SUMMARY OF THE FOURTH 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 Fourth Meeting from 18 to 20 September 2019 at OPCW Headquarters in The Hague. The meeting was chaired by Dr Veronica Borrett on behalf of the SAB, with support from Vice-Chairperson Dr Ed van Zalen.

1.2 After welcoming the TWG members, invited guest speakers and observers, Dr Borrett summarised the outcome of the TWG's Third Meeting which had been held from 2 to 4 April 2019,[2] and discussed objectives for the Fourth Meeting and how these fit with the SAB's mandate to explore new and emerging technologies[3] and the TWG's focus on science and technology relevant to investigations mandated under Articles IX and X of the Chemical Weapons Convention (hereinafter, "the Convention").[4] She

1 These dates are tentative.

2 "Summary of the Third Meeting of the Scientific Advisory Board's Temporary Working Group on Investigative Science and Technology" (SAB-28/WP.3, dated 4 June 2019): www.opcw.org/sites/default/files/documents/2019/06/sab-28-wp03%28e%29.pdf.

3 (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) "Innovative Technologies for Chemical Security", J. E. Forman, C. M. Timperley, 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. (c) "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. (d) "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. (e) "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.

4 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.

thanked the TWG members for intersessional inputs toward the TWG's final report, and welcomed guest speakers along with experts from the Technical Secretariat (hereinafter "the Secretariat") who had kindly given their time to support its meetings. The TWG has greatly benefited from its interactions with the Secretariat and the diversity of technical expertise represented in their meetings. This has ensured the TWG's advice is guided by the needs and experience of those carrying out investigative work.

1.3 A moment of silence was observed in honour of TWG member Mr Valentin Rubaylo of the Russian Federation who passed away in June 2019. Mr Rubaylo, a member of the SAB since 2014, had also served on the TWG in Verification. He was one of the first Chemical Demilitarisation Officers to be appointed to the Secretariat at the time of the entry-into-force of the Convention. Valentin Rubaylo, a colleague, a friend, and a scientist, will be dearly missed.

Executive Summary

1.4 The TWG received briefings on the Secretariat's non-routine activities and work of the OPCW Laboratory, as well as briefings from invited guests with experience in forensics, emerging technologies for emergency response, digital information tracking and provenance, information management and chemical analysis. These provided further inputs for the TWG's final report.

1.5 The sub-groups established at the first TWG meeting reviewed their findings. The TWG will hold its fifth and final meeting from 18 to 20 November in Helsinki, Finland to draft an end-of-mandate report, which will include recommendations for the SAB to consider. This report will be finalised before the Group's mandate ends in February 2020.

1.6 Following the Twenty-Eight Session of the SAB in June 2019, which submitted recommendations from the TWG on forensic advice and training to the Director-General,[5] the TWG focused on addressing remaining topics within its terms of reference (TOR) that had not been fully considered in earlier meetings,[2,6,7] especially with regard to information management, digital approaches for tracking chain-of-custody and determination of provenance, and general needs of the Secretariat with relevance to investigative science. The presentations and discussions support the development of advice to the Director-General which will be brought forward through the TWG's final report, following its review by the SAB.

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5 See paragraphs 1.3 to 1.4 and 9.6 to 9.8 of: "Report of the Scientific Advisory Board at its Twenty-Eighth Session" (SAB-28/1, dated 14 of June 2019); www.opcw.org/sites/default/files/documents/2019/09/sab-28-01%28e%29_0.pdf.

6 "Summary of the Second Meeting of the Scientific Advisory Board's 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

7 "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.

2. AGENDA ITEM TWO – Adoption of the agenda

The TWG adopted the following agenda for its Second Meeting:

1. Opening of the meeting

2. Adoption of the agenda

3. *Tour de table* to introduce the members of the Temporary Working Group, observers and guest speakers

4. Establishment of a drafting committee

5. Recommendations submitted through the Twenty-Eighth Session of the Scientific Advisory Board

6. Engagement with forensic and other relevant experts

    (a) Chemical Forensics International Technical Working Group (CFITWG)

    (b) Forensic science advisory boards

    (c) The Generic Integrated Forensic Toolbox for CBRN incidents (GIFT) - ChemTrace Consortium

7. Updates from the OPCW Technical Secretariat

    (a) Fact-Finding Mission (FFM)

    (b) OPCW Laboratory

    (c) Equipment procurement and evaluation

8. Response and assistance

    (a) EDA BFREE project: sample handling of CBRN mixed samples

    (b) TOXI-triage

    (c) Traceability during mass-casualty incidents

9. Distributed Ledger Technologies (DLT): information transfer, provenance and digital forensics

    (a) Distributed Ledger Technologies and provenance

    (a) Digital tracking of chain-of-custody

10. (Bio)Chemical analysis

    (a) What is that smell? Detection of toxic industrial chemicals

(b) Analysis of chlorohydrins of phospholipids as chlorine biomarkers in biomedical samples of exposed animal models

(c) Application of chemoinformatics to reduce GC/MS false positive identifications during sampling and analysis missions

(d) 1) Short report on the fifth Swiss UNSGM Designated Laboratory meeting project and 2) RefBio "Germany's contribution to strengthen the reference laboratories Bio in the UNSGM"

(e) T4i DOVER: versatile and miniaturised chemical detector as a UAV payload

11. 3D Scanning technology

12. Experience from other sectors: integrating research and application

(a) Nuclear forensics

(b) Environmental forensics

13. Current and future perspectives

(a) Manual neutralisation: the last resort

(b) Assistance and protection

14. Information systems

(a) Information and evidence management

(b) Information management discussion paper

(c) The open digital forensic platform: investigate, innovate and share

15. CBRN crime scene investigation recommended and standard operating procedures (ROPs and SOPs).

16. Influence of quality assurance on the reliability of forensic identification

17. Scenario based operational planning

18. Sub-group updates and discussion

19. Next steps and end of mandate report

20. Adoption of the report

21. Closure of the meeting

3. AGENDA ITEM THREE – *Tour de table* to introduce the members of the temporary working group, 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 drafting committee to prepare the draft report of its Fourth Meeting.

5. AGENDA ITEM FIVE – Recommendations submitted through the Twenty-Eighth Session of the Scientific Advisory Board

5.1 Dr Borrett and the OPCW Science Policy Adviser provided an update on the Director-General's response to the four recommendations from the TWG's Third Meeting that had been submitted to him through the Twenty-Eighth Session of the SAB in June 2019.[5,8]

5.2 In response to the recommendation, that a "forensic advisor with broad experience in forensic science and international law should be considered to provide advice to the Director-General and the OPCW" and that "[a]n independent external expert could be considered", the Director-General noted that the Secretariat is exploring the modalities of how such an advisory role might be operationalised.

5.3 In response to the recommendations, that the "Secretariat should ensure that forensic issues are included in standard operating procedures (SOPs) or working instructions including those related to on-site sample collection, handling, curation and storage, and annotation, in accordance with forensic best practices" and that relevant "OPCW staff should receive training on forensic processes, procedures, and techniques relevant to their role", the Director-General noted that the Secretariat's training programmes and operating procedure review process continue to take these approaches into account.

5.4 In response to the recommendation, that "scenarios developed for mission planning and training should be adapted for the purpose of evaluating sampling and detection systems to meet mission conditions", the Director-General has encouraged the Secretariat to identify capability needs and situations where such capabilities are beneficial. He noted that training scenarios that match these capability needs with suitable enabling technologies are ideally suited for equipment evaluation.

5.5 In the subsequent discussion, the TWG expressed its appreciation for the positive response to the recommendations received from the Director-General. Inputs and feedback from members of the Secretariat were beneficial to understand the needs and gaps where TWG recommendations would be of value.

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8 See paragraph 10 of "Response to the Report of the Twenty-Eighth Session of the Scientific Advisory Board" (EC-92/DG.12, dated 9 September 2019); www.opcw.org/sites/default/files/documents/2019/09/ec92dg12%28e%29.pdf.

6. AGENDA ITEM SIX – Engagement with Forensic and other relevant experts

Subitem 6(a): Chemical Forensics International Technical Working Group (CFITWG)

6.1 Dr Christopher Timperley briefed the TWG on the Sixth Chemical Forensics Symposium (held from 25 to 26 August) and the Third Meeting of the Chemical Forensics International Technical Working Group (CFITWG)[9] (held from 26 to 27 August) during the Fall 2019 National Meeting of the American Chemical Society (ACS), in San Diego, USA. Many of the same participants attended both events, the former being open to all the conference attendees of the ACS meeting, the second a closed meeting for CFITWG members and invited guests.

6.2 The Sixth Chemical Forensics Symposium was organised within the ACS Division of Analytical Chemistry by TWG member Dr Carlos Fraga. Dr Fraga, Dr Timperley and TWG member Dr Crister Åstot served as session chairs. OPCW's Science Policy Adviser opened the symposium with a presentation on the challenging nature of analytical and investigative chemistry for chemical disarmament and non-proliferation, which set the stage for the 22 lectures that comprised the programme of the symposium.[10]

6.3 The meeting of the CFITWG was chaired by Dr Fraga with support from CFITWG Vice-Chair Dr Timperley; there were 47 participants from twelve States Parties. The meeting opened with statements on the background and objectives of the CFITWG, and a review of the Second CFITWG Meeting (held in August 2018)[6] and the March 2019 CFITWG Executive Committee Meeting. Discussions were focused on approaches to material security and chemical analysis.

6.4 The meeting concluded with technical updates on CFITWG projects on inter-laboratory comparison of hydrolysis products of methylphosphonic acid, chemical profiling of small-scale chemical warfare agent stocks, hexamine characterisation, chemical forensics of biomedical samples, the development of a chemical forensics critical review article, and best practices for chemical field evidence. These projects are intended to generate peer-reviewed scientific publications in due course.

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

(a) With small datasets, statistical methods that have been peer-reviewed and forensically accepted to infer similarity to validated sample data are necessary. Gathering suitable data using standardised protocols is encouraged.

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9 For further information on the CFITWG, see (a) paragraphs 12.1 to 12.2 of the report of the First Meeting of the TWG, cited in footnote 7; (b) paragraphs 11.7 to 11.8 of the report of the Second Meeting of the TWG, cited in footnote 6; and, (c) paragraphs 5.1 to 5.2 of the report of the Third Meeting of the TWG, cited in footnote 2.

10 See Abstracts of Papers, 258th American Chemical National Meeting and Exposition, San Diego, CA, United States, August 25-29, 2019, ANYL Section E (Chemical Forensics).

(b) The need for further validated methods and suitable quality control systems for laboratories was emphasised. A greater degree of standardisation across Designated Laboratories could benefit some types of analysis.

(c) A need for science communication and promoting scientific literacy amongst legal professionals was recognised for the proper interpretation of scientific results from a forensic investigation that may be later evaluated under a legal framework.

Subitem 6(b): Forensic science advisory boards

6.6 Dr Borrett, on behalf of the SAB Chair, was invited as an observer to the Sixth Annual Meeting of the Office of the Prosecutor's (OTP's) Scientific Advisory Board (hereinafter, the "OTP SAB") held from 20 to 21 June 2019 at the International Criminal Court (ICC) in The Hague.[11] As the OTP SAB was reviewing its advisory function, Dr Borrett contributed an invited presentation on the role of the OPCW SAB[12] in providing advice to the Director-General in accordance with Article VIII[13] of the Convention and the establishment of the First Session of the SAB in 1998.[14] She described the reporting of each Session of the SAB to the Director-General, and the process through which he responds,[15] the provision of advice through intersessional requests from the Director-General,[16] reports to the Review Conferences[17] and the process through which TWGs are established.[18] Members of

11 ICC News Item, 4 July 2019, The Scientific Advisory Board of the Office of the Prosecutor holds its 6th annual meeting; https://www.icc-cpi.int/Pages/item.aspx?name=pr1464.

12 For further information on the OPCW Scientific Advisory Board, see: www.opcw.org/about-us/subsidiary-bodies/scientific-advisory-board. A series of infographics on the "Science Advice Ecosystem" at the OPCW are also available; (a) www.opcw.org/sites/default/files/documents/2019/07/Bridging_Science_and_Diplomacy_2019.pdf, and (b) www.opcw.org/sites/default/files/documents/2019/07/Science_Advice_Diplomacy_and_Communication_%202019.pdf.

13 See Article VIII, sub-paragraph 21(h) of the Convention; www.opcw.org/chemical-weapons-convention/articles/article-viii-organization.

14 Reports and other documents (including responses from the Director-General) related to Scientific Advisory Board are available at: www.opcw.org/resources/documents/subsidiary-bodies/scientific-advisory-board.

15 "Report of the First Session of the Scientific Advisory Board"(C-III/DG.6, dated 6 October 1998); www.opcw.org/sites/default/files/documents/CSP/C-III/en/CIIIDG6_en.pdf.

16 See for example, responses to requests for advice from the Director-General in 2017 and 2018: (a) "Response to the Director-General's Request to the Scientific Advisory Board to Provide Consideration on Which Riot Control Agents are Subject to Declaration Under the Chemical Weapons Convention" (SAB-25/WP.1, dated 25 March 2017); www.opcw.org/sites/default/files/documents/SAB/en/sab25wp01_e_.pdf. (b) "Response to the Director-General's Request to the Scientific Advisory Board to Provide Advice on New Types of Nerve Agents" (SAB-28/WP.1, dated 3 July 2018).

17 (a) "Report of the Scientific Advisory Board on Developments in Science and Technology" (RC-1/DG.2, dated 23 April 2003); www.opcw.org/sites/default/files/documents/CSP/RC-1/en/RC-1_DG.2-EN.pdf. (b) "Report of the Scientific Advisory Board on Developments in Science and Technology"(RC-2/DG.1, dated 28 February 2008); www.opcw.org/sites/default/files/documents/CSP/RC-2/en/RC-2_DG.1-EN.pdf. (c) "Report of the Scientific Advisory Board on Developments in Science and Technology for the Third Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention" (RC-3/DG.1, dated 29 October 2012); www.opcw.org/sites/default/files/documents/CSP/RC-

the OTP SAB expressed interest in OPCW SAB mechanisms for providing expertise and advice intersessionally, and in relation to new and emerging areas in science and technology. At the same time the OTP SAB will continue the important work of providing advice to the OTP on SOPs and aligning these with quality standards.

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

(a) The two boards, the SAB and OTP SAB have some differences: the SAB is comprised of experts working in their personal capacity, while the OTP SAB comprises representatives of forensic societies. Despite these differences, the two boards have commonalities, including the need to ensure there is effective science communication and literacy for the recipients of the advice. The TWG sees benefit from sharing experiences and best practices in providing scientific advice between the two boards.

(b) The TWG and the SAB have also found the interaction with the OTP SAB to be beneficial for identifying experts in, and gaining insights from, investigative science.[19] This interaction is in line with recommendations of the SAB on the engagement of technical experts across disciplinary boundaries.[20] Continued interaction between the two boards was thought worthwhile to augment forensic chemistry considerations.

Subitem 6(c): The Generic Integrated Forensic Toolbox for CBRN incidents (GIFT) - ChemTrace Consortium

6.8 Dr van Zalen informed the TWG that the Generic Integrated Forensic Toolbox for CBRN incidents (GIFT)[21]-ChemTrace Consortium had submitted a proposal on Horizon 2020 topic SU-FCT02-2019, subtopic 1 Trace Qualification.[22] The proposal seeks to develop an on-site system to identify and profile synthetic drugs, explosives and chemical warfare agents (CWAs), followed by relating samples of these chemicals to possible sources and/or synthesis routes. The method will rely on databases of chemical profiles developed in participating laboratories. Field measurements would be validated by comparisons to results from laboratory investigations. Additionally the GIFT-ChemTrace science, technology and

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3/en/rc3dg01_e_.pdf. (d) "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.

18 See paragraphs 9 to 11 of the Terms of Reference of the Scientific Advisory Board; www.opcw.org/sites/default/files/documents/SAB/en/SAB_ToR_RoP.pdf.

19 For previous interaction between the boards, see (a) paragraphs 11.7 to 11.8 of "Report of the Scientific Advisory Board at its Twenty-Fourth Session" (SAB-24/1, dated 28 October 2016); www.opcw.org/sites/default/files/documents/SAB/en/sab-24-01_e_.pdf. (b) See paragraph 11.5 to 11.9 of "Report of the Scientific Advisory Board at its Twenty-Sixth Session" (SAB-26/1, dated 20 October 2017); www.opcw.org/sites/default/files/documents/SAB/en/sab-26-01_e_.pdf. (c) See paragraphs 11.1 to 11.3 of the report of the Second Meeting of the TWG, cited in footnote 6.

20 See paragraph 333 of Annex 1 of RC-4/DG.1 (footnote 3(a)).

21 For previous discussions within the TWG on GIFT Forensics, see: paragraphs 8.16 to 8.18 of the report of the Third Meeting of the TWG, cited in footnote 2.

22 Horizon 2020 topic SU-FCT02-2019: Technologies to enhance the fight against crime and terrorism; https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/su-fct02-2018-2019-2020.

applications will be tested in exercises, and challenged in a mock trial so that courtroom admissibility of GIFT-ChemTrace results and conclusions can be assessed. The project would start in May 2020 with duration of 4 years for which € 7.1 million has been requested.

6.9 The GIFT-ChemTrace Consortium is coordinated by the University College Cork (Ireland) with the Netherlands Forensics Institute (NFI)[23] as co-coordinator. The consortium includes the OPCW Designated Laboratories of TNO,[24] FOI,[25] VERIFIN,[26] Spiez Laboratory[27] and Laboratory RMA-DLD.[28] The Fraunhofer Institute,[29] forensic institutes from Sweden, Ireland and the Netherlands, law enforcement agencies from Ireland, Northern Ireland, Belgium, the Netherlands and Finland, and national prosecutor offices from Belgium, the Netherlands and Ireland, are also involved.

7. AGENDA ITEM SEVEN – Updates from the OPCW Technical Secretariat

Subitem 7(a): Fact-Finding Mission (FFM)

7.1 The Head of the FFM[30] updated the TWG on developments that have occurred since April 2019.[31] The briefing began with a review of the FFM's mandate to identify whether or not a chemical has been used as a weapon, making use of all available information, but not to attribute use. A discussion of the structure and workflow of FFM missions followed.

7.2 As the FFM continues to work in non-permissive environments, its procedures are continually under review to ensure it can operate with the highest level of attention to proper documentation and handling of the information it collects. With regard to

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23 For further information on NFI, see: https://www.forensicinstitute.nl/.

24 For further information on TNO, see: https://www.tno.nl/en/.

25 For further information on FOI, see: https://www.foi.se/en/foi.html.

26 For further information on VERIFIN, see: https://www.helsinki.fi/en/verifin-finnish-institute-for-verification-of-the-chemical-weapons-convention.

27 For further information on Spiez Laboratory, see: https://www.labor-spiez.ch/en/lab/.

28 RMA-DLD = Royal Military Academy-Belgian Defence Laboratory.

29 For further information on the Fraunhofer Institute, see: https://www.fraunhofer.de/en.html.

30 For further information on the Fact-Finding Mission, see: www.opcw.org/fact-finding-mission.

31 "Update of the Activities Carried out by the OPCW Fact-Finding Mission in Syria" (S/1798/2019, dated 3 October 2019). For additional reports on OPCW mission in the Syrian Arab Republic since the Third Meeting of the TWG, see: (a) "Progress in The Elimination of The Syrian Chemical Weapons Programme" (EC-91/DG.2, dated 24 April 2019); www.opcw.org/sites/default/files/documents/2019/04/ec91dg02%28e%29.pdf. (b) "Progress in The Elimination of The Syrian Chemical Weapons Programme" (EC-91/DG.7, dated 24 May 2019); www.opcw.org/sites/default/files/documents/2019/05/ec91dg07%28e%29.pdf. (c) "Progress in The Elimination of The Syrian Chemical Weapons Programme" (EC-91/DG.14, dated 24 June 2019); www.opcw.org/sites/default/files/documents/2019/06/ec91dg14%28e%29.pdf. (d) "Progress in The Elimination of The Syrian Chemical Weapons Programme" (EC-92/DG.1, dated 24 July 2019); www.opcw.org/sites/default/files/documents/2019/07/ec92dg01%28e%29.pdf. (e) "Progress in The Elimination of The Syrian Chemical Weapons Programme" (EC-92/DG.6, dated 23 August 2019); www.opcw.org/sites/default/files/documents/2019/08/ec92dg06%28e%29.pdf. (f) "Progress in The Elimination of The Syrian Chemical Weapons Programme" (EC-92/DG.22, dated 24 September 2019); www.opcw.org/sites/default/files/documents/2019/09/ec92dg22%28e%29.pdf. (g) "Progress in The Elimination of The Syrian Chemical Weapons Programme" (EC-93/DG.1, dated 23 October 2019).

fieldable equipment, key capabilities include portability and chemical monitoring to provide information that ensures inspectors use appropriate safety equipment in their working environment (this includes monitors for a variety of toxic industrial chemicals, oxygen levels, volatile organic compounds and other indicators of hazardous air quality).

7.3 Engagement with laboratories is important for the FFM; often the types of samples and chemicals of interest fall outside the Convention's schedules and may require capabilities beyond those of some Designated Laboratories. As these analyses may not be pre-defined, knowing the capabilities of individual Designated Laboratories helps ensure OPCW inspection teams are better informed on which laboratories might be approached given a certain type of sample and analytical need.

7.4 The briefing concluded with updates on how the FFM is handling knowledge management, which included drawing on lessons learned from its five-year history, approaches to training of team members, and identifying external expertise that can be engaged to provide advice in areas outside the core chemical warfare agent expertise of the Secretariat when necessary.

7.5 In the subsequent discussion, the TWG recalled its previous considerations of a need to identify laboratories with expertise in forensic analysis,[32] with which arrangements could be put in place to provide access to analysis capabilities outside the scope of Designated Laboratories. This consideration would also usefully apply to other analysis needs outside the capabilities of the Designated Laboratories.

Subitem 7(b): OPCW Laboratory

7.6 The Head of the OPCW Laboratory provided updates on completed and upcoming environmental[33] and biomedical Proficiency Tests,[34] the status of the Designated Laboratories,[35] biotoxin exercises[36] and the OPCW Central Analytical Database (OCAD).[37] A new development is the approval to add high resolution-mass spectral (HRMS) data to the OCAD. However, at this time such information will only be used for off-site analysis.

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32 See paragraph 1.6 of the report of the report of the Second Meeting of the TWG, cited in footnote 5.

33 (a) "Call for Nominations for the Forty-sixth Official OPCW Proficiency Test" (S/1777/2019, dated 25 July 2019): www.opcw.org/sites/default/files/documents/2019/07/s-1777-2019%28e%29.pdf. (b) "Evaluation of the Results of the Forty-Fifth Official OPCW Proficiency Test" (S/1778/2019, dated 25 July 2019); www.opcw.org/sites/default/files/documents/2019/07/s-1778-2019%28e%29.pdf.

34 "Evaluation of the Results of the Fourth Official OPCW Biomedical Proficiency Test" (S/1776/2019, dated 24 July 2019); www.opcw.org/sites/default/files/documents/2019/07/s-1776-2019%28e%29.pdf.

35 (a) "Status of Designated Laboratories for the Analysis of Authentic Biomedical Samples" (S/1779/2019, dated 26 July 2019); www.opcw.org/sites/default/files/documents/2019/07/s-1779-2019%28e%29.pdf. (b) "Status of Laboratories Designated for the Analysis of Authentic Environmental Samples" (S/1775/2019, dated 23 July 2019): www.opcw.org/sites/default/files/documents/2019/07/s-1775-2019%28e%29.pdf.

36 "Call for Nominations for the Fourth Exercise on the Analysis of Biotoxins" (S/1780/2019, dated 29 July 2019); www.opcw.org/sites/default/files/documents/2019/07/s-1780-2019%28e%29.pdf.

37 (a) "Report of the Forty-Ninth Meeting of the Validation Group for the Updating of the OPCW Central Analytical Database, 17-18 September 2019" (S/1803/2019, dated 14 October 2019); www.opcw.org/sites/default/files/documents/2019/10/s-1803-2019%28e%29.pdf. (b) "Decision: Lists of Newly Validated Data on Scheduled Chemicals for Inclusion in the OPCW Central Analytical

7.7 Regarding the proficiency tests, recent approaches to providing more challenging tests, by including optional trace analysis samples were discussed. He noted that not all laboratories choose to run such samples. In the biomedical proficiency tests, Mr Goury noted the increasing use of HRMS in reporting.

7.8 For protein based biotoxins (e.g. ricin and abrin), it was noted that some laboratories perform biological activity assays, while others do not, as such testing may not be part of the capability of some chemistry laboratories. The TWG was also updated on the upcoming biotoxin exercise that will include saxitoxin.[36] The SAB had previously advised that saxitoxin could be detected using the methods developed for environmental samples.[38] Differences in capability for high molecular weight protein toxins and small molecule toxins are further discussed in this meeting report in paragraphs 10.11 to 10.19.

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

(a) Adding additional Proficiency Tests and asking the Designated Laboratories to consider analysis of challenging optional samples (e.g. trace analysis) places a burden on the resources of some laboratories for what might be seen as a limited benefit. It was suggested that the Secretariat might consider incentives that would encourage laboratories to take on such extra work if these challenging samples are deemed valuable for collection of information and further method development.

(b) Optional samples for chemical forensics analysis were also discussed, with similar concerns to those noted in sub-paragraph 7.9(a), on available resources for proficiency testing being expressed.

Subitem 7(c): Equipment procurement and evaluation

7.10 Mr Tamas Elas (OPCW Inspectorate) briefed the TWG on the procurement and evaluation process at OPCW. The presentation focused on the current capability development framework and applicable procurement and evaluation process in place within the Inspectorate Division. This framework has been developed and adapted to meet specific requirements for the Inspectorate Division, but it is a cross-divisional process. While the current process is sufficient to meet operational requirements, there are growing challenges in the field of manpower and sustainability. Maintaining technical awareness and continued access to new developments and relevant research

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Database" (EC-91/DEC.2, dated 11 July 2019): www.opcw.org/sites/default/files/documents/2019/07/ec91dec02%28e%29.pdf. (c) "Note by the Director-General: Lists of Newly Validated Data on Scheduled Chemicals for Approval by the Executive Council for Inclusion in the OPCW Central Analytical Database" (EC-91/DG.5, dated 22 May 2019): www.opcw.org/sites/default/files/documents/2019/05/ec91dg05%28e%29.pdf. (d) "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-91/DEC.1, dated 11 July 2019): www.opcw.org/sites/default/files/documents/2019/07/ec91dec01%28e%29.pdf. (e) "Note by the Director-General: Lists of Newly Validated Data on Non-Scheduled Chemicals Relevant to the Chemical Weapons Convention for Approval by the Executive Council for Inclusion in the OPCW Central Analytical Database" (EC-91/DG.6, dated 22 May 2019): www.opcw.org/sites/default/files/documents/2019/05/ec91dg06%28e%29.pdf.

38 "Saxitoxin Fact Sheet" (SAB-21/WP.4, dated 28 February 2014); www.opcw.org/sites/default/files/documents/SAB/en/sab-21-wp04_e_.pdf.

programmes for Inspectorate personnel is essential to maximise efficiency. Additionally, implementation of multi-year funding modalities for technical development projects would help to improve the Inspectorate's capability development process.

7.11 Mr Elas noted that equipment used in non-routine missions has greater flexibility than approved equipment for routine operations.[39] However, permissions to use non-approved equipment in a non-routine mission are often determined on a case by case basis.

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

(a) Communication of need is critical. In this regard, the OPCW equipment store regularly hosts groups of diplomats to have a chance to view and interact with inspector equipment. Likewise in the approval process for new equipment, National Authorities are invited to familiarise themselves with the newly procured items of approved equipment.[40]

(b) In kind contributions from States Parties have provided equipment for non-routine missions. The TWG, drawing on experiences of the International Atomic Energy Agency (IAEA),[41] has previously identified this as a potentially useful approach to gain access to new equipment, and noted the value in formalising such a mechanism for capability enhancement.[42]

(c) Given the diversity of analysis needs that are plausible in non-routine operations, where high-end capabilities are required on an infrequent basis, consideration could be given to accessing those capabilities through Service Level Agreements (SLA). This could include capabilities for 3D scanning and mapping. In this way the technology can be kept at state-of-the-art levels and the skill sets required for specialist capabilities kept current. Consideration should be given to a mechanism for enabling the TS to negotiate an SLA. The quality standard or accreditation required for the capability should be specified in the SLA.

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39 (a) "Decision: List of Approved Inspection Equipment with Operational Requirements and Technical Specifications" (C-I/DEC.71, dated 30 November 2010); www.opcw.org/sites/default/files/documents/CSP/C-I/en/cidec71__en.pdf. (b) "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.

40 See for example: (a) "Invitation to National Authorities of States Parties to Familiarise Themselves with The Newly Procured Items of Approved Equipment" (S/1787/2019, dated 26 August 2019); www.opcw.org/sites/default/files/documents/2019/08/s-1787-2019%28e%29.pdf. (b) "Invitation to National Authorities of States Parties to Familiarise Themselves with The Newly Procured Items of Approved Equipment" (S/1747/2019, dated 2 May 2019).

41 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.

42 See (a) sub-paragraph 9.19(c) and paragraph 14.18 of the report of the Third Meeting of the TWG, cited in footnote 2; and, (b) paragraph 15.4(d) of "Report of the Scientific Advisory Board at its Twenty-Eighth Session" (SAB-28/1, dated 14 of June 2019); www.opcw.org/sites/default/files/documents/2019/09/sab-28-01%28e%29_0.pdf.

8. AGENDA ITEM EIGHT – Response and assistance

Subitem 8(a): EDA BFREE project: sample handling of CBRN mixed samples

8.1 Dr Marcel van der Schans (TNO, the Netherlands) briefed the TWG on European Defence Agency (EDA)[43] project "Biological Agent Free (abbreviated to BFREE): Safe handling and preparation of CBRN mixed samples: biological challenges and solutions",[44,45] which ran from 2013 to 2015. The project developed methods for receiving and handling samples, beginning with screening to determine if it contained chemical (C), biological (B), radiological (R) and/or nuclear materials (N), so that incompatible materials could be removed for handling the sample in a specific type of laboratory. Dr van der Schans explained that for a C laboratory, there should be no B and/or RN; for a biological laboratory there should be no C and/or RN; and for an RN laboratory there should be no B and/or C.

8.2 Dr van der Schans described how best practices and protocols were identified, evaluated and tested. He reviewed the workflows developed and presented results from inter-laboratory exercises conducted under the project. The main focus was developing ways to remove B from samples containing chemical agents without compromising the ability to analyse the chemicals. For RN contaminated samples, he noted that it would only be possible to dilute the radioactivity levels, not entirely remove the contamination. Of the methods evaluated to render samples free from B agents, the most effective methods (using basic laboratory apparatus available in their labs) were found to be filtration and UV irradiation. Chemical inactivation using ethyl acetate extraction was also found to be effective in removing B, and can be considered if followed by GC/MS analysis.

8.3 While the methods developed and evaluated are useful for the safety of those working with known or suspected CBRN samples, the procedures can produce chemical changes in the samples (oxidation for example after UV exposure of sulfur mustard related chemicals). This would preclude these methods from being used in forensic analysis.

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

(a) BFREE methods were designed for laboratories with readily available equipment and in the field and did not consider some effective inactivation techniques. Objectives were safe handling of materials and hazard identification in the field, rather than forensic analysis.

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43 For further information, see: https://www.eda.europa.eu/.

44 "BFREE. Safe handling and preparation of CBRN mixed samples: Biological challenges and solutions". M. Bentahir; presentation from 12th CoU Meeting, Brussels, December 2018; https://www.securityresearch-cou.eu/sites/default/files/10.%20Mostafa%20Bentahir.pdf.

45 (a) "Non-contact, real-time laser-induced fluorescence detection and monitoring of microbial contaminants on solid surfaces before, during and after Decontamination". S. Babichenko, J. L. Gala, M. Bentahir, A. S. Piette, L. Poryvkina, O. Rebane, B. Smits, I. Sobolev, N. Soboleva; *J. Biosens Bioelectron*,; 2018, *9*, 255. DOI: 10.4172/2155-6210.1000255. (b) "Rapid and efficient filtration-based procedure for separation and safe analysis of CBRN mixed samples" M. Bentahir, F. Laduron, L. Irenge, J. Ambroise, J.-L. Gala J-L.; *PLoS ONE*; 2014, *9(2)*: e88055. DOI: 10.1371/journal.pone.0088055.

(b) From a safety perspective, the BFREE procedure began with a screen for C in a B laboratory to ensure that if any B is present, the agent is contained. It was noted however that some B laboratories would never accept C and/or RN contamination within the laboratory.

Subitem 8(b): TOXI-triage

8.5 Professor Paula Vanninen provided an overview of the TOXI-triage project[46] funded by the European Union's Seventh Framework Programme (for research, technological development and demonstration) (under grant agreement no 653409). The aim of the project was to create tools for detection, traceability, triage and individual monitoring of victims. The main objectives were accelerated delivery of situational awareness, command and control with secure, dynamic, and seamless communication; traceable point-of-care diagnostic tests with an integrated casualty tracking and comprehensive field toolbox for CBRN threats for end users.

8.6 Professor Vanninen discussed the VERIFIN's role in the project, which included evaluation and verification of stand-off, and environmental contamination monitoring methods for C and R/N detection and identification using live agents.[47] Data collected by the detectors were linked via an integrator developed by ATOS so that they could be available in real time to a Command and Control Centre (CCC). The toolbox developed at VERIFIN includes a database of CBRN agent detection and monitoring (including information from manuals and guidelines for devices); CBRN agent protection including cordon, personal protective equipment (PPE) and decontamination; triage of CBRN agent casualties including symptom and treatment guidelines, and ethical aspects (symptom and treatment guidelines). The database can be searched against observed criteria (for example colour and physical state of materials found at the scene). Additionally, the CBRN end-user Toolbox is rich in training materials providing training videos that include the donning of PPE. Information is made easily available to the CCC via the integrator in the field exercises.

8.7 A Social media connector, Toxi-Motive, has been developed at Loughborough University for capturing situational awareness information around CBRN events.[48] It

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46 For further information, see: http://toxi-triage.eu/.

47 Technologies developed for this purpose included miniturised IMS systems, UAV mounted hyperspectral imaging systems and UAV mounted radiation detectors. For additional information, see: (a) "Miniaturized high-performance drift tube ion mobility spectrometer". A. Ahrens, M. Hitzemann, S. Zimmermann; *Int. J. Ion Mobil. Spec.*; 2019, 1-7. DOI: 10.1007/s12127-019-00248-w. (c) "Sprayed liquid-gas extraction in combination with ion mobility spectrometry: a novel approach for the fast determination of semi-volatile compounds in air and from contaminated surfaces". M. Zarejousheghani, M. Cämmerer, T. Mayer, A. Walte, H. Borsdorf; *Int. J. Ion Mob. Spec.*; 2018, *21(1-2)*, 33-41. DOI: 10.1007/s12127-018-0230-6. (d) "Overview on TOXI-Triage Field Training eXercise DISPERSE", Environics news item, 30 May 2019; https://www.environics.fi/overview-on-toxi-triage-field-training-exercise-disperse/. (e) "New portable Finnish technology detects chemical warfare agents safely", University of Jyväskylä news item, 19 October 2018; https://www.jyu.fi/en/current/archive/2018/10/new-portable-finnish-technology-detects-chemical-warfare-agents-safely-1. (f) RanidFly - Drone mounted gamma radiation detector and identifier; http://toxi-triage.eu/sites/default/files/toxi/public/content-files/deliverables/Technology%20Catalogue%20D4.2%20RanidFly%20EOY.pdf.

48 For further information, see: (a) "D5.4 Integration of Social Media Data"; http://toxi-triage.eu/sites/default/files/toxi/public/content-

provides early-detection and emotional analysis, including classifying of Twitter posts ("Tweets") using a unique defined CBRN Ontology, to ascertain if an event falls under CBR or N.

8.8 Detectors and triage screening of human exposure to CBRN agents using breath analysis were tested in two field exercises in Athens, Greece (2018)[49] and Mikkeli, Finland (2019).[50] Tools for breath analysis and multi-dimensional analysis of metabolic vapours from humans based on gas chromatography-ion mobility spectrometry were demonstrated that can provide fast, on-site, ultra-high sensitivity analysis of breath samples.[51] From sampling to result required 40 seconds, with data linked via integrator to the CCC to allow constant updates to improve situational awareness.

8.9 Verification methods for pesticides from samples of patients and an in-vitro platform to study metabolism of toxic chemicals using (human) liver cell homogenates have also been developed. A database of biomarkers was also built and includes a structure search function for CWAs and toxic pesticides.

8.10 The final workshop on the Toxi-Triage project was held on 5 September in Brussels.[52] Professor Vanninen and several members of the Secretariat attended.

Subitem 8(b): Traceability during mass-casualty incidents

8.11 Mr Gert Wijnalda and Mr Florian Käding (Prometech B.V.[53]) provided a demonstration of the Prometech Tag & Trace system.[54] The system is intended to help increase survival rates in victims of a CBRN incident, mitigate capacity and logistical constraints for responders, safeguard chain-of-custody of people (patients) and materials, and provide pertinent information in a timely manner. Development of the system was focused on improvement of situational awareness, efficiency of response, flow of information and logging as much information as possible.

8.12 This system enables a smart and cost-effective capability to share and structure information about casualties, samples and personnel in large-scale incidents. Registration and tracking of persons and objects can be handled through a streamlined IT workflow using affordable and robust identification tags (slap-on wrist bands). The system employs near field communication (NFC) technology, a dedicated tagger device and a smartphone app (that can read and write to the device) to help track victims and items throughout the response and care chain, from the field (scene of incident) through to its multiple possible endings (which could include hospitals,

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files/deliverables/D5.4%20Social%20media%20data%20for%20crisis%20management%20operations.pdf. (b) Toxi-Motive; https://www.lboro.ac.uk/news-events/toxi-triage/toxi-motive/.

49 "Putting the TOXI-Triage technologies to the test: Athens 2018", Loughborough University; https://www.lboro.ac.uk/news-events/toxi-triage/athens-2018/.

50 "TOXI-triage - DISPERSE exercise", Loughborough University; http://toxi-triage.eu/content/toxi-triage-disperse-exercise.

51 See for example, G.A.S. BreathSpec®; http://toxi-triage.eu/sites/default/files/toxi/public/content-files/deliverables/Technology%20Catalogue%20D4.4%20BreathSpec_GAS_0.pdf.

52 For further information, see: http://toxi-triage.eu/content/workshop-cbrn-detection-methods-and-procedures.

53 For further information, see: https://www.prometech.eu/.

54 For further information, see: https://www.prometech.eu/products/tag-trace/.

laboratories as well as morgues). The data stored in the device is important for situations where wireless networks may go offline during an incident. The data can be used for assessment of response by tracking timing of processes, efficiency of decontamination (based on those who need repeated decontamination procedures).

8.13 The system is multi-use with functions across the Toxi-Triage ecosystem, allowing CBRN casualty tracking, environmental and patient tracking, cordon and perimeter control, and critical equipment tracking. Tag and Trace was deployed for the critical steps in the casualty journey during both TOXI-Triage field trials.[49,50]

8.14 In the subsequent discussion, questions were raised about how such a system might be adopted given data privacy regulations and concerns. It was noted that the data collected by Tag and Trace is not associated with any names or biometric information.

9. AGENDA ITEM NINE – Distributed Ledger Technologies (DLT): information transfer, provenance and digital forensics

Subitem 9(a): Distributed Ledger Technologies and provenance

9.1 Mr Yue Jin Tay (guest speaker, Circulor[55]) briefed the TWG on the application of distributed ledger technology (DLT, "blockchain technology") approaches to provenance. Mr Tay used the example of the production of minerals such as cobalt for the manufacture of lithium-ion batteries as having potential adverse social and environmental impacts, which has led to increasing legislative and consumer demand for greater transparency in the provenance of raw materials. This demand has prompted a need for more innovative and effective solutions to prove that materials used throughout the supply chains (which may involve a large number of transformations for the materials and owners across the life-cycle) have been responsibly sourced.

9.2 Mr Tay provided an overview on how DLT can be used to create an immutable chain-of-custody record that potentially sets a new standard for verified responsible sourcing. Manufacturer traceability involves creating a reliable digital twin at the source, the use of artificial intelligence (AI) to detect suspect activity, coding the chemistry to track through industrial processes and enforcing responsible supply chain standards. Mr Tay described solutions that are based on mapped supply chains, tagging and tracking the commodity itself, connecting input material to output product at each step, integrating information with open source intelligence data, and AI for anomaly detection. Circulor's system allows permissioned as well as public systems.

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

(a) In complex supply chains with a multitude of parties, having a third party DLT system that is not owned by any one party in the supply chain is seen as being valuable to ensure transparency.

(b) A number of DLT platforms are now commercially available which can be configured to accommodate a desired use case. The approach might be

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[55] For further information, see: https://www.circulor.com/.

interesting for establishing a digital supply chain of scheduled chemicals using an independent, decentralised, permissioned and private DLT platform.

Subitem 9(b): Digital tracking of chain-of-custody

9.4 Mr Scott McKenzie (guest speaker, SensaData Pty Ltd[56]) described a Next-Gen Full-Stack Internet of Things (IoT) solution[57] that enables the delivery of valuable intelligence from asset-condition sensing and having potential applications across a diversity of industrial sectors. The device was originally developed for deployment in food supply chains with reusable devices that function from production source to end-use. The devices feature edge-processing for optimised, real-time information delivery capture, allowing key parameters across multiple data streams relevant to the sensitive assets to be collected at each stage along a supply chain.

9.5 The SensaData device features a proprietary multi-function microchip and wireless communication. The device is built with flexible system features and industry-standard security and data protocols that provide the potential for augmentation to address specific secure application requirements. The device is intended to deliver a proprietary digital chain-of-custody, and can be combined with third-party systems including DLTs. The value is the data and enabling predictive management. However, as more and more sensors collect more and more data the value of the data can decrease because most of it is not relevant or used for decision making. The information collected would also have applications for monitoring and verifying chain of custody.[58]

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

(a) These systems are valuable for tracking chain-of-custody and monitoring integrity of samples (following in real time temperature and other conditions to which a sample is exposed).

(b) The SensaData system is an example of how IoT devices can complement the digital tracking of chain-of-custody using intelligent sensors capturing valuable data, such as GPS position, temperature and humidity conditions of the containers. The combination of IoT devices and digital chain-of-custody tracking have potential applications for chemical safety and security, as they enable dangerous goods shipments to be tracked, with simultaneous monitoring of shipping conditions that provide real time information and alerts on the integrity of the package. This has potential for detecting the tampering of packages in real-time.

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56 For further information, see: www.sensadata.net.

57 For further information, see: https://www.f6s.com/sensadata-smart-r-tag/about.

58 The United States National Institute of Standards and Technology defines “chain of custody” as: “A process that tracks the movement of evidence through its collection, safeguarding, and analysis lifecycle by documenting each person who handled the evidence, the date/time it was collected or transferred, and the purpose for the transfer”. See: https://csrc.nist.gov/glossary/term/chain-of-custody.

10. AGENDA ITEM TEN – (Bio)Chemical Analysis

Subitem 10(a): What is that smell? Detection of toxic industrial chemicals

10.1 Ms Hoe-Chee Chua (OPCW SAB) provided the TWG with perspectives on toxic industrial chemicals (TICs). While TICs might not be as toxic as CWAs, these chemicals pose a threat due to widespread use and availability. Industrial plants that store large quantities of TICs pose risks for accidental release as well as deliberate acts. Ms Chua discussed some of the guidelines that have been developed to determine the level of toxicity of TICs to inform planning and emergency response.[59]

10.2 For cities surrounded by industrial chemical facilities, it is not uncommon to hear reports of "chemical" smells in the air. The typical approach for early warning of industrial leakage is by fence-line monitoring with fixed-site point sensors or open path detection systems. While chemical detection technologies have been constantly advancing, there is still a gap in detection of TICs not in the databases of the monitoring systems. This lack of generic sampling techniques (manual or automated) does not allow efficient source tracing or provide useful chemical forensic information related to an event involving the release of TICs.

10.3 Ms Chua reviewed the types of detection systems commonly employed[60] and noted research areas that could be beneficial to addressing these issues. She pointed out the need for addressing approaches to identifying unknown substances (that might not be in a given database, e.g. "unknown unknowns"), the lack of generic sampling techniques or kits, the multi-disciplinary skill sets and long analysis times required for source tracing, and the difficulty in defining toxicity in incidents involving multiple TICs.

10.4 In the subsequent discussion, the TWG recognised a pressing need to have the capability to preserve detected TICs for further analysis (in particular, forensic analysis) by investigating bodies.

Subitem 10(b): Analysis of chlorohydrins of phospholipids as chlorine biomarkers in biomedical samples of exposed animal models

10.5 Dr Crister Åstot presented work on the identification of potential biomarkers for chlorine exposure. Chlorohydrins of phospholipids have been identified as potential biomarkers for chlorine exposure in bronchoalveolar lavage fluid (BALF) of chlorine gas-exposed mice.[61] The markers are chlorination products of unsaturated pulmonary surfactant phospholipids (e.g. phosphatidylglycerols and phosphatidylcholines). The

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59 See for example: (a) "Toxic Industrial Chemicals (TICs) Guide", United States Department of Labor, Occupational health and Safety Administration; https://www.osha.gov/SLTC/emergencypreparedness/guides/chemical.html. (b) "Toxic industrial chemicals and chemical weapons: exposure, identification, and management by syndrome". A. J. Tomassoni, R. N. French, F. G. Walter; *Emerg. Med. Clin. North Am.*; 2015, *33(1)*, 13-36. DOI: 10.1016/j.emc.2014.09.004.

60 A compendium of information on available detectors can be found in the MRIGlobal CBRNE Tech Index, http://www.cbrnetechindex.com/.

61 "*l*-α-Phosphatidylglycerol chlorohydrins as potential biomarkers for chlorine gas exposure". P. Hemström, A. Larsson, L. Elfsmark, C. Åstot; *Anal. Chem.*; 2016, *88(20)*, 9972-9979. DOI: 10.1021/acs.analchem.6b01896.

analytical detection limit was improved through chemical derivatisation of these biomarkers, prior to nano-LC-MS/MS analysis. Using the improved analytical method, the biomarkers were detected in blood serum samples from exposed animals. The method has the potential for future use to verify human exposure to chlorine. Detection of chlorinated lipids in blood serum samples offers advantages over methods based on lung fluid sampling. In contrast to the latter, blood serum is a common biomedical sample in medical diagnostics, not requiring advanced medical equipment to be sampled.

10.6 Dr Åstot concluded with a short discussion on potential chlorine exposure markers,[62] which include lipids of lung surfactant (not linked to inflammatory lung disease), chlorinated tyrosines (which can also be produced by inflammation),[63] and 2-chlorostearic acid produced from chlorination of plasmalogen lipids[64] (which can also occur as a result of neutrophilic inflammation and acute respiratory distress syndrome).

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

(a) Low background levels of the chlorinated biomarkers occur as a result of inflammatory or other biological processes in the body. In biomedical samples expressing an endogenous low level background, the biomarkers are still valuable and should be seen as a result of chlorine exposure when levels are significantly elevated compared to baseline levels.[63]

(b) For purposes of providing immediate information that would trigger medical response in the field, the confirmation of a single unique marker is not always necessary. A test method that provides an indication of exposure might have a readout resulting from aggregate signal of a variety of exposure related markers and/or symptomatic observations.

(c) Exploration of whether similar biomarkers form after exposure to other types of chlorinating agents would be useful.

Subitem 10(c): Application of chemoinformatics to reduce GC/MS false positive identifications during sampling and analysis missions

10.8 Albert Kireev (OPCW Inspectorate) briefed the TWG on the application of chemoinformatics to reduce gas chromatography/mass spectrometry (GC/MS) false positives in on-site sampling and analysis. On-site sampling and analysis missions seek to verify the absence of undeclared scheduled chemicals, in-particular

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62 Additional information on biomarkers of chlorine exposure can be found in a recent review article: “Toxic effects of chlorine gas and potential treatments: a literature review”. S. Achanta, S.-E. Jordt; *Tox. Mech. Meth.*; DOI: 10.1080/15376516.2019.1669244.

63 “Simultaneous measurement of 3-chlorotyrosine and 3,5-dichlorotyrosine in whole blood, serum, and plasma by isotope dilution HPLC-MS/MS”. B. S. Crow, J. Quiñones-González, B. G. Pantazides, J. W. Perez, W. Rucks Winkeljohn, J. W. Garton, J. D. Thomas, T. A. Blake, R. C. Johnson; *J. Anal. Tox.*; 2016, *40(4)*, 264–271. DOI: 10.1093/jat/bkw011.

64 “Formation of chlorinated lipids post-chlorine gas exposure”. D. A. Ford, J. Honavar, C. J. A., M. A. Duerr, J. Y. Oh, S. Doran, S. Matalon, R. P. Patel; *J. Lipid Res.*; 2016, *57(8)*: 1529–1540. DOI: 10.1194/jlr.M069005.

Schedule 1 chemicals. The briefing provided examples of how machine learning,[65] using methods—such as classification and multiple linear regression—can resolve false-positive results; proof-of-concept results were presented in this regard. The project he presented builds on previous work in the OPCW Inspectorate to ensure that the results of a sampling and analysis mission are unambiguous.[66]

10.9 When trained and cross-validated using OCAD mass-spectral data, "Decision Tree" and "k-Nearest Neighbours" classification algorithms demonstrated the highest percentage of correct classifications for a number of test sets of scheduled chemicals. This approach allowed identification of the entire class of chemicals in each set, complementing sorted results from a NIST/AMDIS library search.[67] In addition, using an Excel Pivot Table, a dashboard was created on the basis of existing OCAD mass-spectra that includes specific ions previously revealed from fragmentation patterns"; this can be made available on inspection laptops for on-site use. Multiple linear regression was used to calculate retention indices (RI) using one-dimensional molecular descriptors for subsets of *O*-alkyl *S*-2-dialkyl-aminoethyl alkylphosphonothiolates (Schedule 1A.03 chemicals). Selected descriptors count CH_3-, -CH_2-, >CH- and >C< fragments and cycles in the *O*-alkyl group. The linear equations are easy to use and interpret. The results obtained by the Inspectorate demonstrated how a combination of library searching and classification of mass-spectra with RI predictions can increase confidence in identification.

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

(a) The cheminformatics approach described in the briefing would be applicable and useful not only during missions with sampling and analysis, but also for laboratories participating in proficiency testing to identify scheduled chemicals and their degradation products, particularly to calculate RIs for unknown chemicals without library data.

(b) In order to increase the validity of the method, training machine learning algorithms with the OCAD library as well as the NIST Mass Spectral (MS) library would be useful. For this purpose permission to export data in algorithm readable forms (such as .csv) should be pursued. Recent reports of machine learning to predict gas chromatography RIs have used data from NIST,[68] suggesting such permissions can be obtained.

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65 (a) "Machine learning in chemoinformatics and drug discovery". Y. Lo, S. E. Rensi, W. Torng, R. B. Altman: *Drug Discovery Today*; 2018, *23(8)*, 1538-1546. DOI: 10.1016/j.drudis.2018.05.010. (b) *Data Mining: Practical Machine Learning Tools and Techniques*, I. H. Wittne, M. A. Hall, C. J. Pal, Elsevier, 2016. ISBN: 9780128043578.

66 See paragraphs 9.1 to 9.3 of "Report of the Scientific Advisory Board at its Twenty-Sixth Session" (SAB-26/1, dated 2 October 2017); www.opcw.org/sites/default/files/documents/SAB/en/sab-26-01_e_.pdf.

67 National Institute of Standards and Technology/Automated Mass spectral Deconvolution and Identification System; https://chemdata.nist.gov/dokuwiki/doku.php?id=chemdata:amdis.

68 A deep convolutional neural network for the estimation of gas chromatographic retention indices, A. D. D. Matyushin, A. Y. Sholokhova, A. K. Buryak; *J. Chrom. A*; 2019. DOI: 10.1016/j.chroma.2019.460395.

Subitem 10(d): 1) Short report on 5th Swiss UNSGM Designated Laboratory meeting project and 2) RefBio "Germany's contribution to strengthen the reference laboratories Bio in the UNSGM"

10.11 Dr Brigitte Dorner reported on discussions at a recent United Nations Secretary General's Mechanism (UNSGM[69]) Designated Laboratories Meeting in Spiez, Switzerland held from 12 to 13 Sept 2019.[70] The meeting was the fifth in a series of annual meetings supporting the development of a framework for UNSGM investigations on the alleged use of chemical, biological or toxin weapons.[71] During the meeting in Spiez, several activities under the UNSGM umbrella and related European Union (EU) projects were presented.

10.12 A challenge in the case of potential use of biological weapons is that there is no single international organisation which would oversee an investigation. This leaves a number of unresolved technical questions. These being: (1) defining how "roster" laboratories would be qualified to support of an investigation; and, (2) identifying which methods should be used for biological agents to obtain unambiguous results that hold up to technical as well as political scrutiny.

10.13 Dr Dorner introduced the TWG to RefBio (Germany's Contribution to Strengthen the Reference Laboratories Bio in the UNSGM).[72] This project, funded by the German Federal Foreign Office (from August 2017 to December 2020), has established three working groups focusing separately on bacteria, viruses or toxins to gain a better understanding on the role of reference/roster laboratories for the UNSGM. By providing proficiency tests for the three groups of biological agents, it offers the opportunity for self-evaluation of laboratories and helps to define technical requirements for identifying biological agents, including quantitation, activity and viability measurements, reporting, and chain-of-custody. In the medium term, the project is expected to develop a group of qualified UNSGM bioanalytical laboratories with known capabilities and specialisation. The project will also identify best practices for detection of bacteria, viruses and toxins and provide recommendations on the involvement of laboratories to the UNSGM.

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69 Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons; https://www.un.org/disarmament/wmd/secretary-general-mechanism/.

70 Fifth Swiss UNSGM Designated Laboratories Workshop; https://www.labor-spiez.ch/pdf/en/rue/Factsheet%E2%80%93Fifth_UNSGM_Designated_Laboratories_Workshop_2019.pdf.

71 For further information on the Swiss UNSGM Designated Laboratories Workshop series, see: https://www.labor-spiez.ch/en/rue/uno/index.htm. Reports of the previous workshops in the series: (a) UNSGM Designated Laboratories 4th Workshop Report, Spiez Laboratory, 2018; https://www.labor-spiez.ch/pdf/en/rue/UNSGM_Designates_Laboratories_4th_workshop_Report.pdf. (b) UNSGM Designated Laboratories 3rd Workshop Report, Spiez Laboratory, 2017; https://www.labor-spiez.ch/pdf/en/rue/UNSGM_2017_FINAL_Report.pdf. (c) UNSGM Designated Laboratories 2nd Workshop Report, Spiez Laboratory, 2016; https://www.labor-spiez.ch/pdf/en/rue/UNSGM_Def_Report_2016.pdf. (d) UNSGM Designated Laboratories 1st Workshop Report, Spiez Laboratory, 2015; https://www.labor-spiez.ch/pdf/en/rue/UNSGM_Def_Report_2015.pdf.

72 RefBio: German Contribution to Strengthen the Reference Laboratories Bio in the UNSGM; https://www.rki.de/EN/Content/Institute/International/Biological_Security/RefBio.html.

10.14 Dr Dorner continued her briefing with an update on EuroBioTox (European programme for the establishment of validated procedures for the detection and identification of biological toxins).[73] EuroBioTox focuses on quality assurance measures for detection and identification of biological toxins such as ricin, abrin, botulinum neurotoxins, staphylococcal enterotoxins and saxitoxin.[74] The project joins 61 laboratories from 23 countries in evaluating and refining measurement procedures for these specific toxins. The project will provide a comprehensive mechanism to increase quality assurance in the field by producing certified reference materials (of five different toxins), coordinating proficiency tests on the different toxins (11 proficiency tests on laboratory-based and on-site detection) and providing a repository of tools (e.g. antibodies, toxin subtypes) as well as training courses on, technologies and toxins (19 different training courses).

10.15 With respect to biological toxins there is a challenge that affects both OPCW Designated Laboratory and UNSGM Bio Reference Laboratory activities owing to the fact that toxins sit at the interface of biological and chemical substances and are covered under the general purpose criteria of both the Chemical and the Biological Weapons Conventions, and an investigation of an alleged use of a toxin as a weapon could potentially be requested under mechanisms within the OPCW or the UNSGM.

10.16 Toxins are produced by living organisms, but they exist as discrete molecular structures; they are chemicals and do not replicate like pathogens. Many of the high-molecular weight biological toxins (HMW toxins) act as efficient enzymes targeting different molecular pathways in the cell, thus amplifying their toxicity – which from a technical perspective could be viewed as "chemical action on life processes". Some of the HMW toxins are considered to be the most toxic substances known (e.g. botulinum toxins, tetanus toxin, shiga toxins).[75,76] Dr Dorner explained that the detection of HMW toxins requires very different technologies, tools, instrumentation and expertise compared to that of low-molecular weight toxins (LMW toxins, such as saxitoxin). The low-molecular weight toxins are amenable to classic chemical analytical methods, such as mass spectrometry, while analysis of ricin and other HMW toxins involve methods more characteristic of laboratories that carry out biological analyses. For forensic purposes, analysis of ricin must demonstrate both chemical composition, structure and biological activity.

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73 EuroBioTox: European programme for the establishment of validated procedures for the detection and identification of biological toxins; https://www.eurobiotox.eu//. See also, periodic reporting for EuroBioTox period 1: https://cordis.europa.eu/project/rcn/209945/reporting/de.

74 "Challenges in the Development of Reference Materials for Protein Toxins". R. Zeleny, A. Rummel, D. Jansson, B. D. Dorner, in E. Merkley E (ed.), *Case Studies in Forensic Proteomics*; American Chemical Society, Washington DC, USA, 2019; *accepted manuscript*; https://edoc.rki.de/handle/176904/6290.

75 "Biological toxins of potential bioterrorism risk: Current status of detection and identification technology". B. G. Dorner, R. Zeleny, K. Harju, J A. Hennekinne, P. Vanninen, H. Schimmel, A. Rummel; *Trends in Anal. Chem.*; 2016, *85*, 89-102. DOI: 10.1016/j.trac.2016.05.024.

76 Biological toxins and their relative toxicity (Infographic), Organisation for the Prohibition of Chemical Weapons; www.opcw.org/sites/default/files/documents/Science_Technology/Biological_Toxins_and_their_Relative_Toxicity_.pdf.

10.17 Few laboratories are skilled in both HMW and LMW toxin analysis (and given the diversity of molecules within both classes, specialisation on specific groups of toxins would further separate laboratory capability). In particular, the OPCW laboratory and the Designated Laboratories, while expert in classic chemical analysis and potentially experienced in ricin analysis, may not be equipped for the specialised analysis of the broad variety of HMW toxins. Also, laboratories that are skilled in analysis of HMW toxins may not have expertise in analysis of LMW toxins. A consequence of this is that the groups of laboratories which contribute to RefBio, EuroBioTox or serve as OPCW Designated Laboratories have very few overlapping laboratories. This makes it unlikely that a single group of laboratories could be designated for detection of both LMW and HMW toxins. Given the broad diversity of toxins, understanding the capabilities of a wider group of laboratories that perform analyses of toxins would be critical should toxin analysis be required in connection to an investigation.

10.18 An approach to overcoming this capability limitation could be to rely on outside proficiency testing exercises to identify those laboratories experienced in the analysis of HMW toxins. Likewise, laboratories that might be part of the UNSGM with expertise in analysis of HMW toxins, could potentially defer to OPCW Designated Laboratories that are proficient in analysis of LMW toxins if it is deemed necessary.

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

(a) Through the TWG on Verification, the SAB had previously made recommendations on preparing for the analysis of toxins.[77] Specifically, that "ROPs will be required for toxin analysis, criteria for identification documented, and the Secretariat will need to consider how results, e.g. immunoassays and bioassays, should be reported. Sample preparation for the identification of toxins in difficult matrices also needs to be addressed if low detection limits for toxins are to be achieved. A lack of certified reference materials is hindering progress in some laboratories". The recommendation had further noted that not all laboratories will have the capabilities for the identification of toxins and some form of supplementary designation should be considered. The SAB had also recommended that the Secretariat should consider requesting information from Designated Laboratories on their analytical capabilities for toxins other than ricin and saxitoxin. The TWG viewed these previous SAB recommendations as supportive for addressing the issues raised by Dr Dorner.

(b) Further technical consideration on the variety of analysis methods for toxins would be beneficial to better understand the needs and gaps of responding to an incident involving the use of a toxin.

Subitem 10(e): T4i DOVER™: Versatile and miniaturised chemical detector as a UAV payload

10.20 Mr George Psarras (guest speaker, T4i engineering[78]) presented a table top demonstration of a drone operable vapour examiner and recorder (DOVER) based on a proprietary gas chromatography - photoionization detector (GC-PID) technology.

[77] See paragraph 89 of SAB/REP/1/15, dated 11 June 2015, footnote citation 3(e).
[78] For further information, see: http://t4i.co.uk/.

The system (T4i DOVER™)[79] was designed as an unmanned aerial vehicle (UAV) payload to enable capabilities that address challenges of sampling chemical vapours when on-board multi-rotor aircraft by compensating for downwash effects and rapid altitude or pressure changes. A limit of detection (LOD) of less than 50 ppb with a dynamic range of 10^5 has been demonstrated under controlled conditions.

10.21 The T4i DOVER™ was designed to allow integration with other platforms that employ well established and ubiquitous communication protocols (e.g. HTTP, SOS, XML) and wirelessly transmit real-time alarms about potential chemical threats with geo-referencing and timestamping. The system is not an off-the-shelf product, rather it is customised to the end-user needs and integrated with the systems they work with. Mr Psarras demonstrated how transmitted data can be used to define hazardous zones on a map using a "hot/warm/cold" hazard rating scale. He also showed preliminary results from a project using a UAV mounted system to scan the ground for old chemical weapons that might be present (recognising the leakage of chemical agents from corroded and damaged munitions).

10.22 In the subsequent discussion, it was noted that the instrument can be customised, for example produced with a modified casing for hand held use, or coupled with an ion-mobility spectroscopy (IMS) system.

11. AGENDA ITEM ELEVEN – 3D Scanning technology

11.1 Mr Toine Voeten and Mr Mark Ramon Redeker (guest speakers, Expert Team Visualisation and Reconstruction (ETVR) of the Dutch National Police Force) demonstrated the use of 3D laser scanning systems (including both static and dynamic scanning systems) that find application in capturing a digital twin of an investigation scene (for both indoor and outdoor locations).[80] This virtual twin of a scene can be examined at a later point in time off-site using virtual reality systems. The digitalised copy represents a point in time that can be used to compare subsequent on-site changes and events. The police officers described a variety of systems with different levels of portability and resolution. Additionally, they demonstrated how positional data (GPS), satellite imagery, and panoramic photography can be combined with the scanning to give an analyst accurate models of locations to review. Equipment is used in combination since the capabilities of available systems are not identical. Dynamic scanning systems can be UAV-mounted for wide area scanning, or carried by hand or in backpacks to generate images as the user walks through a location. A limitation of scanning systems is that they may lose some detail due to complex shapes hidden by shadows; this is overcome through combining the scan with handheld dynamic systems. It is also possible to extract point clouds (such as those created by laser scanners) from photographs: a large number of photographs are taken and rendered into a 3D model. Forensic applications for these systems include crime scene investigation and forensic archaeology.

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79 For further information, see: http://t4i.co.uk/home/dynamic-adaptive-detection/.

80 "The hiatus in crime scene documentation: visualisation of the location of evidence". R. Leeuwe; *J. Forensic Rad. Imag.*; 2017, *8*, 13-16; DOI: 10.1016/j.jofri.2017.03.002.

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

(a) The laser scanners provide their own light source, such that scanning in the dark is possible. However, rain and snow can interfere with the ability of the system to function due to light scattering induced by water droplets and snowflakes.

(b) 3D laser scanner systems are commercially available and used for a variety of applications (including, but not limited to, forensics, real-estate, archaeology and agriculture). Despite their accessibility, to use these systems effectively requires the development of suitable methods and approaches to image complex spaces and environments

12. AGENDA ITEM TWELVE – Experiences from other sectors: integrating research and application

Subitem 12(a): Nuclear forensics

12.1 Dr Klaus Mayer (guest speaker, European Commission – Joint Research Centre, Karlsruhe, Germany) briefed the TWG on nuclear forensics.[81] Dr Mayer presented the definition of nuclear forensics as "the examination of nuclear or other radioactive material, or of evidence that is contaminated with radionuclides, in the context of legal proceedings under international or national law related to nuclear security. The analysis of nuclear or other radioactive material seeks to identify what the materials are, how, when and where the materials were made, and what their intended uses were".

12.2 In the discussion Dr Mayer explained that nuclear forensic science has emerged as a relatively new and fascinating multidisciplinary area of research, combining methods of traditional forensics, radiochemistry, analytical chemistry, material science, isotope geochemistry, and nuclear physics. By providing case studies of actual incidents, he illustrated the evolution of the discipline from an ad-hoc analysis to maturity with remarkable capabilities. It should be noted, however, that nuclear forensics first of all provides a comprehensive characterisation of the material which includes the

[81] (a) State of practice and emerging application of analytical techniques of nuclear forensic analysis: highlights from the 4th Collaborative Materials Exercise of the Nuclear Forensics International Technical Working Group (ITWG)". J. M. Schwantes, O. Marsden, K. L. Pellegrini; *J. Radioanal. Nuclear Chem.*; 2016, *311(2)*, 1441-1452. DOI: 10.1007/s10967-016-5037-5. (b) "Advances in Nuclear Forensics: Countering the Evolving Threat of Nuclear and Other Radioactive Material out of Regulatory Control", IAEA, summary of an international conference, 2015; https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1706_web.pdf. (c) "Nuclear forensic science: correlating measurable material parameters to the history of nuclear material". K. Mayer, M. Wallenius, V. Zsolt; *Chem. Rev.*; 2013, *113(2)*, 884-900. DOI: 10.1021/cr300273f. (d) "The Nuclear Forensics International Technical Working Group (ITWG) An overview". B. Garrett, K. Mayer, P. Thompson, B. Pong, G. Lasou, Gauthier; International Conference on Advances in Nuclear Forensics: Countering the Evolving Threat of Nuclear and Other Radioactive Material out of Regulatory Control; Vienna, Austria, 2014; https://www.researchgate.net/publication/264057954_The_Nuclear_Forensics_International_Technical_Working_Group_ITWG_An_overview. (e) "Nuclear forensics—a methodology providing clues on the origin of illicitly trafficked nuclear materials", K. Mayer, M. Wallenius, I. Ray; *Analyst*, 2005, *130*, 433-441. DOI: 10.1039/B412922A. (f) For further information on the Nuclear Forensics International Technical Working Group, see http://www.nf-itwg.org/.

measurement of isotopic composition, elemental composition, chemical impurities and morphology. These parameters are best understood by comparing them against data of materials of known history. Such an evaluation may either be a direct comparison of data (e.g. a database query seeking to match records) or a point-to-model comparison (e.g. comparing analytical results to model calculations). The findings provide investigative leads for law enforcement or other competent authorities; and may allow conclusions to be drawn on the possible origin of the material.

12.3 The development or adaptation of analytical methods and the quest for signatures which are characteristic for the processing history of the material has often been inspired by real incidents.[82] The development of nuclear forensics is seen as a key element of the response to nuclear security incidents, which serves to deter nuclear proliferation and nuclear terrorism through the wealth of information it may provide on the history of an unknown material.

12.4 In the subsequent discussion it was noted that the statistics for reported nuclear trafficking incidents appears to have increased after 2004; however these reflect greater deployment of detectors at border crossings and increased levels of reporting by States. The current yearly average number of reported incidents is ~ 150 cases/year.[82]

Subitem 12(b): Environmental forensics

12.5 Dr Stephan Mudge (guest speaker, Norwegian Institute for Air Research,[83] and International Network of Environmental Forensics[84]) briefed the TWG on the field of environmental forensics. Environmental forensics is the scientific investigation of chemicals in the environment primarily to identify the sources, attribute from where and/or from whom the chemicals may have originated, and to track the environmental fate and any observed adverse effects.[85] To conduct such studies, a significant toolbox of techniques has been developed. The process starts with defining the questions to address, which determines the sampling and analysis approach.

12.6 Typical analytical approaches include the use of chemical signatures to define individual sources and to separate these from background or baseline conditions. These multi-compounds signatures are used quantitatively through multivariate statistical methods[86] such as principal components analysis (PCA), the projection to

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82 (a) International Atomic Energy Agency Incident and Trafficking Database (ITDB); https://www.iaea.org/resources/databases/itdb. (b) "Evaluation of Radioactive Scrap Metal Recycling". L. A. Nieves, S. Y. Chen, E. J. Kohout, B. Nabelssi, R. W. Tilbrook, S. E. Wilson; Argonne National Laboratory, ANL/EAD/TM-50, 1995; https://inis.iaea.org/collection/NCLCollectionStore/_Public/27/048/27048468.pdf.

83 For further information, see: https://www.nilu.no/en/.

84 For further information, see: https://www.rsc.org/Membership/Networking/InterestGroups/INEF/.

85 "Environmental Forensics and the Importance of Source Identification". S. M. Mudge; *Issues in Environmental Science and Technology*; 2008, 26, 1-16. DOI: 10.1039/9781847558343-00001.

86 (a) "Principal components analysis and receptor models in environmental forensics". G. W. Johnson, R. Ehrlich, W. Full, S. Ramos; Chapter 18 in: *An Introduction to Environmental Forensics*. R. Morrison, B. Murphy (eds); Elsevier. Amsterdam. 609-653, 2015. (b) "Principal components analysis of environmental chemical data: Experience and application". G. W. Johnson; *Environmental Forensics: Proceedings of the 2009 INEF Annual Conference*; Royal Society of Chemistry Special

latent structures by means of partial least squares regression (PLS), positive matrix factorisation (PMF) and polytopic vector analysis (PVA). Often there is less interest in the major components of a contaminant compared to the trace materials that differentiate between sources and synthetic pathways. Typical chemical analysis tools of environmental forensics include GC/MS, two-dimensional gas chromatography (GC × GC),[87] inductively coupled plasma mass spectrometry (ICP-MS) [88] and Aerosol Mass Spectrometry (AMS).[89]

12.7 When reconstructing environmental histories, signatures of environmental change can be found in sources such as sediments or tree rings[90] which act as proxy (passive) samplers, depending on the timescales involved. In some cases, stable isotopes of metals or organic components can be used to identify the geographical origin and, with position specific analyses, the reactants in the synthetic pathways. Critical to success is the use of multiple independent lines of evidence with quantified measures of the uncertainty.

12.8 In closing, Dr Mudge explained that environmental forensics is for investigations not monitoring. Each case is different, potentially requiring different tools on a case by case basis. It is also important to clearly identify the question that needs answering and collect samples and conduct analyses using approaches that are suitable for answering the question.

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

(a) The approaches employed in environmental forensics have relevance to chemical weapon related investigations and analysis. Continued interaction with the environmental forensics community to learn from their experiences could benefit the Secretariat.

(b) Dr Mudge has been involved with environmental forensic work that has been brought into the legal realm. The experiences from the field of environmental forensics are valuable to draw upon for understanding how chemical analysis is discussed and scrutinised under legal frameworks.

Publications, 2010, *327*, 202-209. (c) "Multivariate Statistical Methods in Environmental Forensics". S. M. Mudge; *Environmental Forensics*; 2007, *8*, 155-163. DOI: 10.1080/15275920601180693.

87 (a) "GC × GC - A new analytical tool for environmental forensics". G. S. Frysinger, R. B. Gaines, C. M. Reddy; *Env. Forensics*, 2002, 3(1), 27-34. DOI: 10.1080/713848318. (b) For a review of GC × GC in broader forensic applications, see: "Forensic potential of comprehensive two-dimensional gas chromatography". A. Sampat, M. Lopatka, M. Sjerps, G. Vivo-Truyols, P. Schoenmakers, A. van Asten; TrAC Trends in Analytical Chemistry; 2016, 80, 345-363. DOI: 10.1016/j.trac.2015.10.011.

88 (a) "Inductively coupled plasma mass spectrometry (ICP MS): a versatile tool". A. A. Ammann; *J Mass Spec.*; 2007, *42(4)*, 419-427. DOI: 10.1002/jms.1206. (b) For a review of ICP-MS in broader forensic applications, see: "Applications of LA–ICP–MS to forensic science". J. R. Almirall; T. Trejos; *Elements*; 2016, *12(5)*: 335-340. DOI: 10.2113/gselements.12.5.335.

89 "Aerosol mass spectrometry: an introductory review". D. G. Nash, T. Baer, M. V. Johnston; *Int. J. Mass Spec.*; 2006, *258(1-3)*, 2-12. DOI: 10.1016/j.ijms.2006.09.017.

90 An example of the use of tree-rings in reconstructing historical events: "Warfare dendrochronology: trees witness the deployment of the German battleship Tirpitz in Norway". C. Hartl, S. St. George, O. Konter, L. Harr, D. Scholz, A. Kirchhefer, J. Esper; *Anthropocene*; 2019, *27*, 100-212. DOI: 10.1016/j.ancene.2019.100212.

13. AGENDA ITEM THIRTEEN – Current and future perspectives

Subitem 13(a): Manual neutralisation: the last resort

13.1 Mr Sven Devroe (OPCW, Chemical Demilitarisation Branch) provided perspectives on current challenges and future perspectives in the demilitarisation of improvised explosive devices (IED's) with CBRN payloads, which cannot be neutralised using normal explosive ordnance (EOD) disposal procedures. In these cases, an EOD operator will manually render the device safe. While this does allow for collection of useful forensic information, manual neutralisation is a very technical and dangerous task, requiring trained experts with good knowledge of the components of the device and its payload.

13.2 Mr Devroe described the need for preservation of life and property, returning a situation to normal, and preservation and collection of components and information as objectives for the safe handling of IED devices. He discussed the need to approach the issues from a prevention angle rather than only a response perspective. In this "left of the boom" approach, information and intelligence might be used to reduce access to materials that would allow IEDs to be prepared. Benefits of this approach would include the potential for capacity building (especially in regard to exchange of pertinent information on explosives, munitions and IEDs), adoption of new technologies that might help recognise when something is unusual, and assistance to investigations.

Subitem 13(b): Assistance and protection

13.3 Mr Shawn DeCaluwe (Head, Assistance and Protection Branch) provided perspectives on current and future directions of OPCW assistance and protection activities under Article X of the Convention.[91] Mr DeCaluwe updated the TWG on the status of several projects that the Assistance and Protection Branch (APB) had previously briefed to the SAB and/or TWG. This included the chemical forensics and evidence management (CHEMFORM) project,[92] which has evolved into the development of forensics and evidence management approaches to build capacity within States Parties for the responders first on-scene.[93] APB is also participating in the INTERPOL Chemical Analysis, Recovery and Sampling Expert Working Group (CHARS), which seeks to develop a training standard for sample collection. Training activities would fit well with the capacity building intentions of the OPCW Centre for Chemistry and Technology.[94]

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91 "Status of Implementation of Article X of The Chemical Weapons Convention as at 30 June 2019" (EC-92/DG.10, dated 27 August 2019); www.opcw.org/sites/default/files/documents/2019/08/ec92dg10%28e%29.pdf.

92 For previous discussions on CHEMFORM in the SAB, see: (a) paragraphs 5.6 to 5.7 of SAB-26/WP.1, dated 21 July 2017, footnote citation 3(b); and, (b) paragraphs 12.6 to 12.7 of "Report of the Scientific Advisory Board at its Twenty-Fifth Session" (SAB-25/1*, dated 31 March 2017); www.opcw.org/sites/default/files/documents/SAB/en/sab2501_e_.pdf.

93 For previous discussion in the TWG on this project, see: paragraphs 10.1 to 10.3 of the report of the Second Meeting of the TWG, cited in footnote 6.

94 "Progress in the Project to Upgrade the OPCW Laboratory and Equipment Store to a Centre for Chemistry and Technology" (S/1769/2019, dated 9 July 2019): www.opcw.org/sites/default/files/documents/2019/07/s-1769-2019%28e%29.pdf.

13.4 In the subsequent discussion, it was recognised that the forensic evidence collection training that APB is helping to develop has great value for capacity building as well as the OPCW. Best practices could also be shared with Designated Laboratories to help analysts understand the methods used in the field for sample collection.

14. AGENDA ITEM FOURTEEN – Information systems

Subitem 14(a): Information and evidence management

14.1 Mr Sunghoon Lee (OPCW Investigation and Identification Team) briefed the TWG on how OPCW's IIT—which has been mandated to identify those responsible for the use of chemical weapons in the Syrian Arab Republic**Error! Bookmark not defined.**,[95]—is approaching information management. This requires the team to identify and report on all information potentially relevant to the origin of those chemical weapons for the instances being examined. To support this mandate, proper and secure information management systems and work instructions are required. Mr Lee discussed the considerations for managing IIT information, the types of information that have been collected and how these are being managed based on functional requirements.

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

(a) While there are a number of available forensic data management systems, these systems will almost always need some customisation for the specific needs of a given investigation. Care should be taken to prevent the data from becoming incompatible with other investigative data across related cases.

(b) Questions were raised about best practices for data management in a forensic environment. Many factors were considered, such as isolating systems for greater security, a need to be able to have systems connect to other systems, and the volumes of data being handled. The Secretariat might give consideration to the best practices used by forensic laboratories. In this regard, understanding how to most effectively manage information was recognised as more critical than technological solutions.

(c) The Secretariat's SIX system[96] has utility for secure information exchange for data related to non-routine investigations with the Designated Laboratories.

(d) Dr van Zalen kindly offered to bring interested members of the Secretariat to NFI for a briefing on the data management solutions they have developed.[97]

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95 For previous further information on the decision that led to the formation of the IIT, see: "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.

96 For further information on "SIX", see: www.opcw.org/resources/declarations/secure-information-exchange-six. For updates on recent developments, see: "Update on The Secure Information Exchange System" (S/1786/2019, dated 21 August 2019); www.opcw.org/sites/default/files/documents/2019/08/s-1786-2019%28e%29.pdf.

97 For previous discussions within the TWG on data management and analysis systems from NFI, see: (a) paragraphs 13.1 to 13.2 of the report of the First Meeting of the TWG, cited in footnote 6; and, (b) paragraphs 8.14 to 8.15 of the report of the Third Meeting of the TWG, cited in footnote 2.

Subitem 14(b): Discussion paper on information management

14.3 Dr Borrett and OPCW's Science Policy Adviser facilitated a discussion on information governance from a paper drafted by Dr Robert Mikulak. The paper considered information management in the context of three of the questions from the TOR of the TWG, In the area of information management, the TWG has the following tasks under its mandate:

(a) What are the best practices and analysis tools used in the forensic sciences for effectively cross-referencing, validating, and linking together information related to investigation sites, materials collected/analysed and individuals interviewed? (TOR sub-paragraph 4(b)).

(b) What are the best practices for management of data collected in investigations, including compilation, curation, and analytics? (TOR sub-paragraph 4(c)).

(c) What are the best practices for the collection, handling, curation and storage, and annotation of evidence? (TOR sub-paragraph 4(d)).

14.4 The considerations required to address these questions are not unique to the OPCW. Rather, they are very similar to tasks faced by other international investigatory bodies, in particular international criminal justice related mechanisms, such bodies would have considerable experience and capability on which the OPCW can draw. Four points were addressed during the discussion: (1) plan for continuing capability, (2) managing information from investigations separately, (3) considering information management in a systematic way, and (4) drawing on capabilities from other international organisations.

14.5 In regard to planning for continuing capability, it was discussed that even when investigations are only conducted on an infrequent ad-hoc basis, there needs to be a continuing capability to manage information from past investigations, and to be prepared to manage information from any investigations that may be undertaken in the future. For the OPCW, there is a need to ensure that this capability continues to be available at any point in the future, rather than trying to re-create such a capability after an investigation is mandated.

14.6 In regard to managing information from investigations separately, it was discussed that because of the sensitivity and stringent forensic requirements, information from investigations, which could lead to decisions by international policy-making organs (including the UN Security Council), or to national or international judicial action, should be managed separately from information related to routine verification activities.

14.7 In regard to considering information management in a systematic way, it was discussed that information management should be thought of in terms of the availability, usability, integrity and security of the data employed in an investigation. Information management is not primarily a matter of hardware and software, people and processes are of key importance. An information management structure should ideally be hardware and software-agnostic.

14.8 In regard to drawing on capabilities from other international organisations, it was noted that the OPCW has created its own special information management capability for the current work of the IIT. For the foreseeable future, such capability would need to be maintained and strengthened. This is expected to require bespoke updates to take account of developments in software, hardware, and information management practices, which would necessitate having adequate resources. As an alternative to maintaining a stand-alone in-house information management system for specific investigations, partnering with another international body in the UN system that maintains a similar capability on a continuing long-term basis might be explored to gain access to existing tools and methodologies. Doing so might be a way to minimise start-up time and cost if an investigation is mandated.

Subitem 14(c): The open digital forensic platform: investigate, innovate and share

14.9 Dr Dion Varrosieau, (guest speaker, NFI) discussed the modalities and considerations that are taken into account when multiple organisations may be sharing information relevant to investigations that they are working on either separately or in cooperation with other partners. NFI has used its Hansken[98] platform for this purpose. Dr Varrosieau described how traditional digital forensic workflows are challenged by the wealth of data available. He explained that a data management system needs to allow case investigators to have access to relevant data streams and analysis tools to evaluate their linkages and relationships for a case of interest.

14.10 Hansken is based in three principles: “trust no-one” (ensures security), “you can only access what you need” (ensures privacy), and “all actions are visible” (ensures transparency within the group of investigators working on common cases). This set of requirements allows the platform to be used across agencies and across forensic disciplines. Several projects have been demonstrated with international partners (with appropriate agreements and modalities in place). NFI has developed Hansken as an open digital innovation platform.

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

(a) How tools such as Hansken are configured for use depends on the needs of the organisation and investigation. The system allows searching across cases that may not necessarily be related or can be set up to limit access to individual cases in isolation from others.

(b) Effective use of tools like Hansken requires access to information management and digital forensics expertise. This is necessary to provide guidance to investigators.

98 For further information on Hansken, see https://www.forensicinstitute.nl/products-and-services/forensic-products/hansken.

15. AGENDA ITEM FIFTEEN – CBRN crime scene investigation recommended and standard operation procedures (SOPs and ROPs).

15.1 Dr van Zalen briefed TWG on CBRN crime scene investigation recommended and standard operating procedures (ROPs and SOPs, collectively R/SOPs), providing perspectives on the approaches and situations where certain procedures are best suited or required. He used the opportunity to amalgamate the thematic topics and discussions that had previously taken place in the TWG, and discussed an investigative process workflow guided by relevant R/SOPs (Figure 1).

15.2 The TWG has considered a large amount of information from a diversity of expertise, received briefings on applications and technologies, and forensic R/SOPs from a variety of sources (including EU FP7,[99] GIFT,[100] the European Network of Forensic Science Institutes (ENFSI)[101] and others[102]) that have been made available for the TWG to draw upon. A forensic process constitutes several steps from assignment to reporting (Figure 1). Each of step of an investigation process normally has a dedicated SOP compliant with ISO 17020 (inspections),[103] ISO 17025 (laboratories)[104] and/or other similar quality assurance systems.

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99 EU FP7: European Union Framework Programme 7. Funded projects relevant to forensics include: (a) 3D-FORENSICS (Mobile high-resolution 3D-Scanner and 3D data analysis for forensic evidence); https://cordis.europa.eu/project/rcn/108475/reporting/en. (b) BBFOR2 (Bayesian Biometrics For Forensics); https://cordis.europa.eu/project/rcn/93020/reporting/en. (c) DIVEFOR (Digital Image and Video Forensics); https://cordis.europa.eu/project/rcn/95060/reporting/en. (d) EVIDENCE (European Informatics Data Exchange Framework for Courts and Evidence); https://cordis.europa.eu/project/rcn/185514/reporting/en. (e) FASLW (FORENSIC ARCHITECTURE: The Space of Law in War); https://cordis.europa.eu/project/rcn/97850/reporting/en. (f) FORENSICIDFRONTIERS (Forensic Identification Frontiers); https://cordis.europa.eu/project/rcn/92268/reporting/en. (g) FORLAB (Forensic Laboratory for in-situ evidence analysis in a post blast scenario); https://cordis.europa.eu/project/rcn/102645/reporting/en. (h) HYPERION (Hyperspectral imaging IED and explosives reconnaissance system); https://cordis.europa.eu/project/rcn/104277/reporting/en. (i) IDENTITY (Computer Vision Enabled Multimedia Forensics and People Identification); https://cordis.europa.eu/project/rcn/200056/reporting/en. (j) LASIE (LArge Scale Information Exploitation of Forensic Data); https://cordis.europa.eu/project/rcn/185486/reporting/en. (k) MIDAS (The Development and Validation of a Rapid Millifluidic DNA analysis system for forensic casework samples); https://cordis.europa.eu/project/rcn/95760/reporting/en. (l) MISAFE (The Development and Validation of Microbial Soil Community Analyses for Forensics Purposes); https://cordis.europa.eu/project/rcn/108678/reporting/en. (m) PRIVACY4FORENSICS (A Formal Rule-Processing Engine for Privacy-Respecting Forensic Investigation); https://cordis.europa.eu/project/rcn/186180/reporting/en.

100 Final Report Summary - GIFT CBRN (Generic Integrated Forensic Toolbox for CBRN incidents), European Commission, 2018; https://cordis.europa.eu/project/rcn/192217/reporting/en.

101 Guidelines and best practices made available by the European Network of Forensic Science Institutes are available at: http://enfsi.eu/documents/.

102 See for example: paragraphs 10.1 to 10.6 of the report of the First Meeting of the TWG, cited in footnote 6.

103 ISO 17020: Conformity Assessment - Requirements for the operation of various types of bodies performing inspection; International Organization for Standardization, ISO/IEC 17020:2012; https://www.iso.org/standard/52994.html.

104 ISO 17025: General requirements for the competence of testing and calibration laboratories; International Organization for Standardization, ISO/IEC 17025:2017; https://www.iso.org/standard/66912.html.

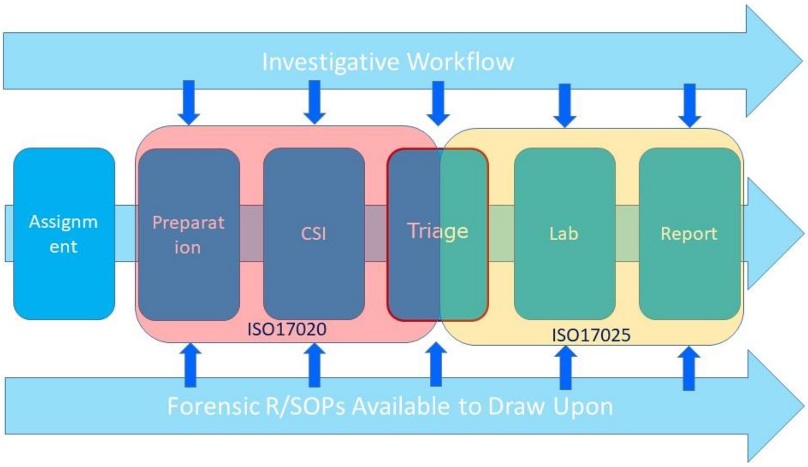

FIGURE 1: FORENSIC WORKFLOW

15.3 For each of the investigation phases (Figure 1), and especially for crime scene investigation (CSI), R/SOPs, applications and technologies need to be identified and selected for implementation in the workflow. It is of great importance to adjust and integrate R/SOPs into the existing workflows of an organisation. An impartial forensic advisor is a useful resource across the different phases of the investigation to advise on the questions asked, selection of the exhibits to be examined, and reporting the results of the laboratory investigations. At the end of the investigative process, integrated reports—where the results of the investigations are evaluated on whether or not they support the narrative of the incident, including any conclusions that have been determined—are useful for communicating the findings.

15.4 These points were highlighted for consideration for formulating recommendations:

(a) The different investigative phases should be supported by an impartial forensic adviser.

(b) Ownership must be created for any forensic SOPs, and this can be realised through:

(i) Establishing a working group with inspectors and forensic experts to integrate R/SOPS, applications and technologies into the OPCW workflows. Such a working group could also develop a training curriculum to enhance forensic awareness for inspectors.

(ii) Having this working group select the forensic R/SOPs, applications and technologies to be implemented.

(iii) Adapting and integrating relevant selected forensic R/SOPs into the OPCW workflows where appropriate.

(c) Implementing OPCW specific forensic SOPs, and providing training for those required to use them.

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

(a) The SOPs that are required will vary with the mission.

(b) In making comparisons of exhibits and samples, it is important that the purpose is clear, e.g. is an analysis trying to establish consistency between sets of materials or to show consistency of different materials with a bigger picture narrative?

(c) Raw data from any analysis can be valuable to review. A forensic adviser would be helpful to provide guidance.

(d) All stakeholders in an investigative function (including laboratories) benefit from insights gained from having access to R/SOPs for other functions in the process (to understand the working methods across the phases of an investigation).

(e) Moot courts provide a way to test robustness and validity of methods that bring evidence to a legal forum, which ensures that the scientific reporting is held to a high standard. This approach might be considered for training.

(f) Investigators must frame their questions in an informed way that ensures the laboratory analysis is relevant to the investigation and the exhibits submitted. The OPCW Laboratory has an important role in this regard, working with inspectors and key experts to help formulate relevant questions, and to facilitate dialogue between the inspectors and laboratories that perform analysis.

16. AGENDA ITEM SIXTEEN – Influence of quality assurance on the reliability of forensic identification

16.1 Mr Jos Tóth (guest speaker, Netherlands Forensic Institute) provided the TWG with an overview of best practices for quality assurance for forensic investigations. Achieving reliability of results within an investigation of production, use or presence of chemical weapons in a complex international arena poses a number of challenges; requiring that reported results are of high quality. For example, ensuring that the chain-of-custody has been properly followed and documented. When an organisation manages the chain-of-custody, measures must also be taken to ensure procedures comply with a quality management system (QMS).

16.2 An operational QMS provides transparency into the way investigations are performed, and defines the responsibilities of those involved in different aspects of the process. For chain-of-custody this would encompass critical steps along the process of packaging and transport of traces (evidence). An effective QMS ensures that further examinations of results from any laboratories undertaking analysis of evidence can be relied upon even years after the initial investigations. The objective is to guarantee that the reliability of on-site investigation and any subsequent (i.e. chemical in the case of OPCW) analysis of secured traces are verifiable. The overall objective being to ensure the credibility and reliability of all results and conclusions coming out of an investigation process.

16.3 Setting up a QMS requires that an organisation has a defined mission, and a vision to fulfil it. A key objective in the vision is the need to deliver reliable results and conclusions to stakeholders. This need can be accomplished with a quality-policy accepted by the responsible management. The quality policy and the nature of the investigation (quick and dirty and/or useful for legal cases as evidence) determines which quality standard is suitable; for example, whether an organisation needs to use an accredited QMS such as ISO 17020 (investigating teams)[103] and/or ISO 17025 (laboratories),[104] or certified QMS such as ISO 9001 (general QMS).[105] These standards also must be applied to the unique workflows and processes of a specific organisation.

16.4 There are four key elements to setting up a QMS.

(a) establishing quality awareness for all staff;

(b) management of and ownership of SOPs;

(c) education and training of staff (competency); and

(d) validated processes for investigations and analysis of traces.

16.5 Management has a key role supporting the implementation of a QMS and ensuring it is given the appropriate resources and priority within an organisation. Further information on QMS is available from ISO,[106] the International Laboratory Accreditation Cooperation (ILAC),[107] ENSFI[101] and NIST Scientific Working Groups.[108]

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

(a) As investigations require that inspectors ask pertinent questions to the analysts in off-site laboratories, there is a need for understanding processes and workflows across the investigative process. R/SOPs should be shared amongst the laboratories and inspectors on the ground so that they understand one another’s methods. The OPCW Laboratory has a critical role working with inspectors to ensure that questions to Designated Laboratories are well formulated and to facilitate the communication between the analysts and the inspection team.

(b) Quality documents must fit with the mandate of the mission.

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105 ISO 9001: Quality management systems — Requirements; International Organization for Standardization, ISO 9001:2015; https://www.iso.org/standard/62085.html.

106 International Organization for Standardization; https://www.iso.org/home.html.

107 For further information, see: https://ilac.org/.

108 Documents from the National Institute of Standards and Technology Scientific Working Groups are available at: https://www.nist.gov/oles/scientific-working-groups.

17. AGENDA ITEM SEVENTEEN – Scenario based operational planning

17.1 Mr Kenneth Aoki (OPCW Office of Strategy and Policy) updated the TWG on the Secretariat's initiative to pre-plan a series of archetypal scenarios involving the use of chemical weapons, in which the affected State Party requests the Secretariat's help to manage. The ultimate aim of applying a structured and systematic operational planning approach to such scenarios is to enhance the Secretariat's preparedness to respond to new types of missions.[109] Specifically, to identify the range of response capacities needed across the Secretariat to support its various missions. Capacities in this regard cover the range of "people", "equipment and hardware", and "methods, processes and practices."

17.2 Mr Aoki noted that a "pilot" of the aforementioned approach is currently in progress. A cross-divisional planning team, trained earlier in the year and comprising individuals from key divisions across the Secretariat, recently applied a well-established planning method to a specific type of scenario.

17.3 Mr Aoki also noted that the detailed planning phase will result in a better articulation of the capacities (i.e. within the aforementioned "people, equipment and process" framework) needed to support the Secretariat's operational response to the specific scenario. A gap analysis of the required and existing capacities, within the context of the scenario type, may also be of interest for the SAB and TWG.

17.4 As part of the overall initiative, such pre-planning of a number of diverse, yet still plausible, archetypal scenarios would help "triangulate" the Secretariat's core response capacities, and yield a more concise picture of the capacity gaps that could be addressed through the application of science and technology, as well as through other means such as partnerships and/or other targeted capacity building programmes for States Parties.

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

(a) Lessons learned are an important consideration, usefully collected with independent assessors.

(b) It is foreseeable that situations are dynamic, meaning that a given response approach in the early stage may need to be modified based on how events on the ground unfold as the mission moves forward.

(c) For deployment in response to an incident, the mission could be defined under existing mechanisms or may have unique modalities. Likewise, given existing missions and modalities, specific scenarios falling under these missions could be valuable.

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109 For previous discussions on scenario based training in the SAB and TWG, see: paragraphs 9.10 to 9.14 of "Report of the Scientific Advisory Board at its Twenty-Eighth Session" (SAB-28/1, dated 14 of June 2019); www.opcw.org/sites/default/files/documents/2019/09/sab-28-01%28e%29_0.pdf; (b) sub-paragraphs 10.7(a)(c)(g)(h)(i)(j) of the report of the Third Meeting of the TWG, cited in footnote 2; and (c) paragraphs 7.2 to 7.3 and sub-paragraphs 7.4(b)(c) of the report of the Second Meeting of the TWG, cited in footnote 5.

(d) As scenario planning and scenario-based training is used in many sectors and organisations, engagement with other organisations to understand their experiences could be helpful. In this regard, the Secretariat's involvement in the UNOCT[110] may provide useful connections to draw upon.

(e) Scenarios involving response to a mixed CBRN incident would also be relevant to consider, as it may require that a mission to provide assistance draws on expertise outside the Secretariat.

(f) The TWG continues to emphasise the benefit of using scenario based training for new equipment evaluation.

18. AGENDA ITEM EIGHTEEN – Sub-group updates and discussion

18.1 The sub-groups established at the First Meeting of the TWG moved into breakout sessions to review information they had compiled during the intersessional period and begin the process of taking this information forward into a final TWG report and recommendations. The sub-group leads briefed the TWG on the breakout session outcomes.

Sub-group A, forensic methods and capabilities

18.2 Sub-group A provided further considerations on its previous recommendations related to an impartial forensic adviser. The sub-group reviewed investigative workflows and how these might look in the context of OPCW, indicating points along the workflow where an impartial forensic adviser would be beneficial. Additionally, the sub-group discussed the value of having an impartial review process (involving suitable sets of expertise) for reports from investigations. The sub-group will look to develop these concepts further for the TWGs final report.

Sub-group B, data collection and management

18.3 Sub-group B referred to its previous considerations that an impartial forensic adviser take part in any review of forensically relevant SOPs to ensure they are sound and fit for purpose; and that in addition, Secretariat staff tasked with either reviewing or creating SOPs for investigations visit a forensic institute to observe how a case is managed from start to finish. These points further support the discussions of Sub-group A.

18.4 Additionally, Sub-group B gave further consideration to the information management discussion points outlined in paragraphs 14.3 to 14.8, and highlighted the following areas for development of recommendations.

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110 United nations – Office of Counter terrorism. For further information see: (a) Coordination and coherence of the counter-terrorism efforts of the United Nations; https://www.un.org/counterterrorism/ctitf/en. (b) "Ensuring Effective Interagency Interoperability and Coordinated Communication in Case of Chemical and/or Biological Attacks"; United nations – Office of Counter terrorism; United Nations, New York, 2017; https://www.un.org/counterterrorism/ctitf/sites/www.un.org.counterterrorism.ctitf/files/UNCCT_CTITF_WMD_WG_Project_Publication_FINAL.PDF.

(a) It is important to ensure that any information management capabilities that have been developed for any specific OPCW mission continue to be available at any point in the future. Appropriate planning to address this issue should be prioritised.

(b) Information management should be considered in a systematic way. In this regard, there may be value in exploring and drawing on capabilities from other international organisations to ensure continuing capability.

(c) Information management capabilities must be maintained and strengthened to help ensure there is not loss of capability in future.

Sub-group C, sampling, detection and analysis

18.5 The Sub-group C discussion reflected on topics that came up over the course of the TWG meeting, providing the following consideration to take toward the final report:

(a) Procurement of state-of-the art detection and protective equipment would help ensure that missions can be conducted in the most efficient and safest manner. A market watch function to closely follow developments in relation with the real needs of the Secretariat would be beneficial to recognise what is needed and more efficiently initiate evaluation and procurement processes. Furthermore, flexibility in the procedures for the procurement of equipment for non-routine inspections would allow the Secretariat to more rapidly adopt new technologies, these are especially important when considering the changing nature of threats that require new types of detection equipment and/or protection measures (for example, new types of nerve agents[16(b)]).

(b) The new Centre of Chemistry and Technology provides a potential facility where evaluation of new equipment might be usefully performed; see also paragraph 13.3. The results of equipment evaluations from States Parties would also be useful to consider in the assessment of new equipment.

(c) In regard to changing threats, non-routine missions can be expected to require a greater diversity of analysis tools, within this framework. Therefore, exploring SLA-based access to specific types of off-site laboratory analysis would be useful (see sub-paragraph 7.12(c)).

18.6 The sub-group also discussed the inputs it has previously compiled for the final report of the TWG, with additional information identified for inclusion (in particularly, the inclusion of information on point-of-care diagnostic kits for saxitoxin detection).

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

18.7 Sub-group D discussed issues related to chain-of-custody noting that a number of technologies and methods are available to ensure the chain-of-custody for all types of evidence. Additionally, with the capability for verifying authenticity of digital information being available in forensic institutes, consultation in this regard according to the requirements of the OPCW could be explored to ensure state-of-the-art approaches can be applied.

Sub-group E, provenance

18.8 Sub-group E considered the application of provenancing for CWA science, where both intrinsic and extrinsic signatures from a sample are considered. Developing laboratory capabilities for the provenance of chemical samples would broaden the scope of analysis available in some Designated Laboratories. Chemical profiling (extrinsic) training exercises could be considered. However, as discussed in paragraph 7.9, participation may be limited due to resource constraints. With provenance being one of the areas of method development in the CFITWG, exploring how to work with some of the laboratories involved in that working group may be a way forward.

Sub-group F, additional considerations

18.9 Sub-group F reviewed the inputs it had previously submitted for inclusion in the TWG's final report.

19. AGENDA ITEM NINETEEN – Next steps and End of Mandate Report

19.1 Dr Borrett facilitated a discussion amongst the TWG on the way forward toward a final report. The TWG will be provided with compiled inputs from the six sub-groups to begin the editing process, and will divide up the workload for preparing an executive summary and drafting the recommendations.

(a) The TWG will meet in Helsinki from 18-20 November to finalise and agree on the final report. A draft of the report will be developed intersessionally.

(b) The final report will be distributed to the SAB intersessionally for feedback, suggestions and endorsement.

20. AGENDA ITEM SEVENTEEN – Adoption of the report

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

21. AGENDA ITEM EIGHTEEN – Closure of meeting

The Chairperson closed the meeting at 17:39 on 20 September 2019.

ACKNOWLEDGEMENTS

The TWG members thank all the guest speakers and staff of the Secretariat who gave presentations at their Second Meeting: Mr Kenneth Aoki, Mr Boban Cekovic, Ms Hoe-Chee Chua, Mr Shawn DeCaluwe, Mr Sven Devroe, Ms Doris Eerhart, Mr Tamas Elas, the OPCW Science Policy Adviser, the Head of the OPCW Laboratory, Mr Florian Käding, Mr Albert Kireev, Mr Sunghoon Lee, Dr Klaus Mayar, Mr Scott McKenzie, Dr Stephan Mudge, Mr George Psarras, Mr Mark Ramon Redeker, Mr Yue Jin Tay, Mr Jos Tóth, Mr Gert Wijnalda, Dr Marcel van der Schans, Dr Dion Varrosieau, and Mr Toine Voeten. The TWG also thanks Ms Nadezda Malyutina, Ms Marlene Payva, Ms Giovanna Pontes and Ms Juliana Schneider of the OPCW Office of Strategy and Policy, for their support and contributions to the meeting and its preparations.

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

Annex

LIST OF PARTICIPANTS AT THE FOURTH 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]	La Trobe Institute for Agriculture and Food, Melbourne, Australia
3.	Dr Christophe Curty*[113]	Spiez Laboratory, Switzerland
4.	Dr Brigitte Dorner	Robert Koch Institute, Berlin, Germany
5.	Dr Daan Noort*	TNO, Rijswijk, the Netherlands
6.	Dr Syed K. Raza*	Chairperson Accreditation Committee, National Accreditation Board for Testing and Calibration Laboratories (NABL), India
7.	Mr Cheng Tang*[114]	Office for the Disposal of Japanese Abandoned Chemical Weapons, Ministry of National Defence, China
8.	Dr Christopher Timperley	Defence Science and Technology Laboratory (Dstl), Porton Down, United Kingdom of Great Britain and Northern Ireland
9.	Mr Francois Mauritz van Straten	Independent former SAB member, South Africa
10.	Dr Ed van Zalen[115]	Netherlands Forensic Institute (NFI), The Netherlands
11.	Professor Paula Vanninen	University of Helsinki and VERIFIN, Helsinki, Finland
12.	Ms Farhat Waqar*	Pakistan Atomic Energy Commission
13.	Ms Hoe-Chee Chua* (guest speaker)	Member of OPCW Scientific Advisory Board
14.	Ms Doris Eerhart (guest participant)	Netherlands Forensic Institute, the Netherlands
15.	Mr Florian Käding (guest speaker)	Prometech B.V., Utrecht, the Netherlands
16.	Dr Klaus Mayar (guest speaker)	European Commission, Joint Research Centre, Karlsruhe, Germany
17.	Mr Scott McKenzie (guest speaker)	SensaData, Melbourne, Australia
18.	Dr Stephan Mudge (guest speaker)	Norwegian Institute for Air Research, Oslo, Norway
19.	Mr George Psarras (guest	T4i Engineering, Loughborough, United Kingdom of

[111] Dr Augustin Baulig, Dr Carlos Fraga, Professor David Gonzalez and Dr Robert Mikulak having sent their apologies were unable to attend this meeting of the TWG.
[112] Chairperson of the TWG.
[113] 2019 Vice-Chairperson/2020 Chairperson of the SAB.
[114] 2019 Chairperson of the SAB.
[115] Vice-Chairperson of the TWG.

	Participant	Institution
	speaker)	Great Britain and Northern Ireland
20.	Mr Mark Ramon Redeker (guest speaker)	Expert Team Visualisation and Reconstruction (ETVR) of the Dutch National Police Force. Police, Central Unit, DLOS, Central Forensic Service Centre, Driebergen, the Netherlands
21.	Mr Yue Jin Tay (guest speaker)	Circulor, London, United Kingdom of Great Britain and Northern Ireland
22.	Mr Jos Tóth (guest speaker)	Netherlands Forensic Institute, the Netherlands
23.	Mr Gert Wijnalda (guest speaker)	Prometech B.V., Utrecht, the Netherlands
24.	Dr Marcel van der Schans (guest speaker)	TNO, the Netherlands
25.	Dr Dion Varrosieau (guest speaker)	Netherlands Forensic Institute, the Netherlands
26.	Mr Toine Voeten (guest speaker)	Expert Team Visualisation and Reconstruction (ETVR) of the Dutch National Police Force Police. Central Unit, DLOS, Central Forensic Service Centre, Driebergen, the Netherlands

* Member of the Scientific Advisory Board.

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