguards (declarations are correct and complete), and how IAEA verification is conducted. This was followed by an overview of the DPRK's nuclear programme, including the 1992 frontend reprocessing scheme of the Yongbyon Radiochemical laboratory, and a discussion of the 1992 finding of

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Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2016/888, dated 21 October 2016); http://undocs.org/S/2016/888; (d) Fifth report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2017/131, dated 13 February 2017); http://undocs.org/S/2017/131; (e) Sixth report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2017/552, dated 28 June 2017); http://undocs.org/S/2017/552; and (f) Seventh report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2017/904, dated 26 October 2017); http://undocs.org/S/2017/904.

76 Foundation for the Defense of Democracies, https://www.fdd.org/.

77 Safeguards and Verification, International Atomic Energy Agency; https://www.iaea.org/topics/safeguards-and-verification.

78 International Atomic Energy Agency (IAEA), https://www.iaea.org/.

undeclared plutonium that led to a request for and the subsequent special inspection at Yongbyon.[79] Dr Heinonen also described IAEA verification of the Al Kibar/Dair Alzour site in the Syrian Arab Republic starting from 2007.[80] In the discussions of events and safeguards verification, Dr Heinonen described the negotiation and impact of implementation agreements, challenges and considerations for logistical and resource issues, consultations with States Parties on information that was provided and found to be inconsistent with the findings of inspectors, observations on the sites inspected that informed decision making on where to collect samples, and how impurities and physical properties of samples had been used to determine their origin.

9.18 Dr Heinonen concluded with two observations. First, that there is need to continue improving current methods and developing new techniques to analyse chemical composition of nanometer scale uranium and plutonium particles. And secondly, that international cooperation is vital in combating against black markets and terrorism. In the case of the latter, Dr Heinonen highlighted benefits that had been realised from the sharing of nuclear forensics "finger-print" information between relevant stakeholders.

9.19 In the subsequent discussion, the following points were raised:

(a) Several factors were discussed that are required for effective verification of non-compliance. These include the need to understand how to approach and speak to a given actor, recognising and engaging with the most relevant counterparts between inspection teams and the State in which the investigation is being conducted; fully understanding the cradle to grave flow charts and processes related to WMD production (these can aid the identification of locations and infrastructure); understanding the availability, and types of supplies used in WMD processes; understanding the logistical requirements to operate within a certain status; reviewing any available scientific publications and patents, and understanding the technical expertise of the authors.

(b) A number of areas of technical expertise that had overlap between the OPCW and the IAEA were recognised (see also paragraphs 13.1 to 13.4). While the missions and mandates are different, both organisations have developed capabilities that could be of interest to the other. Seeking further opportunities so share experiences would be beneficial to consider.

(c) The IAEA Research and Development plan[81] was highlighted as a useful approach to evaluate and adopt new technologies for enhancing the organisation's capabilities. The process involves an on-going 5, 10, and 15 year horizon scan matched to needs assessments and on-going research and

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79 For further information on International Atomic Energy Agency verification in the DPRK, see IAEA and DPRK: Chronology of Key Events; https://www.iaea.org/newscenter/focus/dprk/chronology-of-key-events.

80 For further information on International Atomic Energy Agency verification in the Syrian Arab Republic, see IAEA and Syria: Chronology of Key Events; https://www.iaea.org/newscenter/focus/syria/chronology-of-key-events.

81 Research and Development Plan: Enhancing Capabilities for Nuclear Verification, IAEA Safeguards STR-385, 2018; https://www.bnl.gov/ISPO/docs/STR-385-IAEA-Department-of-Safeguards-RD-Plan.pdf.

development directions across Member States (who are engaged as contributors in providing the organisation with access to new tools[82]). More recently, the IAEA has also made use of crowd-source challenges to gain access to new capabilities.[83]

10. AGENDA ITEM TEN – Verification in inaccessible areas

Subitem 10(a): Lessons learned from remote verification

10.1 Ms Lynn Hoggins (OPCW Chemical Demilitarisation Branch) and Mr Björn Krichels (Communications Officer OPCW Situation Centre) briefed the TWG on lessons learned using remote verification methods in Libya. Ms Hoggins provided background information on the history of chemical weapons in Libya, including OPCW destruction activities, the subsequent cessation of operations during the Arab Spring, current instability in the region and the circumstances that preceded the decision to employ remote verification at the former chemical weapons site in Ruwagha, Libya.[84] Ms Hoggins discussed the conditions that made live-streaming video monitoring a possibility and the motives for employment of this methodology after the request from Libya to remove chemicals from its territory for final destruction.[85] Mr Krichels described the equipment that was selected for the remote monitoring, and how it was used to overcome some of the unique challenges associated with live streaming in a non-permissive environment.

10.2 Ms Hoggins concluded with a discussion of the requirements for adoption of new equipment (including funding and redundancy). She explained why remote monitoring options may not always be available (these approaches may require creative solutions with some potential that it may not work). There may be resource limitations preventing use of certain equipment, and the set of circumstances that would be necessary for remote monitoring in a non-permissive environment may not allow it (in some cases, the State Party whose territory is involved may constrain the use of certain equipment).

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82 See for example *Development and Implementation Support Programme for Nuclear Verification 2018 - 2019*, IAEA Safeguards STR-386, 2018; https://www.iaea.org/sites/default/files/18/09/sg-str-386-development-support-programme.pdf.

83 See https://challenge.iaea.org/challenges/all. For additional information, including outcomes of previous challenges see: (a) Robotics Challenge Winning Design Helps Speed up Spent Fuel Verification, 18 March 2019; https://www.iaea.org/newscenter/news/robotics-challenge-winning-design-helps-speed-up-spent-fuel-verification (d) Robotics in Nuclear Verification: Sparking Innovation Through Crowdsourcing, 19 September 2018; https://www.iaea.org/newscenter/news/robotics-in-nuclear-verification-sparking-innovation-through-crowdsourcing. (c) IAEA Issues Crowdsourcing Challenge for Materials for Fusion Technology, 11 June 2018; https://www.iaea.org/newscenter/news/iaea-issues-crowdsourcing-challenge-for-materials-for-fusion-technology.

84 (a) "Results of samples associated with the Technical Secretariat's evaluation of the amended declaration submitted by Libya with regard to the Category 2 chemical weapons stored at the Ruwagha chemical weapons storage facility" (EC-89/S/3, dated 2 October 2018 (b) "Technical Secretariat's Evaluation of the Amended Declaration Submitted by Libya with Regard to the Category 2 Chemical Weapons Stored at the Ruwagha Chemical Weapons Storage Facility" (EC-83/S/2, dated 12 August 2016).

85 Libya and the OPCW; www.opcw.org/media-centre/featured-topics/libya-and-opcw.

Subitem 10(b): Robotics and Artificial Intelligence to support investigations in hazardous environments

10.3 Professor Michael Madden (guest speaker, National University of Ireland Galway) briefed the TWG on the Horizon 2020 Remotely Operated CBRNe (Chemical, Biological, Radiation, Nuclear, explosive) Scene Assessment and Forensic Examination (ROCSAFE) project.[86] Its goals are to take advantage of the potential of robotics and AI to enable faster and safer assessment of hazardous environments and collection of forensic evidence. These help to reduce the need for investigators to enter areas with unquantified threats and to support decision-making on the scene. The project involves 13 universities, research organisations and companies across Europe. The consortium is adapting ground and air vehicles for the task, and developing new remote-controlled sensors, sampling systems, and remote tools for collection and handling of forensic evidence. The team is also developing AI-based analytics and innovative Central Decision Support software[87] for investigators, linked to a graphical Command and Control Centre.[88] These coordinate the robotic systems and sensors, and provide a user interface with maps and video, showing results from real-time analytics, building an overview of the scene, with geographical context and relevant documentation. Because of the challenges of testing such systems, the team has also built virtual reality environments that allow some aspects of the system to be tested.[89]

10.4 Professor Madden emphasised that AI cannot and should not replace forensic and other experts from the decision making process (these are tools to aid decision making by supporting the experts). He also noted that as AI and machine learning improve, they will become more widely adopted, which can increase incentives for trying to disrupt their use, cautioning that "hackable" robots and machine learning may pose challenges for critical scientific applications.

10.5 In the subsequent discussion, the following points were raised:

(a) Video game engines have very good modelling capabilities and provide useful tools for simulations of incidents that can be used for training of remotely

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86 Remotely Operated CBRNe (Chemical, Biological, Radiation, Nuclear, Explosive) Scene Assessment and Forensic Examination (ROCSAFE) project; www.rocsafe.eu.

87 Data mining and machine learning group at the National University of Ireland Galway; http://datamining.it.nuigalway.ie/.

88 B. Drury, I. Ullah, M. Madden; "An Information Retrieval System for CBRNe Incidents"; *ECML PKDD 2018 Workshops*, 2018, *11329*, 216-221. DOI: 10.1007/978-3-030-13453-2_17.

89 (a) I. Ullah, S. Abinesh, D. Smyth, N. Karimi, B. Drury, F. Glavin, M. Madden; "A virtual testbed for critical incident investigation with autonomous remote aerial vehicle surveying, artificial intelligence, and decision support"; *ECML PKDD 2018 Workshops*, 2018, *11329*, 216-221. DOI: 10.1007/978-3-030-13453-2_18. (b) D. Smyth, F. Glavin, M. Madden; "Using a game engine to simulate critical incidents and data collection by autonomous drones"; *IEEE Games and Entertainment Media*, National University of Galway, 2018. DOI: 10.1109/GEM.2018.8516527. (c) D. Smyth, J. Fennell, S. Abinesh, N. Karimi, F. Glavin, I. Ullah, B. Drury, M. Madden; "A virtual environment with multi-robot navigation, analytics, and decision support for critical incident investigation"; Preprint *arXiv:1806.04497*, 2018.

operated systems. The use of virtual reality based training tools for CBRN emergency response has also been demonstrated.[90]

(b) Unmanned robotic systems (air or ground based) for sample collection could be very useful. Concern was raised about their use in contaminated environments where there is potential for the robotic system to become contaminated and then transfer the contamination to any new sampling spot it subsequently moves to. Using unmanned systems (specifically UAVs) to map a site using sensors is thought to be a more practical approach as the map will inform decision making and the section of sampling locations.

Subitem 10(c): Panel discussion

10.6 Along with members of the Secretariat, speakers from the sessions on “unmet technical needs for verification” (Agenda Item 9) and “verification in inaccessible areas” (Agenda Item 10) participated in a panel discussion moderated by Dr Borrett.

10.7 In the discussion, the following points were raised:

(a) As non-routine operations and tasks increase, teams are going to be challenged more, necessitating greater levels of readiness and team cohesiveness. Developing scenarios to train against and challenge procedures, tools and methods is valuable for preparation. Such training scenarios should involve the team as a whole and provide opportunities for evaluation of any new technologies to assess their robustness under field conditions. Technology cannot be a substitute for team cohesiveness, preparedness and operational experience (especially in regard to situational awareness in an insecure environment).

(b) Cross training of skills and functions within a team and across teams was recognised as useful. This allows the team members to contribute to other areas needed without compromising the mission when a specific individual is unavailable.

(c) The NFI, with experts from over 40 different technical skill sets, has used workshops, courses and training scenarios to facilitate engagement across the disciplines to recognise complementary areas of expertise. These have been a useful approach to interdisciplinary engagement.

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90 See for example: (a) M. Kako, M., Hammad, S. Mitani, P. Arbon; “Existing approaches to chemical, biological, radiological, and nuclear (CBRN) education and training for health professionals: findings from an integrative literature review”; *Prehospital and Disaster Medicine*, 2018, *33(2)*, 182-190. DOI: 10.1017/S1049023X18000043. (b) A. Mossel, M. Froeschl, C. Schoenauer, A. Peer, J. Goellner and H. Kaufmann; "VROnSite: Towards immersive training of first responder squad leaders in untethered virtual reality"; *2017 IEEE Virtual Reality (VR)*, 2017, 357-358. DOI: 10.1109/VR.2017.7892324. (c) P. Maciejewski; “ICT tools in CBRN troops’ education and training”; *Zeszyty Naukowe / Wyższa Szkoła Oficerska Wojsk Lądowych im. gen.*; T. Kościuszki, 2017, 4, 121—137.

(d) Technologies that provide enhanced capabilities to establish and monitor chain of custody from remote sample collection and that can aid in the minimisation of risk to inspectors were highlighted as warranting consideration in TWG advice.

(e) Restrictions on the use of technologies can be expected; some technological tools may be unavailable in the operating environment of an investigation (particularly technologies that record information in ways that authorities might find difficult to control).

(f) Practical adoption of new tools and methods requires the integration of these into the operating procedures of an inspection team. Familiarity with new technologies and their limitations is necessary across the team employing them.

(g) Given the range of potential scenarios, creativity and innovation are required. There may be ways to use familiar technology and simple methodologies to solve non-routine problems, and the value of these approaches cannot be overstated.

(h) When new technologies are considered, it is important to consider what is fieldable, and provides capabilities to efficiently aid the fulfilment of mission requirements. Adoption and testing of new technologies should be informed by capability requirements, not the technology itself.[91] Developing scenarios, which include constraints in the operating environment, could assist the identification of enabling tools (familiar or new technologies) that are fit for purpose.

(i) The panel supported the Secretariat developing scenarios for possible future non-routine missions, drawing on past experience and lessons learned. Identification of linkages across different scenarios and activities would be useful for recognising where current procedures may be challenged and where new tools and methods might be beneficial. These considerations could be insightful for the final report of the TWG.

(j) A review of Secretariat ROPs and SOPs for assessment against forensic guidelines and best practices[92] was recognised as a useful exercise.

(k) The discussion also touched upon the challenges of working in insecure and non-permissive environments.

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[91] This part of the discussion mimics previous advice of the SAB, see paragraph 22 of: “Report of the Scientific Advisory Board on Developments in Science and Technology for the Fourth Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention” (RC-4/DG.1, dated 30 April 2018); www.opcw.org/sites/default/files/documents/CSP/RC-4/en/rc4dg01_e_.pdf.

[92] Of possible interest are guidelines and best practices made available by the European Network of Forensic Science Institutes; http://enfsi.eu/documents/.

(i) Under these circumstances, ROPs and SOPs may not always fit operational realities, requiring flexibility in carrying out a mission and placing additional stress on the individuals involved.

(ii) Insecure operating environments can place constraints, both natural and malicious, on the effectiveness of an investigation. In the face of such constraints, operational capability can be a compromise between the consideration of immediate access, security issues and the resources required on-site. In some circumstances, competing objectives between humanitarian and investigative international agencies operating in the same locations can create additional constraints.

(iii) A key issue is the timeline from occurrence of an event through to the analysis of information and evidence. The longer it takes to reach a site, the greater the challenges that might be expected to be raised toward the investigation's conclusions. The higher the visibility of an incident and investigation, the greater the likelihood of intensive scrutiny in regard to provenance, ownership and control of evidence.

11. AGENDA ITEM ELEVEN – International Organisations and their differing mandates: effects on forensic investigations

11.1 Ms Doris Eerhart discussed the impact of differing mandates, operating procedures and evidence requirements on forensic investigations. She described mandates and the impact that changes to them have on the nature of the work and how it is performed. Mandates can impact how organisations interact with one another, an organisation involved in an international inspection or investigation never works in complete isolation from others. Yet as every organisation has its own mandate, without communication and coordination (knowing who else is on the ground in the area of interest), there can be duplication of efforts and the information that any one organisation has on a given incident may be incomplete. In some instances, sensitivity of the information being collected and the different mandates of the organisations may prevent cooperation and information sharing. Forensic work can therefore be potentially hampered by constraints set out in the mandate of the mission.

11.2 Discussing the stages of a crime and what information the evidence (traces) can provide, Ms Eerhart explained that in a "pre-crime" stage, traces produced in planning and preparing for the crime may be found (from the "criminal event" stage, traces may be found that indicate the transfer of physical evidence from perpetrator to victim, victim to perpetrator, and from both the victim and perpetrator to the scene of the incident); and in a "post-crime" stage, the traces might indicate attempts to destroy or transfer (hide) evidence, avoid apprehension and clean up a crime scene. Any evidence collected must be preserved as much as possible in the state it was received, as this might allow it to be used to collect information that might be used under different mission mandates.

11.3 Of critical importance for the collection and analysis of evidence is that the procedures followed must be documented and any changes to ROPs and SOPs used throughout an investigation must be recorded. Any diversion from a standard procedure must be captured and explained (justified). All SOPs (including older versions) should be saved. Technologies for analysis will also change (improve) over time; if the technologies and methods used over the course of an investigation change, this must also be recorded. Questions on the validity of information will often be raised in a courtroom. Changes in procedures and deviation form ROPs and SOPs may generate questions and challenges to the information that will need to explained and justified. If the evidence being collected has any chance of being used in a courtroom, the methods employed must fit the legal requirements for that court, otherwise it may not be accepted for this purpose.

11.4 In regard to documenting investigative work, a forensic case file should contain the case report and notes, analytical results and interpretation, quality control records, images, evidential material descriptions, phone logs and the curriculum vitae and proficiencies of the scientists performing the work. Knowing who was involved at each stage of an investigation is important for cases that eventually go to court. Scientists performing analyses on any evidence presented in the courtroom can be potentially called as witnesses. This could be relevant to DLs should any of the results they produced be used as evidence in a trial.

11.5 To make use of the information provided by the analysis of evidence, clear forensic questions must be asked: “did an offence occur?”, “who committed the offense?”, “what happened?”, and “was the accused at the crime scene?”. Additionally, the possible influence on the results arising from methods and procedures must be fully understood.

11.6 In the subsequent discussion, the following points were raised:

(a) Continued engagement of the TWG and the SAB with the global forensic community would be useful for providing informed advice on the investigative capabilities of the OPCW.

(b) Cooperation with other organisations can be valuable and help to avoid duplication of work. Effective cooperation requires an understanding of who can be called upon and actively engaged. Lack of coordination (even if coordination is only informal) can be problematic for organisations operating in a similar locality with similar or competing objectives. A mapping of organisations with overlapping objectives, but a diversity of functions, mandates, and specific expertise can be useful in identifying who to approach.[93]

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93 An example of such a mapping was produced by Pacific Northwest National Laboratory for biodefence in the United States of America. See: K. M. Omberg, L. R. Franklin, D. R. Jackson, K. L. Taylor, K. L. Wahl, A. Lesperance, E. M. Wynkoop, J. A. S. Gray, O. P. Leiser, S. L. Frazar, R. Ozanich, R. Bartholomew; “A publicly available landscape analysis tool for biodefense policy”; *Health Security*, 2018, *16(1)*, Published Online. DOI: 10.1089/hs.2017.0088.The tool produced in interactive and available online https://bplat.pnnl.gov.

12. AGENDA ITEM TWELVE – VX incident at KLIA2 International Airport: national experience

12.1 Dr Subramanian Raja (guest speaker, Centre for Chemical Weapons Analysis, Malaysia) briefed the TWG on the work of this Centre, including its experience in relation to the 2017 VX incident at KLIA2 International Airport.[94]

12.2 In the subsequent discussion, the following points were raised:

(a) The presentation exemplified the importance of scientific expertise and rigor necessary for obtaining robust analytical results, and the need for clear and precise communication, when presenting evidence of the use of chemical weapons in a court of law.

(b) The TWG expresses its appreciation to the Malaysian authorities for permitting Dr Subramaniam Raja to present this informative and well-received briefing during its Third Meeting.

13. AGENDA ITEM THIRTEEN – Unmanned systems

Subitem 13(a): UAV-based radiation monitoring and mapping

13.1 Professor Ralf Kaiser (guest speaker, University of Glasgow and Lynkeos Technology Ltd,[95] United Kingdom) provided the TWG with an introduction to an unmanned aerial vehicle (UAV) system that had been developed by the International Atomic Energy Agency (IAEA) for radiation mapping and its development history. He provided examples of applications and insights from experiences in deploying UAV systems in remote and/or hazardous environments.

13.2 Unmanned Aerial Vehicles (UAVs) are a rapidly developing technology that has already created a new billion-dollar market.[96] The technological development has been accelerated by the fact that many of the components, e.g. GPS chips, accelerometers and LiPo batteries are produced as parts of the worldwide smartphone market. UAVs make it possible to place sensors accurately and remotely in 3D, to follow pre-programmed patterns and to collect data in real-time. In hazardous environments, e.g. after a nuclear accident, this allows measurements to be made with reduced or no hazard exposure to human operators. UAV systems flying “low” can produce very high resolution mapping data (whether visual imagery or through the use of sensors).

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94 (a) “Malaysia: Statement at the 84th session of the Executive Council”, 7 March 2017; www.opcw.org/sites/default/files/documents/EC/84/en/Malaysia_ec84_statement.pdf. (b) “Decision: Chemical Weapons Incident In Kuala Lumpur, Malaysia” (EC-84/DEC.8, dated 9 March 2017); www.opcw.org/sites/default/files/documents/EC/84/en/ec84dec08_e_.pdf..

95 Linkeos Technology Ltd; https://www.lynkeos.co.uk/.

96 *Drone Market Environment Map 2018*; https://www.droneii.com/drone-market-environment-map-2018.

13.3 Following the accident at the Fukushima Dai-ichi nuclear power plant in Japan in 2011,[97] the IAEA Physics Section[98] and the IAEA Nuclear Science and Instrumentation Laboratory embarked on the development of a UAV-based radiation monitoring and mapping system. The project was partially funded by the government of Japan and the system was delivered to Fukushima Prefecture in 2016. Based on a "hexacopter" platform, it features real-time data transfer, high-resolution global navigation satellite systems (GNSS), a laser altimeter and a selection of sensors and cameras including a Geiger-Mueller counter and a LaBr gamma spectrometer. The system has since been used on three continents – Europe, Asia, and South America.

13.4 In the subsequent discussion, the following points were raised:

(a) Commercial UAVs are primarily designed to carry cameras. If alternate payloads are required (e.g. chemical detectors), modified gimbal systems are needed to mount the equipment, and the cable and data ports of the UAV may not be configured for the new equipment. 3D printers are useful tools for prototyping and producing the needed parts.

(b) UAV systems must be tested under real-world conditions for their fieldability, as the manufacturers specifications for flight time and other capabilities may not be met under operating conditions that differ from those the manufacturer had developed the specifications for.

(c) UAV systems are subject to operating rules and oversights that vary across States Parties;[99] and how fit for purpose a given system may be will be impacted by the operating constraints. Additional guidelines on remotely operated aircraft are available from the International Civil Aviation Organization.[100]

Subitem 13(b): Utilization of cargo drones for logistics in low resource settings

13.5 Mr Scott Dubin (guest speaker, USAID Global Health Supply Chain Program Procurement and Supply Management) briefed the TWG on the use of UAVs to overcome the infrastructure challenges that can significantly impact health outcomes for people living in remote rural communities. Without access to proper medical testing facilities, patients and healthcare providers cannot get the information they need to make informed treatment decisions; without a source of commodities during medical emergencies, populations do not have access to critical supplies. And because

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97 *Report of Japanese Government to IAEA Ministerial Conference on Nuclear Safety - Accident at TEPCO's Fukushima Nuclear Power Stations*; Nuclear Emergency Response Headquarters, Government of Japan, 15 September 2011; https://www.iaea.org/report-japanese-government-iaea-ministerial-conference-nuclear-safety-accident-tepcos-fukushima-nuclear-power-stations.

98 International Atomic Energy Agency Physics Section, https://www.iaea.org/about/organizational-structure/department-of-nuclear-sciences-and-applications/division-of-physical-and-chemical-sciences/physics-section.

99 A global drone regulations database is available at: https://www.droneregulations.info/.

100 *Manual on Remotely Piloted Aircraft Systems (RPAS)*; International Civil Aviation Organization Doc 10019 AN/507, 2015; https://skybrary.aero/bookshelf/books/4053.pdf.

roads may be impassable or non-existent, there are often delays sending physical items to these communities.

13.6 UAVs provide an innovative and lightweight means of circumventing these challenges. USAID is leveraging this growing technology to improve the delivery of medical samples to laboratories and results back to patients, as well as improving the availability of health commodities that are needed during an emergency. When UAVs are introduced into the existing health infrastructure and become a viable conduit by which essential commodities and lab samples can be efficiently transported between districts and remote facilities, barriers to access faced by those living in remote areas are reduced, and health outcomes would be expected to improve.[101]

13.7 Through its Global Health Supply Chain-Procurement and Supply Management (GHSC-PSM) Project,[102] USAID is utilizing tilt-rotor UAVs for transporting lab samples and health commodities in rural communities in sub-Saharan Africa. The specific platform being used, the Wingcopter 178 Heavy Lift (HL),[103] differs from UAVs used in other health supply chain projects because its rotor mechanism allows the device to shift during flight from a multi-rotor vehicle to an energy-efficient, fixed-wing configuration. As such, it has the unique ability to take off and land vertically, like a helicopter, which means that it can land easily in small spaces and does not require a landing strip, catapult, or prohibitive infrastructure investments. Mr Dubin invited the OPCW to send an expert to observe the UASAID project in the field in Malawi.

13.8 Mr Dubin discussed procurement[104] and testing and implementing of UAVs or UAV services, which is unchartered territory for many organizations seeking to apply the technology within their own supply chain activities. Although these technologies have been identified as valuable tools with high potential for impact, to date, there has been limited implementation of UAVs for logistics purposes.[105] The GHSC-PSM Project seeks to expedite the rate at which the technology is applied and scaled up by sharing its successful experiences in the UAV service procurement process so that other organizations can gain and benefit from these insights. Mr Dubin gave examples of the applications for internet of things (IoT) devices in logistics, and provided an example with temperature sensors.[106]

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101 *UAVs in Global Health Defining a Collective Path Forward*, Center for Innovation and Impact USAID Global Health; https://www.usaid.gov/cii/uavs-global-health.

102 USAID Global Health Supply Chain-Procurement and Supply Management Program; https://www.ghsupplychain.org/index.php/PSM.

103 Wingcopter; https://wingcopter.com/.

104 *Unmanned Aerial Vehicle Procurement Guide: Specifications, Questions and Other Criteria to Consider*, USAID Global Health Supply Chain Program, 2018; https://www.ictworks.org/wp-content/uploads/2018/10/usaid-UAV-buying-guide.pdf.

105 *Unmanned Aerial Vehicles Landscape Analysis: Applications in the Development Context*, USAID Global Health Supply Chain Program, 2017; https://www.ghsupplychain.org/sites/default/files/2017-06/GHSC_PSM_UAV%20Analysis_final.pdf.

106 *Using Technology to Monitor the Temperature of Health Commodities*, USAID Global Health Supply Chain Program, 2019; https://www.ghsupplychain.org/news/using-technology-monitor-temperature-health-commodities.

13.9 In the subsequent discussion, it was recognised that the use of cargo drones may be relevant to OPCW activities for delivering assistance. The invitation extended to the Secretariat to familiarise itself with the real-world experience of the use of cargo delivery drones in Malawi is an invaluable opportunity which should be taken advantage of.

Subitem 13(c): Panel discussion

13.10 Speakers from the sessions on “unmanned system” (Agenda Item 13) along with members of the Secretariat participated in a panel discussion moderated by Dr Mikulak.

13.11 In the discussion, the following points were raised:

(a) Applications of UAVs for the work of OPCW were recognised for capabilities to quickly document a site with visual imagery (commercially available systems are well suited and readily available), collect samples and/or real time chemical sensor data from difficult to access locations, and especially for assistance missions (for both sample/information collection and delivery of medical supplies). Assistance missions were seen as the most likely situations in which permissions to use UAVs would be given (however, these are unlikely to be missions where OPCW is a first responder).

(b) that the use of UAVs offer many advantages for the work of the OPCW, but acceptance of these new capabilities within established processes and specific mission mandates may pose challenges.

(c) Any application for sample collection would need to consider how to ensure the chain of custody. This could be achieved by having multiple UAVs; as a UAV performs sample recovery, another UAV could provide surveillance and live stream visual data to inspectors. Services for hire are also available for high resolution UAV imaging (and data processing).

(d) Multiple UAVs (“drone swarms”) would provide a means to more quickly survey a site (with visual imaging and/or chemicals sensors). The flightpaths of UAV systems can also be programmed to maximise the effectiveness of any type of data collection they are undertaking and to avoid interferences.

(e) Concerns were raised on whether a UAV would damage a site where it is collecting samples. Air sampling is possible however, for solid and liquid samples down draft of rotors might disturb a sampling a site and could lead to potential contamination (see also sub-paragraph 10.5(b)).

(f) With the capability to collect many types of data (e.g. GPS coordinates, imagery, chemical sensor data, altitude, and more) it is possible to make some very useful 2D and 3D maps that overlay multiple types of information. A data analytics capability for the information collected is as important as the UAV itself.

(g) UAVs can also augment satellite imagery for site assessment.

(h) As the tasks of a UAV go beyond imagery, customised robotics and software development may be necessary, as the capabilities would not always be off-the-shelf systems.

(i) Consideration of the scenarios where UAVs could be useful and what the requirements of a UAV system would need for these situations is the place to start. Reviews of available systems and their uses in a variety of applications should be undertaken to inform decision making (see paragraph 13.8). Systems with a best fit for specific purposes can be identified, as well as any potential customisation. Ease of operation and training requirements should also be taken into account. Demonstrations by manufacturers are important for evaluation of any system being considered.

(j) Operating constrains for UAVs must also be taken into consideration. Safety regulations, flight path and other usage restrictions will impact the scenarios for which they are best suited (this is also location dependent due to differences in regulations within and between State Parties).

14. AGENDA ITEM FOURTEEN – Sub-group updates and discussion

14.1 Breakout sessions of the sub-groups established at the First Meeting of the TWG were held to review and comment on information compiled during the intersessional period. The sub-group leads briefed the TWG on the breakout session outcomes, and discussed issues that warrant further consideration.

Sub-group A, forensic methods and capabilities

14.2 The sub-group discussed the further development of the forensic advisor role at OPCW and the process for the selection of forensic laboratories for off-site analysis.

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14.3 The discourse on a forensic advisor was informed by the discussion with Ms O'Sullivan (see paragraphs 7.1 - 7.6). The SAB could provide advice on how to develop this role in the OPCW and to consider the advantages and disadvantages of having the forensic advisor within a team or as an external advisor to the Director-General. A team of forensic advisors could also be considered that the OPCW can draw from when needed. It would be valuable for the forensic advisor to have knowledge of applicable international laws and laboratory networks (including the DL Network).

14.4 Regarding the selection of laboratories, these should have ISO 17025 or similar accreditation, participate in relevant proficiency testing, possess the capability to handle contaminated exhibits, be able to maintain chain of custody and confidentiality, have access to a range of forensic capabilities (which may require access to multiple laboratories) and be capable of taking information into a legal system. Agreements with suitable labs should be pursued to allow a selection of laboratories to call upon when needed. Relationships and working procedures would need to be developed.

Sub-group B, data collection and management

14.5 The sub-group focused their discussion on operating procedures. Existing inspection SOPs were recognised as useful templates for developing new procedures that incorporate additional layers of forensic best practices. It was noted that SOPs are living documents that must be regularly reviewed and updated as appropriate (especially as new mandates for missions dictate).

14.6 Having inspectors observe the process through which a forensic laboratory moves from exhibits collected from crime scene to courtroom was also suggested as beneficial for training, so that a holistic view of a forensic process is understood.

Sub-group C, sampling, detection and analysis

14.7 The sub-group focused their discussion on on-site sampling and analysis. Many new tools and technologies have been recognised as beneficial however, for any new methods and technologies to be adopted, these should be commercially available and fieldable.

14.8 Making staff available for evaluating new technologies as they would be used in the field (a necessary condition for adoption) was discussed. This would require training scenarios that mimic real-world conditions and a continual review and evaluation of technologies. Inputs and evaluations by suitable external partners (e.g. DLs, agencies within Member States) could also be considered.

14.9 To identify enabling on-site sensors, the Secretariat could leverage the efforts of others. For example, a list of commercially available CBRN sensors is maintained (and regularly updated) by MRI global.[107] Some of these sensors may be useful to consider for field evaluation and potential addition to approved equipment lists.[108] As technology development often outpaces the ability to evaluate and approve equipment, the sub-group discussed the value of fast and flexible evaluation processes.

14.10 In regard to the types of sensors useful for on-site analysis, the sub-group recognises toxic industrial chemicals (TICs) as a challenge given the broad range of chemicals these include. More discussion on methods to recognise TICs and appropriate on-site response is needed.

14.11 The sub-group also discussed the use of apps such as eyeWitness for documenting sample collection by local personnel. Such an app could be used in combination with reliable and field expedient sealing methods. This combination would be intended to improve the relevance and reliability of samples provided to the OPCW. Further consideration of such an approach could be useful.

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107 *CBENe Tech Index*; http://www.cbrnetechindex.com/.

108 (a) "Information for Familiarisation Purposes for National Authorities of States Parties on Approved Inspection Equipment" (S/1375/2016, dated 18 April 2016); www.opcw.org/sites/default/files/documents/S_series/2016/en/s-1375-2016_e_.pdf. (b) "Decision: List of Approved Inspection Equipment with Operational Requirements and Technical Specifications" (C-I/DEC.71*, dated 30 November 2010).

14.12 In discussions with the Secretariat, the sub-group was informed that the weight of the sample shipping container currently used exceeds the weight limit for accompanied luggage on commercial aircraft. As a consequence, the container must be shipped as cargo and may well not be transported on the same aircraft as the inspection team. This creates a risk that the container may not be available to inspectors when they first arrive and that receipt of samples may be delayed after the team leaves the host state. Consideration could usefully be given to procuring a sample transport container, with suitable specifications, that will allow shipment on the same commercial flight used by inspectors. At least one model with potentially suitable specifications is commercially available.[109]

Sub-group D data collection and integrity of scene, evidence and evidence collection

14.13 Operating procedures were discussed with a view to collecting best practices and procedures (such as those from ENFSI[92]) for the OPCW.

14.14 The need to make procedures for documentation of chain of custody more efficient without compromising integrity and reliability was further discussed, with similar suggestions to the discussions in sub-group C. The use of RFID tags and a greater degree of digitalisation were suggested (this could include apps and tech-stacks such as described by Ms Betts and Dr Gordon in paragraphs 8.8 to 8.13). Engagement with experts who use such tools was identified to understand better how these tools are used in operational settings.

14.15 Given the importance of chain of custody and verifying authenticity, an "exhibit officer" role could be considered, this would be a person with expertise in forensic evidence collection. Expertise and knowledge in digital forensic capabilities could also be valuable.

Sub-group E, provenance

14.16 The on-going work of the CFITWG (see paragraphs 5.1 and 5.2) helped informed discussions within subgroup E. The sub-group discussed analytical tools for profiling, and emphasised the need to maintain strong relationships with the international forensic community and standardisation of methods for comparison of data across laboratories.

14.17 Given that the data sets available for chemical weapons investigations are limited in size, the development of methods to aid in the evaluation (and validation) of small data sets was viewed as important.

Sub-group F, additional considerations

14.18 Sub-group F recognised a need to systematically monitor technical developments and consider how they could be used to further strengthen OPCW verification capabilities.

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109 SAAB CBRNe Transport Packaging; https://saab.com/globalassets/commercial/land/force-protection/cbrn/saab_0086_crbne_transport-packaging.pdf.

SAB reports will continue to provide information on technologies of potential value, however the Secretariat would benefit from taking a more active role. Consideration could be given to increased regular budget support for a modest technology evaluation and adaptation programme, which could be supplemented by systematic technical support by Member States to meet OPCW requirements. Such a function would usefully include field evaluation in relevant training scenarios. The technology foresight experience of the IAEA was seen as informative for this purpose (see sub-paragraph 9.19(c)).

14.19 Information collected on-site by inspectors and/or generated through off-site analysis may potentially be transferred to others for further review. If the transferred information is to be subjected to such further evaluations, suitability of the methods and approaches to meet the needs of the evaluators must be considered.

15. AGENDA ITEM FIFTEEN – Next steps and agendas for the Fourth and Fifth Meetings of the Temporary Working Group

15.1 The TWG discussed its progress across the first three meetings and prioritized areas of future work. Dr Forman reviewed timelines and milestones for development of the final report in the lead-up to the end of the TWG's term of reference in February of 2020.

15.2 The TWG intends to hold its Fourth Meeting in September 2019 and its Fifth and final Meeting (which will be dedicated to drafting of a final report) in November 2019. TWG members will identify suitable dates intersessionally.

(a) For the Fourth Meeting, a discussion of scenarios was recommended so that the findings of the TWG could be better understood in an operational context. A topic of this meeting would be the integration and combination of technology in an operational setting.

(b) Other specific topics suggested for the Fourth Meeting included Toxi-triage,[110] mixed CBRN response, chlorine exposure biomarkers, and chemical sensors for on-site analysis.

16. AGENDA ITEM SIXTEEN – Adoption of the report

The TWG considered and adopted the report of its Third Meeting.

17. AGENDA ITEM SEVENTEEN – Closure of meeting

The Chairperson closed the meeting at 17:59 on 4 April 2019.

110 A Toxi-triage field exercise is planned for May 2019.

ACKNOWLEDGEMENTS

The TWG members thank the guests and members of the Secretariat who participated in discussions and provided presentations: Mr Nihad Alihodzic, Ms Wendy Betts, Dr Marc-Michael Blum, Dr Carolyn Browne, Mr Boban Cekovic, Mr Scott Dubin, Ms Doris Eerhart, Dr Geoff Gordon, Dr Olli Heinonen, Professor Ralf Kaiser, Mr Björn Krichels, Ms Grace Liu, Dr Evandro De Souza Nogueira, Mr Santiago Oñate, Ms Irene O'Sullivan, Professor Michael Madden, Dr Didier Meuwly, Dr Subramanian Raja, Professor Åke Sellström, Mr Rolf Ypma and Mr Leo Zaal. The TWG also wishes to acknowledge Mr Peter Brud, Ms Maria Hemme, Ms Nadezda Malyutina, Ms Marlene Payva and Ms Giovanna Pontes of the OPCW Office of Strategy and Policy, for their support and contributions to the meeting and its preparations. The members of the TWG express appreciation to Mr Leo Zaal and the Netherlands Forensics Institute for hosting the second day of the meeting, and providing an informative forensic laboratory tour. The TWG thanks the members of the Secretariat who shared their views on the TWG's considerations and provided feedback to the sub-groups: Mr Cristhian Almeida, Mr John Baguma, Mr Chaouki Belgacem, Mr Shawn DeCaluwe, Mr Tamás Eles, Mr Theo Juurlink, Mr Albert Kireev, Mr Joao Hoefel, Mr Chunzheng Li, Mr Haifeng Li, Ms Jie Li, Mr Luciano Passos, Mr Rakeshkumar Patel, Mr Vishal Solanki, Mr Guy Valente, Dr Gareth Williams and Mr Brendan Wilki.

Annex: List of Participants at the Third Meeting of the Scientific Advisory Board's Temporary Working Group on Investigative Science and Technology

Annex

LIST OF PARTICIPANTS AT THE THIRD MEETING OF THE SCIENTIFIC ADVISORY BOARD'S TEMPORARY WORKING GROUP ON INVESTIGATIVE SCIENCE AND TECHNOLOGY[111]

	Participant	Institution
1	Dr Crister Åstot	Swedish Defence Research Agency (FOI), Umeå, Sweden
2	Dr Veronica Borrett*[112]	BAI Scientific, Australia
3	Dr Christophe Curty*[113]	Spiez Laboratory, Switzerland
4	Dr Carlos Fraga	Pacific Northwest National Laboratory, Richland, Washington, United States of America
5	Professor David Gonzalez	Department of Chemistry, University of the Republic of Uruguay and Ministry of Education, Montevideo, Uruguay
6	Dr Robert Mikulak*	Department of State, Washington, D.C., United States of America
7	Dr Syed K. Raza*	Chairperson Accreditation Committee, National Accreditation Board for Testing and Calibration Laboratories (NABL), India
8	Mr Valentin Rubaylo*	State Scientific Research Institute of Organic Chemistry and Technology, Moscow, Russian Federation
9	Mr Cheng Tang*[114]	Office for the Disposal of Japanese Abandoned Chemical Weapons, Ministry of National Defence, China
10	Dr Christopher Timperley	Defence Science and Technology Laboratory (Dstl), Porton Down, United Kingdom of Great Britain and Northern Ireland
11	Mr Francois Mauritz van Straten	Chemical Weapons Working Committee, South Africa
12	Dr Ed van Zalen[115]	Netherlands Forensic Institute (NFI), the Netherlands
13	Professor Paula Vanninen	University of Helsinki and VERIFIN, Helsinki, Finland
14	Ms Farhat Waqar*	Pakistan Atomic Energy Commission
15	Ms Wendy Betts (guest speaker)	eyeWitness to Atrocities, London, United Kingdom
16	Mr Scott Dubin (guest speaker)	Contractor USAID Global Health Supply Chain Program Procurement and Supply Management, Washing DC, United States of America
17	Ms Doris Eerhart (guest	Netherlands Forensic Institute (NFI), the Netherlands

111 Having sent their regrets, TWG members Dr Augustin Baulig, Dr Brigitte Dorner and Dr Daan Noort were unable to attend the Third Meeting.

112 Chairperson of the TWG.

113 Vice-Chairperson of the SAB.

114 Chairperson of the SAB.

115 Vice-Chairperson of the TWG.

	Participant	Institution
	speaker)	
18	Dr Geoff Gordon (guest speaker)	Global Legal Action Network and T. M. C. Asser Institute, The Hague, the Netherlands
19	Dr Olli Heinonen (guest speaker)	Foundation for Defence of Democracies, Washington, DC, United States of America
20	Professor Ralf Kaiser (guest speaker)	University of Glasgow and Lynkeos Technology Ltd, United Kingdom
21	Ms Grace Liu (guest speaker)	James Martin Center for Nonproliferation Studies
22	Ms Irene O'Sullivan (guest speaker)	Netherlands Forensic Institute (NFI), the Netherlands
23	Professor Michael Madden (guest speaker)	National University of Ireland Galway
24	Dr Didier Meuwly (guest speaker)	Netherlands Forensic Institute (NFI), the Netherlands
25	Dr Subramanian Raja (guest speaker)	Centre for Chemical Weapons Analysis, Malaysia
26	Professor Åke Sellström (guest speaker)	Umeå University, Sweden
27	Mr Rolf Ypma (guest speaker)	Netherlands Forensic Institute (NFI), the Netherlands
28	Mr Leo Zaal (guest speaker)	Netherlands Forensic Institute (NFI), the Netherlands
29	Dr Jonathan Forman (Secretary to the SAB, Technical Secretariat)	Organisation for the Prohibition of Chemical Weapons, The Hague, the Netherlands

* Member of the Scientific Advisory Board.

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