Twenty-Seventh Session
19 – 23 March 2018

SAB-27/WP.1
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ENGLISH only

SUMMARY OF THE FIRST MEETING OF THE SCIENTIFIC ADVISORY BOARD'S 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 first meeting from 12 to 14 February at OPCW Headquarters in The Hague. The meeting was chaired by Dr Veronica Borrett on behalf of the SAB. The Vice-Chairperson was Dr Ed van Zalen who was appointed by the TWG during the meeting.

1.2 Dr Borrett opened the meeting, introducing the SAB Chairperson and SAB Vice-Chairperson, Dr Christopher Timperley and Mr Cheng Tang; who briefed the participants on the work of the SAB[1] and the establishment of the TWG. Recognising the valuable and actionable information that modern investigative techniques can provide, the SAB recommended at its Twenty-Fourth Session, the establishment of a TWG to conduct an in-depth review of methods and technologies that could be used by OPCW inspectors for investigative work.[2] Capabilities enabled through these methods and technologies are crucial for the non-routine contingency operations that the Technical Secretariat (hereinafter, "the Secretariat") has been increasingly deploying. Key inputs for the recommendation came through findings of the SAB's TWG on Verification,[3] and the SAB's 2016 international workshop on chemical forensics.[4] In response to the recommendation,[5] the Director-General requested that a

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1 Further information on the OPCW Scientific Advisory Board is available at: www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/.

2 See paragraphs 1.2 and 8.12 to 8.17 of the Report of the Scientific Advisory Board at its Twenty-Fourth Session, SAB-24/1, dated 28 October 2016. Available at: www.opcw.org/fileadmin/OPCW/SAB/en/sab-24-01_e_.pdf.

3 Verification: Report of the Scientific Advisory Board's Temporary Working Group (SAB/REP/1/15, dated June 2015). Available at: www.opcw.org/fileadmin/OPCW/SAB/en/Final_Report_of_SAB_TWG_on_Verification_-_as_presented_to_SAB.pdf.

4 Chemical Forensics: Capabilities across the Field and the Potential Applications in Chemical Weapons Convention Implementation, held from 20 to 22 June 2016 in Helsinki, Finland (SAB/24-WP.1, dated 14 July 2016). Report is available at: www.opcw.org/fileadmin/OPCW/SAB/en/sab24wp01_e_.pdf.

5 See paragraphs 8 to 9 of Response to the Report of the Twenty-Fourth Session of the Scientific Advisory Board, EC-84/DG.9, dated 18 January 2017. Available at: www.opcw.org/fileadmin/OPCW/EC/84/en/ec84dg09_e_.pdf.

TWG be established in accordance with paragraph 9 of the SAB's terms of reference (TOR)[6]. At the SAB's Twenty-Fifth Session[7] the TOR for the new TWG were agreed and a Chairperson appointed. The TWG membership was appointed during the intersessional period between the SAB's Twenty-Fifth and Twenty-Sixth Sessions. The TOR of the TWG are provided in Annex 1 of this report.

1.3 Following the briefing from the SAB, Dr Jonathan Forman (OPCW Science Policy Adviser and Secretary to the SAB) explained rules of procedure and reporting for the TWG; noting that the TWG will produce an end-of-mandate report for submission to the SAB, from which recommendations will be agreed upon (by the SAB) and submitted to the Director-General.

2. AGENDA ITEM TWO – Adoption of the agenda

The TWG adopted the following agenda for its First Meeting:

1. Opening of the meeting
2. Adoption of the agenda
3. *Tour de table* to introduce temporary working group members, observers and guest speakers
4. Establishment of a drafting committee
5. Objectives of the temporary working group
    (a) Background, terms of reference and key questions
    (b) Mandate, responsibilities and issues
    (c) Developing the programme of work
6. Allegations and fact-finding in the Syrian Arab Republic
    (a) OPCW missions in the Syrian Arab Republic
    (b) OPCW-United Nations Joint Investigative Mechanism investigations 2017: a technical overview
    (c) Operational aspects of the OPCW Fact-Finding Mission outside of the Syrian Arab Republic
    (d) OPCW Fact-Finding Mission
    (e) Declaration Assessment Team: challenges and lessons learned

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6 See Annex to Decision: Scientific Advisory Board, C-II/DEC.10/Rev.1, dated 2 December 2004. Available at: www.opcw.org/fileadmin/OPCW/CSP/C-II/en/C-II_DEC.10_Rev.1-EN.pdf.

7 See paragraphs 12.3 to 12.5 of the Report of the Scientific Advisory Board at its Twenty-Fifth Session, SAB-25/1*, dated 31 March 2017. Available at: www.opcw.org/fileadmin/OPCW/SAB/en/sab-24-01_e_.pdf.

7. OPCW Operations

   (a) Inspections and contingency operations

   (b) Challenge Inspection and the Rapid Response and Assistance Mission

8. Operational realities of OPCW contingency operations

9. The role of laboratories

   (a) The role of the OPCW Laboratory

   (b) Atmospheric pressure photoionisation-mass spectrometry - mass spectrometry: an alternative data rich method of analysis of Chemical Weapons Convention related chemicals

   (c) The role of designated laboratories in chemical weapons related investigations: bringing forensic techniques into the designated laboratory toolbox

10. From collection to courtroom

11. Crime scene management and forensic analysis

   (a) CBRN crime scene management and forensic analysis in Serbia

   (b) The collection, preservation and analysis of trace evidence in explosion cases

   (c) An overview of forensic techniques

12. Chemical warfare agent analysis

   (a) Chemical Forensics International Technical Working Group: objectives, gaps and collaboration

   (b) Fatal sarin poisoning in the Syrian Arab Republic 2013: forensic verification within an international laboratory network

13. Data management

14. Engagement with forensic science experts

15. Discussion, establishment of sub-groups and the way forward

   (a) Agreement of topics and establishment of sub-groups

   (b) Identification of key areas for intersessional work, and gaps that may need further clarification

   (c) Plan of work for sub-groups and their leads; milestones and timelines

   (d) Agenda for the second meeting

16. Adoption of the report

17. Closure of the meeting

3. AGENDA ITEM THREE – *Tour de table* to introduce temporary working group members, observers and guest speakers

A *tour de table* was undertaken to introduce the TWG members, observers and guest speakers. A list of participants appears in Annex 2 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 First Meeting.

5. AGENDA ITEM FIVE – Objectives of the temporary working group

Subitem 5(a): Background, terms of reference and key questions. 5(b): Mandate, responsibilities and issues. And 5(c): Developing the programme of work.

5.1 Dr Borrett discussed the objectives of the TWG which, as outlined in the TOR (Annex 1) are "…to review the science and technology relevant to investigations such as those mandated under Articles IX and X of the Chemical Weapons Convention. This would include science and technology for the validation and provenancing (i.e. determining the chronology of ownership, custody and/or location) of evidence, and the integration of multiple and diverse inputs to reconstruct a past event...". Dr Borrett noted that this would usefully include further consideration of topics in the recommendations from the SAB's 2016 chemical forensics workshop and where appropriate, the assessment of the scientific and technological merits of methodologies with verification relevance, and the assessment and reporting on emerging technologies and new equipment which could be used in OPCW verification activities.[8] The questions to be addressed by the TWG are summarised in the TOR in Annex 1 of this report.[9]

6. AGENDA ITEM SIX – Allegations and fact-finding in the Syrian Arab Republic

6.1 Beginning with the 2013 United Nations led mission,[10] the Secretariat has conducted a series of non-routine inspection and verification activities in the Syrian Arab Republic. These contingency operations have increasingly required investigations, analysis, and fact-finding, with collection and evaluation of oral, material, and digital evidence of the use of chemical agents. The unique and non-routine situations in

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8 Relevant considerations might also be found in: Report of the Scientific Advisory Board's Workshop on Emerging Technologies (SAB-26/WP.1, dated 21 July 2017); www.opcw.org/fileadmin/OPCW/SAB/en/sab26wp01_SAB.pdf.

9 A quick reference guide to the questions of the TOR can be downloaded from the OPCW public website, www.opcw.org/fileadmin/OPCW/SAB/en/TWG_Investigative_Science_Tech_Questions.pdf.

10 United Nations Mission to Investigate Allegations of the Use of Chemical Weapons in the Syrian Arab Republic (A/68/663-S/2013/735, dated 13 December 2013); https://unoda-web.s3.amazonaws.com/wpcontent/uploads/2013/12/report.pdf.

which these operations have taken place and the lessons learned[11] are highly insightful for the consideration of how tools and methods used in investigative work could better enable OPCW inspectors to meet the objectives of their mission mandates.

Subitem 6(a): OPCW missions in the Syrian Arab Republic

6.2 Mr Aamir Shouket (OPCW Deputy Chief of Cabinet) provided an overview of the OPCW's missions in the Syrian Arab Republic,[12] covering the 2013 United Nations-led Mission, the OPCW-United Nations Joint Mission to remove and destroy chemical weapons,[13] the status of destruction of the chemical weapons production facilities,[14] the Declaration Assessment Team (DAT),[15] inspections at Syrian Scientific Studies and Research Centre,[16] the on-going work of the Fact-Finding Mission (FFM)[17] and incidents of the use of sarin in 2017.[18,19] Mr Shouket noted that

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11 (a) R. Trapp, Lessons Learned from the OPCW Mission in Syria, dated 16 December 2015; www.opcw.org/fileadmin/OPCW/PDF/Lessons_learned_from_the_OPCW_Mission_in_Syria.pdf; (b) The Secretary-General's Mechanism for Investigation of Alleged Use of Chemical, Bacteriological (Biological) or Toxin Weapons: A lessons-learned exercise for the United Nations Mission in the Syrian Arab Republic (2015); https://unoda-web.s3-accelerate.amazonaws.com/wp-content/uploads/assets/publications/more/syrian-ll-report/syrian-ll-report-2015.pdf; and (c) Workshop on the Lessons Learned from the International Maritime Operation to Remove and Transport the Syrian Chemical Materials in Furtherance of Security Council Resolution 2118 (2013) and Relevant OPCW Executive Council Decisions; United Nations office of Disarmament Affairs, March 2015; https://unoda-web.s3-accelerate.amazonaws.com/wp-content/uploads/2015/05/proceedings-maritime-public.pdf.

12 For a recent update, see: Progress in the Elimination of the Syrian Chemical Weapons Programme (EC-87/DG.16, dated 23 February 2018). For further information on OPCW activities in the Syrian Arab Republic, see: www.opcw.org/special sections/syria/.

13 The OPCW-United Nations Joint Mission to remove and destroy chemical weapons ran from 16 October 2013 to 30 September 2014; further information is available at: https://opcw.unmissions.org/.

14 Request by the Syrian Arab Republic for Assistance with the Destruction of its Chemical Weapons Production Facilities (S/1541/2017, dated 9 October 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1541-2017_e_.pdf.

15 For further information see: (a) Report on the work of the Declaration Assessment Team, EC-85/DG.25, dated 4 July 2017; (b) Outcome of Further Consultations with the Syrian Arab Republic Regarding its Chemical Weapons Declaration, EC-86/DG.30 dated 4 October 2017; and (c) Conclusions on the Outcome of Consultations with the Syrian Arab Republic Regarding its Chemical Weapons Declaration (EC-82/DG.18, dated 6 July 2016); www.opcw.org/fileadmin/OPCW/EC/82/en/ec82dg18_e_.pdf.

16 (a) Status of Implementation of Executive Council Decision EC-83/DEC.5 (dated 11 November 2016) (EC-84/DG.25, dated 6 March 2017); www.opcw.org/fileadmin/OPCW/EC/84/en/ec84dg25_e_.pdf. (b) First Inspections at the Barzah and Jamrayah Syrian Scientific Studies and Research Centre Facilities in Syrian Arab Republic in Accordance with Decision EC-83/DEC.5 (dated 11 November 2016); (EC-85/DG.16, dated 2 June 2017); (c) Status of Implementation of Executive Council Decision EC-83/DEC.5 (dated 11 November 2016) (EC-87/DG.15, dated 23 February 2018).

17 Fact-Finding Missions reports are available at: www.opcw.org/special-sections/syria/fact-finding-mission-reports/.

18 Analysis Results of Samples Relating to the Alleged Use of Chemicals as Weapons in Ltamenah, Hama Governorate, Syrian Arab Republic, March 2017 (S/1544/2017, dated 12 October 2017).

19 (a) Report of the OPCW Fact-Finding Mission in Syria regarding an alleged incident in Khan Shaykhun, Syrian Arab Republic April 2017 (S/1510/2017, dated 29 June 2017). Available at: www.opcw.org/fileadmin/OPCW/Fact_Finding_Mission/s-1510-2017_e_.pdf; (b) Analysis Results of The Samples Provided by the Government of the Syrian Arab Republic in Relation to the Alleged

the OPCW missions involving allegations of the use of chemical weapons have a mandate to determine if chemical weapons have been used, not to attribute who is responsible. In regard to attribution, FFM reports and supporting information were provided to the OPCW-United Nations Joint Investigative Mechanism (JIM)[20] for further information.[21, 22]

6.3 The TWG thanked Mr Shouket for his presentation and expressed its concern and condemnation for the use of chemicals as weapons.

Subitem 6(b): OPCW-United Nations Joint Investigative Mechanism investigations 2017: a technical overview

6.4 Mr Stefan Mogl (Spiez Laboratory,[23] guest speaker) briefed the TWG on two incidents investigated by the JIM from May to November 2017; the first involving the use of sulfur mustard, and the second involving the use of sarin.[24] He provided an overview of the JIM's general method of work, explaining the significance of a study the JIM had conducted into the chemistry of sarin samples from one of the incidents, and summarised some of the lessons learned from a personal perspective.

6.5 Mr Mogl explained that both investigations were initiated by the JIM's Leadership Panel after the OPCW FFM had confirmed the use of chemical weapons. For each case, an investigation plan was developed which formed the basis for the conduct of the respective investigation. These plans included various scenarios of how the incident may have occurred, including all scenarios presented by the parties concerned. The JIM investigators then searched for information supporting any of these scenarios. The JIM's information collection unit included information from the OPCW FFM as well as from any other source it could access. Factual information supporting the scenarios of the investigation plan were analysed, checked and

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Incident in Khan Shaykhun, Syrian Arab Republic, April 2017 (S/1521/2017, dated 28 July 2017); (c) Note by the Technical Secretariat: Further Clarifications why the OPCW Fact-Finding Mission did not Deploy to Khan Shaykhun (S/1545/2017, dated 17 October 2017).

20 OPCW-United Nations Joint Investigative Mechanism Fact Sheet, available at: https://unoda-web.s3-accelerate.amazonaws.com/wp-content/uploads/2016/08/JIM-Fact-Sheet-July2016.pdf.

21 Reports from the JIM: (a) First report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2016/142, dated 12 February 2016); http://undocs.org/S/2016/142; (b) Third report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2016/738, dated 24 August 2016); http://undocs.org/S/2016/738; (c) Fourth report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2016/888, dated 21 October 2016); http://undocs.org/S/2016/888; (d) Fifth report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2017/131, dated 13 February 2017); http://undocs.org/S/2017/131; (e) Sixth report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism; (United Nations Security Council, S/2017/552, dated 28 June 2017); http://undocs.org/S/2017/552; and (f) Seventh report of the Organisation for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism (United Nations Security Council, S/2017/904, dated 26 October 2017); http://undocs.org/S/2017/904.

22 The mandate for the JIM ended in October 2017.

23 For further information on Spiez Laboratory, see: https://www.labor-spiez.ch/enindex.htm.

24 These cases are described in the sixth and seventh reports of the JIM.

corroborated by the JIM's analysis and corroboration unit. Only corroborated information was considered by the JIM as evidence.

6.6 As an example of the JIM's technical work Mr Mogl described the in-depth study the JIM had conducted with support from the OPCW and the OPCW designated laboratories into the chemistry of samples obtained from Khan Shaykhun. The results of this study demonstrated how certain chemical impurities that were identified by the designated laboratories in the samples could form during the production process for sarin precursor chemicals. The impurities in the samples became chemical markers that informed the conclusions reported by the JIM.

6.7 Mr Mogl further summarised some of the lessons learned from the operation of the JIM in 2017. In order to conduct an investigation into chemical weapons use successfully, the importance of the availability of a wide ranging set of expertise to the investigation team was emphasised. While some of the expertise may be procured externally, such as laboratory analysis or authentication of video and other digital information sources, certain core competences must be part of the skillset of the investigation team. The investigation team also requires direct access to a range of technical expertise. The ability to consult with experts for example: on the use of satellite imagery, medical effects and symptoms of chemical weapons poisoning, vapour dispersion modelling and munitions and explosives effects will be useful. Broader expertise, for which the subject may vary, may also be required depending on the peculiarities of an incident. Furthermore, crucial to an investigation is expeditious operational support to facilitate field missions. In this regard, the OPCW's support was instrumental for the work of the JIM during 2017.

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

(a) The work of bodies such as the JIM can be highly politicised. It was noted that reports of such importance cannot be written without substantive legal expertise. Likewise, the standard of evidence must remain at the highest level, such that information which cannot be corroborated, cannot be used to draw conclusions. It must also be realised that such investigation mechanisms are not prosecutorial or judicial bodies.

(b) A number of areas were identified that require careful considerations for investigative work into allegations of use of chemical weapons. These include data management (especially for keeping information confidential), sample management (especially in regard to contaminated samples and how to properly handle and store them), and the authentication of documents and/or digital evidence.

(c) For purposes of attribution, much more than analytical chemistry results are required. The need to link together timelines, physical objects and people requires a diversity of data streams that must be connected together. Given the diversity of information that might be considered, outside experts may need to be called upon. In relying on outside expertise, consideration must be given to the use of validated and accredited methods and approaches.

(d) Impurity profiling to determine synthesis routes for chemical agents provides valuable information. However, it was noted that in regard to chemical warfare agents, this methodology is still being developed. It was also noted that such method development requires the ability to both synthesise and analyse Schedule 1 chemicals.

(e) The use of dispersion models had also been considered in the work of the JIM. However the use of any modelling approaches requires assumptions to use with the model, as well as selection of an appropriate model. This can be limiting in the absence of on-site information at the time of an incident.

(f) There is significant interest in publishing scientific studies related to the work coming from chemical-weapon related investigations. However, such data may be confidential and unavailable for publication in scientific literature. The visibility of such publications would help to validate methods used for analysis under real-world conditions, and help increase investigative capacity worldwide, especially by demonstrating the utility of the methods used, and by highlighting the chemical markers of investigative relevance, that might be used by a larger number of designated laboratories. Keeping this scientific data confidential can hinder such collaboration and might restrict investigative capability that the OPCW could require in the future. The publication considerations are focused strictly on scientific results and need not include sensitive information. See paragraphs 12.3-12.4, specifically subparagraph 12.4(e), for an example of a peer-reviewed scientific publication that contained data obtained from the United Nations led mission to the Syrian Arab Republic in 2013.

Subitem 6(c): Operational aspects of the OPCW Fact-Finding Mission outside of the Syrian Arab Republic

6.9 Mr Lennie Phillips (Consultant, guest speaker) briefed the TWG on operational aspects of the FFM. He noted that it is not possible to investigate every possible report of the use of a chemical weapon. In some cases, there is not sufficient potential evidence to warrant sending a team; while in other cases, it may not be possible to reach the scene of an alleged incident, particularly when the location is in territory that is not under the control of a State Party. As the security situation,[25] travel restrictions and time constraints can limit access to the site of an allegation, Mr Phillips explained that FFM missions additionally collect information through contact with victims and witnesses, and through other available sources.

6.10 FFM teams collect physical evidence that requires laboratory analysis and corroboration with witness testimony and other relevant information. Forensic awareness within the teams is valuable for guidance of collection and treatment of evidence in such a way as to not compromise future evaluation. Mr Phillips noted that there can be large variations in the type of available evidence for FFM missions. Information collected is reliant on availability of witnesses, supporting evidence and access to locations of relevance. How precise the FFM findings can be reported is also a matter of careful consideration, as the corroboration of information is crucial to making any conclusions.

[25] See for example: 28 May 2014 OPCW news item, OPCW Team Arrives Safely Back in Damascus; www.opcw.org/news/article/opcw-team-arrives-safely-back-in-damascus/.

6.11 Mr Phillips identified areas that the TWG might consider in their deliberations for optimisation. These include analytical methods (and reporting of results) for relevant unscheduled chemicals (especially toxic industrial chemicals such as chlorine and ammonia, riot control agents, and central nervous system acting compounds), the use of chemical forensics methodologies, providing more detailed quantitative information on chemicals identified in a sample where relevant, and providing guidance on control samples and sampling strategies (including how to train and inform others who might be able to access the site before an FFM team can arrive). He also noted that for the results received back from a laboratory, more information about the methods used, including limits of detection and other pertinent performance indicators can be helpful for investigators.

6.12 Other capabilities that Mr Phillips identified as valuable to the work of the FFM included physical analysis of munition parts; impact analysis on physical objects (especially munitions); inorganic analysis (in particular of metal containers and munition fragments, as well as chemicals); biomedical sampling and analysis for industrial chemicals; the use of biomarkers from humans, animals and plants; and the ability to recognise biomarkers that result from metabolic processes in samples such as hair.

Subitem 6(d): OPCW Fact-Finding Mission

6.13 Mr Steven Wallis (Consultant, guest speaker) briefed the TWG on the work of the FFM team tasked with assessments of incidents reported by the Government of the Syrian Arab Republic. Mr Wallis explained the relationship of his team to the FFM as a whole, and described missions where physical evidence and samples were retrieved for further analysis (either by the FFM or through the Syrian Arab Republic and/or the Russian Federation). These missions included Darayya in February 2015,[26] Al Awamid in August 2016,[27] Um Housh in September 2016,[28] and Khan Shaykhun in April 2017.[29] Mr Wallis described the nature of the samples taken, the respective methodologies that were used and the results of the subsequent analyses.

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26 (a) Interim Report of the OPCW Fact-Finding Mission in Syria Regarding the Incidents Described in Communications from the Deputy Minister for Foreign Affairs and Expatriates and Head of National Authority of Syria from 15 Dec 2014 to 15 June 2015 (S/1318/2015, dated 29 October 2015). Available at: www.opcw.org/fileadmin/OPCW/Fact_Finding_Mission/s-1318-2015_e_.pdf; (b) Report of the OPCW Fact-Finding Mission in Syria Regarding the Incidents Described in Communications from the Deputy Minister for Foreign Affairs and Expatriates and Head of the National Authority of the Syrian Arab Republic (S/1318/2015/Rev.1/Add.1, dated 29 February 2016).Available at: www.opcw.org/fileadmin/OPCW/Fact_Finding_Mission/s-1318-2015r1a1_e_.pdf.

27 Report of the OPCW Fact-Finding Mission in Syria Regarding the Incident of 2 August 2016 as Reported in the Note Verbale of the Syrian Arab Republic Number 69 dated 16 August 2016 (S/1444/2016, dated 21 December 2016). Available at: www.opcw.org/fileadmin/OPCW/Fact_Finding_Mission/s-1444-2016_e_.pdf.

28 Report of The OPCW Fact-Finding Mission in Syria Regarding the Incident Of 16 September 2016 as Reported in the Note Verbale of the Syrian Arab Republic Number 113 Dated 29 November 2016 (S/1491/2017, dated 1 May 2017). Available at: www.opcw.org/fileadmin/OPCW/Fact_Finding_Mission/s-1491-2017_e_.pdf.

29 (a) Report of the OPCW Fact-Finding Mission in Syria regarding an alleged incident in Khan Shaykhun, Syrian Arab Republic, April 2017 (S/1510/2017, dated 29 June 2017). Available at: www.opcw.org/fileadmin/OPCW/Fact_Finding_Mission/s-1510-2017_e_.pdf; (b) Analysis Results of

6.14 Mr Wallis discussed some of the lessons learned from retrieval and subsequent analysis of samples and other evidence related to the use of chemical weapons in non-routine scenarios. These issues included ensuring FFM teams have adequate skill sets to undertake their missions, the remit of the OPCW Laboratory in environments that are not restricted to verification activities alone, and a need for developing training and other related opportunities to engage with States Parties, International Organisations, and subject matter experts.

Subitem 6(e): Declaration Assessment Team: challenges and lessons learned

6.15 Mr Nihad Alihodzic (Head, OPCW Declarations Assessment Team) briefed the TWG on the work of the DAT, explaining its formation and mandate to resolve gaps and inconsistencies in the declaration from the Syrian Arab Republic; the types of information and samples collected; gaps, discrepancies and inconsistencies identified; on-going progress in addressing the issues raised (including amendments made to the declarations); and challenges faced by the team in the undertaking of its work.

6.16 Mr Alihodzic discussed the use of remote monitoring data to pre-assess sites that the team might want to visit before deployment, impurity analysis to make connections between chemical samples, and data analytics.

6.17 In the subsequent discussions of presentations on the FFM and DAT, the following points were raised:

(a) While each mission had its unique mandate and procedures and approaches, the challenges encountered and capabilities required had many areas of commonality. These challenges included the security situation, dynamic operating environments that often required improvisation by team members in order to accomplish their work, environmental conditions unsuitable for operation of some equipment, limitations from available (and transportable) equipment, other logistical challenges (for example, the transport of hazardous substances), and the pressures of working under stressful circumstances.

(b) Given the varied experiences and skills team members have obtained in the Syrian Arab Republic missions, qualified people who can mentor and guide new inspectors will remain a valuable asset to the Secretariat. As inspectors end their tenure at OPCW, their specialist experience may be difficult to replace.

(c) Inspectors benefit from a fast turnaround on chemical analysis after submission to the OPCW Laboratory to aid in decision making while deployed under time constrained circumstances. The TWG members noted that there is a balance between speed of returning results and thoroughness and/or quality of the results. The designated laboratories have achieved a high level of credibility that could be potentially compromised by relaxing some of the stringent quality measures in efforts to achieve a faster result.

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the Samples Provided by the Government of the Syrian Arab Republic in Relation to the Alleged Incident in Khan Shaykhun, Syrian Arab Republic, April 2017 (S/1521/2017, dated 28 July 2017); and (c) Note by the Technical Secretariat: Further Clarifications why the OPCW Fact-Finding Mission did not Deploy to Khan Shaykhun (S/1545/2017, dated 17 October 2017).

(d) On-site tools that could inform sampling could help alleviate pressure for immediate off-site laboratory analysis. Another approach could have the OPCW lab run preliminary tests to give quicker feedback to teams in the field, while the designated laboratories can conduct the customary thorough analysis of the samples according to the usual arrangements. Maintaining the reachback capability between the field team and OPCW Laboratory staff is critical for maximising efficiency of both of these approaches.

(e) Inspection teams could benefit from including a trained forensic expert. Other team members might receive forensic training as part of their overall inspector training.

(f) Confidential information obtained during the Syrian Arab Republic missions differs significantly from routine confidential information collected from States parties by OPCW. Ensuring that there are systems set up for storage and archiving that also allow retrieval and cross-referencing information collected in an investigation is important.

(g) Remote sampling technologies were briefly discussed, and should continue to be considered. However, easily transportable UAVs do not have the range and flight time suitable for deployment from very remote distances. Such tools have utility for mapping and imaging on-site once a team arrives, however specific use scenarios and operating procedures would need to be developed and tested. In regard to UAVs, the TWG was made aware of an EU Horizon 2020 Project, Remotely Operated CBRNe Scene Assessment Forensic Examination (ROCSAFE),[30] which is developing remote-controlled technologies to assess CBRNe crime scenes; progress of this project should be monitored.

(h) In addition to specific technical capabilities identified in the previous paragraphs, a need was identified for access to small mobile laboratories to enhance capabilities for on-site sample handling, and to make available an expanded set of analytical tools that can provide initial indications to inform sampling.

(i) For a number of the areas identified for further optimisation of capability, outside expertise would be needed. Understanding how to identify such expertise with suitable accreditation should be considered, as well as understanding the cases and types of scenarios (which in future, may include situations beyond what has been experienced to date within OPCW contingency operations) where a given expert is best suited.

7. AGENDA ITEM SEVEN – OPCW Operations

Subitem 7(a): Inspections and contingency operations

7.1 Dr Gareth Williams (Head, OPCW Inspectorate Safety and Chemistry Cell) presented an overview of routine and non-routine OPCW inspections. He began with the organisation of OPCW's Inspectorate and how it interacts with other units across the

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30 For further information on ROCSAFE, see: http://rocsafe.eu/.

Secretariat (including legal, security, policy, external relations, and capacity building functions). Backgrounds of OPCW inspectors include chemistry, chemical engineering, health and safety, chemical weapons and/or munitions, and toxicology. Routine missions include verification of chemical weapon stockpile destruction, industry inspections, and inspections related to old and abandoned chemical weapons.[31] While contingency operations refer to non-routine missions such as the DAT, FFM, technical assistance visits (TAV) at the request of a States Party,[32] the Rapid Response and Assistance Mission (RRAM),[33] and the recent removal and destruction of Category 2 chemical weapons from Libya.[34] Challenge inspections (CI) and investigations of alleged use (IAU) would also be non-routine missions.

7.2 Dr Williams described the process of mission planning and the logistics involved, including mission mandates and criteria for team selection, noting the need to consider scientific aspects of the mission, safety and security, confidentiality and any legal implications. Inspectors receive special training for safety and security, negotiation, forensic awareness, interview skills, communication from the field and monitoring of information. Dr Williams also noted that there is a wealth of expertise across the Secretariat that can be leveraged for advice for missions when necessary.

7.3 There is a need to constantly recognise and evaluate (under field conditions when possible) the availability of new equipment that could enhance the capability of inspection teams. Dr Williams briefly described the approved equipment list[35] and the approval processes. Equipment amenable to rapid deployment and use in non-permissive environments, such as unmanned systems for sampling and site surveillance and on-site analysis methods, are of particular interest for evaluation.

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

(a) With increasing involvement in non-routine inspections, hiring requirements for inspectors with broader and more flexible skill sets was discussed. In this regard, there may be benefit to moving away from current routine job descriptions. Some inspectors joining the Secretariat already possessing a degree of relevant forensic awareness would be desirable.

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31 For an overview of yearly OPCW Verification Activities, see: Summary of Verification Activities for 2016 (S/1537/2017, dated 19 September 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1537-2017_e_.pdf.

32 For example: Report of the Technical Assistance Visit to Iraq (S/1559/2017, dated 6 December 2017).

33 (a) Establishment of a Rapid Response Assistance Team (S/1381/2016, dated 10 May 2016); www.opcw.org/fileadmin/OPCW/S_series/2016/en/s-1381-2016_e_.pdf; (b) Guidelines for States Parties Requesting a Rapid Response and Assistance Mission (S/1429/2016, dated 17 October 2016); www.opcw.org/fileadmin/OPCW/S_series/2016/en/s-1429-2016_e_.pdf.

34 For recent updates on this work, see: (a) Status of the Implementation of the Plan for the Destruction of Libya's Remaining Category 2 Chemical Weapons Outside the Territory of Libya (EC-87/DG.6, dated 22 December 2017); www.opcw.org/fileadmin/OPCW/EC/87/en/ec87dg06_e_.pdf; and (b) Completion by Libya of the Destruction of its Chemical Weapons Stockpiles (EC-87/DG.9, dated 24 January 2018).

35 See for example: Information for Familiarisation Purposes for National Authorities of States Parties on Approved Inspection Equipment (S/1375/2016, dated 18 April 2016); www.opcw.org/fileadmin/OPCW/S_series/2016/en/s-1375-2016_e_.pdf.

(b) Technical capabilities of value for inspectors include on-site chemical forensic analysis, miniaturised analytical instruments and data analytics.

(c) The value of further developing sampling and analysis guidelines for the field was also discussed, and could be the focus of OPCW facilitated training in member States.

(d) Continuity for training procedures and incorporating lessons learned from the Secretariat's involvement with contingency operations into training was also noted as important.

Subitem 7(b): Challenge Inspection and the Rapid Response and Assistance Mission

7.5 Mr Ian Henderson (OPCW Inspection Team Leader) presented an overview of a CI and the RRAM, the latter having recently completed a training exercise in Romania.[36]

7.6 Beginning with a CI, Mr Henderson explained that since entry-into-force of the Convention, a CI has never been requested; however the Secretariat is obliged to maintain preparedness for this possibility. Compared with other contingency operations the CI is somewhat specific, in that it is an inspection mandated and structured in some detail in the Convention. Provisions include using only approved equipment, and the understanding that all activities in the inspected State Party are subject to their agreement. The modalities of a CI appear to be aimed at circumstances where one State Party raises concerns about possible non-compliance in another State Party, relating to something that is militarily significant (e.g. hundreds of tonnes of chemical weapon agents or munitions). The procedures are predicated on a State Party finding it difficult to hide a major chemical weapons programme in a chemical weapons free world. Mr Henderson noted that a CI may not be well suited to alternative scenarios (specifically, situations that were not foreseen at the time of the drafting of the Convention).

7.7 Moving on to the RRAM, Mr Henderson explained that this is a new type of OPCW mission that presents new challenges in areas where the Secretariat has previously not needed to maintain readiness. The mission can be considered unconstrained by any Convention inspection-type requirements, seeing as a RRAM is an assistance operation in response to a request from a State Party. However the location and unknown scope of the circumstances makes it difficult to prepare for all possible scenarios. A RRAM mission is intended to provide emergency measures of assistance to a State Party that has been affected by an incident of alleged use of toxic chemicals by a non-State actor. The main elements of assistance that can be provided in a RRAM, are:

(a) recommendations on how to secure and isolate the affected area and on how to avoid cross-contamination of other areas;

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36 See OPCW News Item: Field Exercise in Romania to Improve OPCW's Rapid Response and Assistance Capabilities, dated 14 December 2017; www.opcw.org/news/article/field-exercise-in-romania-to-improve-opcws-rapid-response-and-assistance-capabilities/.

(b) detection and characterisation of toxic chemicals using on-site analytical equipment brought by the team;

(c) taking of samples for off-site analysis, in accordance with OPCW procedures;

(d) advice on decontamination;

(e) advice on treatment for the victims;

(f) advice on reconnaissance of the affected location(s) or other security efforts; and

(g) advice on how to secure the area for forensic examination and isolate forensic evidence.

7.8 A RRAM might be deployed when a State Party has limited capability to respond to an attack involving toxic chemicals, with the RRAM providing emergency measures of assistance, and requiring rapid deployment. In the absence of any definitive means of rapid transportation for the RRAM team (such as a memorandum of understanding with an existing rapid deployment agency), it may be assumed that the most rapid means of deployment will be by commercial air travel. Equipment carried by the team, whilst being non-constrained by the Requesting State Party (RSP), will thus not be allowed to contain dangerous goods. These, if required, may follow at a later stage as a cargo shipment and would thus arrive too late to support the initial emergency measures.

7.9 Perhaps the most critical element of support the RRAM team can provide is to positively identify any toxic chemicals that have been used in an attack as soon as possible. This plays a major role in most aspects of the RRAM, as the nature of the toxic chemical will influence medical treatment protocols, incident site management, and decontamination. The toxic chemical will also be a factor in any subsequent investigation by the RSP or other agencies. Available detection and analysis equipment that can be carried with the team is limited currently to the handheld chemical agent monitors (such as the LCD 3.3), detection paper, and portable Raman and FTIR[37] spectrometers.[38] The Secretariat could benefit from enhanced detectors and analysers, including truly portable and transportable GC-MS systems that can be carried by the team without requiring transport of dangerous goods.

7.10 The RRAM team would also include Health & Safety Specialists (e.g. paramedics) whose role it will be to assist and provide advice on treatment of victims. However, even with a rapid deployment, a RRAM team would arrive at an incident location after the first-responder period has elapsed, and most likely the casualties will already be under hospital care. Whatever the case, it is envisaged that the RRAM team may still be one of the first external agencies to arrive at the scene, and team members may facilitate useful exchanges of information by interviewing patients and hospital staff, relaying this to headquarters (or other agencies), and by providing whatever advice

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37 FTIR = Fourier-transform infrared spectroscopy.

38 For a review of hand held chemical agent detectors, see. Testing of hand-held detectors for chemical warfare agents; A.-B. Gerber, *SPIEZ LABORATORY Annual Report 2015*, 38-39. Available at: https://www.labor-spiez.ch/pdf/en/dok/jab/88_003_e_laborspiez_jahresbericht_2015_web.pdf.

and assistance they can to the medical specialists under whom the victims are being treated. There may well be new developments in portable diagnostic or biomedical analytics that could enhance the effectiveness of the team.

7.11 Mr Henderson provided further views on areas where technologies could play a role in improving RRAM team effectiveness, these include:

(a) incident site investigation (reconnaissance) using remote access, sensing and sampling/analysis;

(b) detection equipment for other threat materials such as biological warfare agents (especially toxins); and

(c) advances in plume modelling and decontamination.

7.12 Concluding, Mr Henderson noted that the RRAM team is not mandated to conduct an investigation, yet it may be expected that an incident it responds to could be designated a crime scene. Under such circumstances it would be likely that the RRAM team will be reporting to a RSP incident commander, who in turn will be interfacing with a lead investigator from the RSP. Any onsite activities of the RRAM team, as pertaining to the investigation, might thus be under the direction of the RSP authorities and subject to their protocols. Training and tools for investigative science and forensics, in-particular non-destructive chemical analysis methods and information analysis capabilities, could be valuable for RRAM.

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

(a) While CI's may be constrained by approved equipment and other limitations, an area of investigative science that could be valuable is the authentication of documents and digital information.

(b) Given the rapid deployment requirements, it was noted that many of the constraints currently found in contingency operations would also impact RRAM; especially regarding logistics and transportation of equipment and/or dangerous goods.

(c) Forensic awareness within a RRAM is an area that should be carefully considered. If a RRAM becomes tied to a criminal investigation conducted by a requesting States Party, the methods and processes used may have legal implications.

8. AGENDA ITEM EIGHT – Operational realities of OPCW contingency operations

8.1 Ms Katarina Grolmusova (Analytical Chemist, OPCW Inspectorate) provided the TWG with an operational level perspective on OPCW contingency operations. Using examples from FFM and TAV missions in which she had participated, pre-deployment planning and activities, and how these can impact the mission capabilities, post-deployment activities, and challenges faced by inspectors in the field were highlighted. Ms Grolmusova emphasised that these missions require inspectors to be able to operate in unpredictable and dynamic environments, where improvised problem solving is often required.

8.2 The challenges in conducting non-routine missions have many dimensions, including non-technical issues that can impact on the capabilities of a mission team. These can include customs and transportation regulations (especially regarding dangerous goods) that can delay arrival of, or prohibit access to, certain equipment, short-notice deployment and security concerns. Once inspectors are on the ground, they may have time limited access to investigation sites, find themselves working under unfavourable environmental conditions (this can generate challenges with the operation of portable analysis equipment and protective equipment) and samples they collect may have low purity and/or impurities that interfere with analytical methods. Chain-of-custody and properly documenting evidence is required from the point of collecting/receiving a sample through its handling, transportation, storage and analysis (and beyond); requiring careful attention under potentially stressful conditions. Collected evidence often includes videos, photos and witness statements, which must also be authenticated, requiring expertise beyond chemical analysis. Cultural differences and gender issues can impact interviews, requiring awareness of these issues and how to address them by the inspectors. Finally, on return from a mission, inspectors may also be under time pressure to produce a mission report.

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

(a) The TWG noted the importance of capturing the views and practices of the inspectors from the field to provide guidance to others who might be involved in similar missions.

(b) The human side of inspection teams is another important area that should not be overlooked, to ensure mental and physical health for those working in stressful and potentially dangerous environments.

9. AGENDA ITEM NINE – The role of laboratories

Subitem 9(a): The role of the OPCW Laboratory

9.1 Dr Marc-Michael Blum (Head OPCW Laboratory) introduced the TWG to the OPCW Laboratory, describing its core mission to enable the Secretariat to conduct sampling and analysis missions through maintaining and certifying GC-MS systems for on-site analysis; maintaining and coordinating a network of designated laboratories[39] through Proficiency Testing[40] (and through other means such as biotoxin analysis

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39 OPCW Designated Laboratories as of 31 August 2017 (a) Status of Laboratories Designated for Analysis of Authentic Environmental Samples (S/1529/2017, dated 31 August 2017 and Corr.1, dated 8 September 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1529-2017_e_.pdf; and (b) Status of the Laboratories Designated for the Analysis of Authentic Biomedical Samples (S/1516/2017, dated 11 July 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1516-2017_e_.pdf.

40 (a) For a tentative schedule of upcoming proficiency tests, see Tentative Schedule for Official OPCW Proficiency Tests in 2018 and 2019 (S/1563/2017, dated 21 December 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1563-2017_e_.pdf; (b) For recent results of an environmental sample proficiency test, see: Evaluation of the Results of the Forty-First Official OPCW Proficiency Test (S/1528/2017, dated 31 August 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1528-2017_e_.pdf; and (c) For the recent results

exercises[41]); maintaining and expanding the OPCW Central Analytical Database (which recently was allowed to include non-scheduled chemicals); method development and validation; and the certification of analytical chemist inspectors. The OPCW Laboratory also serves as a central focal point within the Secretariat on all matters related to chemical analysis, for which it provides science based advice.

9.2 Explaining where capabilities in chemical forensics would provide enhancements to the OPCW Laboratory, Dr Blum identified impurity profiling (qualitative and quantitative), the use of chemometrics and the determination of stable isotopes (using methods such as IRMS[42] and SNIF-NMR[43,44]) as methods of interest. These capabilities might be realised through collaborations, and exchanging best practices with the designated laboratories. Outside the designated laboratories, sharing of knowledge and expertise with other laboratories in States Parties, and recognising potential methods that could be transferred from academia for further development would be useful to consider. Dr Blum concluded with an update on the OPCW Laboratory enhancement project,[45] noting that this would increase the level of capability and expertise of the OPCW Laboratory, allowing it to better engage with a broader network of laboratories in areas of common interest.

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

(a) Following Dr Blum's presentation, discussion on reachback between field inspection teams and the off-site laboratory in regard to sampling guidance and sample prioritisation continued. The ability of the OPCW Laboratory to act as a point of contact for designated laboratories provides greater opportunities for ensuring field teams receive necessary expert advice when needed.

(b) Developing methods that include greater uses of forensic approaches will require learning from practitioners of applied scientific fields whose work relies on investigation and reconstruction of past events. Access to experts

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of a biomedical sample proficiency testing, see: Evaluation of the Results of the Second Official OPCW Biomedical Proficiency Test (S/1515/2017, dated 11 July 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1515-2017_e_.pdf.

41 The second protein biotoxin exercise was run in December 2017, see: Call for Nominations for an Exercise on Analysis on Protein Biotoxins (S/1538/2017, dated 4 October 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1538-2017_e_.pdf.

42 IRMS = isotope ratio mass spectrometry.

43 SNIF - NMR = site-specific natural isotope fractionation - nuclear magnetic resonance.

44 Accurate quantitative ^{13}C NMR spectroscopy: repeatability over time of site-specific ^{13}C isotope ratio determination; E. Caytan, E. P. Botosoa, V. Silvestre, R. J. Robins, S. Akoka, and G. S. Remaud; *Anal. Chem.*; 2007, *79(21)*, 8266 – 8269. DOI: 10.1021/ac070826k.

45 (a) Upgrading the OPCW Chemical Laboratory to a Centre for Chemistry and Technology (S/1512/2017, dated 10 July 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1512-2017_e_.pdf; (b) Request from the Director-General to States Parties for Voluntary Contributions to a New Trust Fund for Upgrading the OPCW Chemical Laboratory to a Centre for Chemistry and Technology (S/1561/2017, dated 8 December 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1561-2017_e_.pdf; and (c) Needs Statement for Upgrading the OPCW Chemical Laboratory to a Centre for Chemistry and Technology (S/1564/2017, dated 22 December 2017); www.opcw.org/fileadmin/OPCW/S_series/2017/en/s-1564-2017_e_.pdf.

from beyond established networks of chemical warfare agent analytical chemistry with suitable accreditation will be needed.

(c) Understanding the performance of a given method has value for the review of results by the inspection teams. Understanding the limit of detection (LOD), interferences and other performance characteristics of a given method, and between methods used in each of the laboratories that analysed a split sample, could be helpful to explain possible differences in reported results. For example, a chemical might be reported as detected by one laboratory and not another because its concentration in the sample was below the LOD of the method employed by the non-reporting laboratory.

Subitem 9(b): Atmospheric pressure photoionisation-mass spectrometry - mass spectrometry: an alternative data rich method of analysis of Chemical Weapons Convention related chemicals

9.4 Dr Murty Mamidanna (Senior Analytical Chemist, OPCW Laboratory) presented work from the OPCW Laboratory. He began by describing methods used for analyses of environmental samples, noting that the identification of a chemical must be based on at least two different analytical techniques giving consistent results. The primary technique must be a data rich spectrometric or spectroscopic technique such as GC-MS (EI),[46] GC-MS/MS (CI),[47] LC-MS/MS (ESI),[48] NMR or IR[49] spectroscopy. The most widely used primary technique for the detection and identification of chemical warfare agents, and their reaction or degradation products, is GC-MS. For some of the relevant chemicals, GC-MS is only possible through derivatisation.[50] LC-MS/MS (ESI) and GC-MS/MS (CI) are also considered as data rich primary techniques; however for these there are no available spectral databases. There is also ambiguity in the reporting criteria, according to which adequate fragmentation is required, however with LC-MS/MS (ESI) or GC-MS/MS (CI) methods, very limited fragmentation is possible.

9.5 With the increase in OPCW contingency operations, Dr Mamidanna indicated that large numbers of samples are often collected for off-site analysis. Off-site analysis of samples is a laborious process, requiring extensive sample preparations to screen for various Convention relevant chemicals. Due to complex matrix interferences in the samples, solvent extractions and/or sample clean-up is often necessary. One must also obtain analytical data from at least two techniques for each and every chemical identified in the samples. Reducing work load without compromising data quality will require new methods and approaches.

46 GC-MS (EI) = gas chromatography – mass spectrometry (electron ionisation).

47 GC-MS/MS (CI) = gas chromatography – mass spectrometry/mass spectrometry (chemical ionisation).

48 LC-MS/MS (ESI) = liquid chromatography – mass spectrometry/mass spectrometry (electrospray ionisation).

49 IR = infrared.

50 Analysis of chemical warfare agents by gas chromatography-mass spectrometry: methods for their direct detection and derivatization approaches for the analysis of their degradation products; C. A. Valdez, R. N. Leif, S. Hok, B. R. Hart; *Reviews in Analytical Chemistry*; 2017, ISSN (Online) 2191-0189. DOI: doi.org/10.1515/revac-2017-0007.

9.6 Dr Mamidanna has been exploring the use of atmospheric pressure photoionisation (APPI) as a possible alternative technique which can produce adequate fragmentation for structural elucidation. APPI is a relatively novel ionisation interface for an LC-MS/MS system that is used to produce ions that enter the mass spectrometer.[51] APPI initiates ionisation with 10 eV photons emitted by a krypton discharge lamp; this lamp replacing the discharge needle used in atmospheric pressure chemical ionisation (APCI). Otherwise the APPI ion source is very similar to the heated nebuliser body in APCI. To initiate the ionisation process, a substance of favourable ionisation energy, referred to as a dopant, is introduced into the source.[52]

9.7 Results were presented from analysis of sulfur mustard degradation products. Hexane, toluene and anisole were tested as dopants, optimising the conditions to generate dopant radical cations. The mustard degradation product samples were analysed without any sample preparation and/or derivatisation, and data rich EI-like spectra were generated. Using a dual mode APPI-APCI source, it might be possible to obtain data from the two techniques in a single analytical run; this could meet OPCW proficiency test criteria. The OPCW Laboratory is testing the feasibility of this approach. While the results appear promising, more research is necessary to find optimised conditions which could work for the broad range of Convention relevant chemicals that might be analysed.

9.8 The TWG considered the work presented by Dr Mamidanna to be very promising as a soft ionisation technique that allows fragmentation patterns to be produced. The TWG encourages the OPCW Laboratory to continue further development.

Subitem 9(c): The role of designated laboratories in chemical weapons related investigations: bringing forensic techniques into the designated laboratory toolbox

9.9 Professor Paula Vanninen provided an overview on criteria for the OPCW designated laboratories and their operational requirements. As an example of forensic analysis she introduced ricin analysis at VERIFIN for collecting forensic evidence for Finnish police. OPCW designated laboratories have highly qualified experts, are well equipped and use established reporting criteria. Laboratories are also capable of analysing various chemicals beyond chemical warfare agents.[53]

9.10 OPCW designated laboratories do not carry out forensic chemical investigations of samples that have been provided to them by the OPCW. That is, the laboratories do not establish linkages of chemical analysis results with other information to attribute a chemical attack.. Noting that outsourcing/subcontracting is not allowed for the designated laboratories for analysis of authentic samples, Professor Vanninen inquired

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51 Atmospheric pressure photoionization: An ionization method for liquid chromatography–mass spectrometry; D. B. Robb, T. R. Covey, A. P. Bruins; Anal. Chem.; 2000, *72(15)*, 3653 – 3659. DOI: 10.1021/ac0001636.

52 Atmospheric pressure photoionization mass spectrometry. ionization mechanism and the effect of solvent on the ionization of naphthalenes; T. J. Kauppila, T. Kuuranne, E. C. Meurer, M. N. Eberlin, T. Kotiaho, R. Kostiainen; *Anal. Chem.*; 2002, *74(21)*, 5470–5479. DOI: 10.1021/ac025659x.

53 *Recommended operating procedures for analysis in the verification of chemical disarmament 2017 Edition*; P. Vanninen (ed); University of Helsinki, Finland, 2017. For further information see: http://www.helsinki.fi/verifin/bluebook/.

about the possibility of the OPCW Laboratory collaborating not only with designated laboratories but also with accredited forensic laboratories in the area of provenancing. If OPCW designated laboratories were required to conduct these types of forensic investigations, new types of training and new resources would be required. The TWG might define minimum levels of technical capability. Professor Vanninen brought up points for further discussion in the TWG that included guidance on sampling strategies and procedures, developing confidence building exercises for forensic analysis, creating and testing of new recommended operating procedures (ROPs) for forensic analysis, and whether or not reporting criteria could be re-evaluated to allow one identification method combined with other supporting evidence for forensic purposes.

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

(a) Designated laboratories can learn from the experiences of forensic laboratories and their approaches to provenancing chemicals and materials. Table top exercises might be a valuable way to start, allowing the Secretariat, the designated laboratories, and forensic experts to better understand the needs and approaches of one another.

(b) Current procedures do not allow designated laboratories to send samples to other labs for outsourced analysis; this may be an opportunity for the OPCW Laboratory to expand its capability to handle these specialised analysis requirements and/or facilitate access to laboratories with suitable capabilities.

(c) Not all designated laboratories have technical agreements allowing them to participate in the analysis of authentic samples from OPCW investigations this limits the number of laboratories that can be available when necessary.

(d) Procedures for sample prioritisation in laboratory analysis would be helpful for those laboratories receiving authentic samples. Pre-screening or obtaining initial results on-site and at the OPCW Laboratory could be useful in this regard.

(e) Having as much information as possible on a sample when received by a designated laboratory helps guide which chemicals to test for. This is viewed as especially valuable for biomedical samples, where information on symptoms exhibited by the individual might be provided.

(f) For interpretation of results where authentic samples are compared to reference standards, the purity of the standards would be useful to report.

(g) Probabilistic outputs of an analysis that help to identify a given chemical present in a sample would be useful to consider. Developing such methods requires statistical rigour. It was also noted that if there are changes to reporting criteria for designated laboratories, those receiving the reports must be able to understand the impact of any changes on how to interpret the results.

(h) Data access and the ability to draw on data produced for (and owned by) the United Nations or the OPCW was discussed. Such data has scientific value for validation of methods. United Nations data (in specific cases) have been made available for scientific purposes, and published in scientific literature (see paragraphs 12.3 – 12.4).

(i) Communication from laboratory to the field was further discussed, the OPCW Laboratory is the contact point for teams in the field and for the designated laboratories. Practices could be reviewed as part of the on-going enhancement of capability.

(j) Areas where the TWG could provide guidance would include how to define minimum instrumentation and capability requirements for a validated analysis, defining criteria for acceptance of new techniques and technologies, and the development of inorganic analysis.

10. AGENDA ITEM TEN – From collection to courtroom

10.1 Ms Anna Davey (Forensic Foundations™,[54] guest speaker) provided an overview on how scientific information is brought into a courtroom. Traditionally the term 'forensic' means 'pertaining to or used in courts of law' but over time the meaning has expanded to work conducted for investigative and/or intelligence purposes in addition to that used in court proceedings. The audiences of these different scopes of work differ, as do the questions they ask, and the level of scrutiny they apply to the work. Work examined as part of the legal process often undergoes a degree of scrutiny that routine testing does not, and that scrutiny may be by non-scientists. In addition, courts have developed their own rules and procedures for the presentation of expert evidence.

10.2 Beginning with understanding the legal environment, Ms Davey pointed out the number of different legal systems in use across the world and how these will affect the way in which the work is received and the level of scrutiny given. The investigative/legal process is often thought of as a linear process, but the forensic process is better represented as a Venn diagram of three overlapping domains. These domains being: (1) searching, recording, examination and collection; (2) examination, analysis, interpretation and review; and (3) legal applications, report writing, and provision of court testimony and discovery. The activities in each domain impact on the activities in the other domains. There are significant differences in the scientific and legal methods of enquiry which impact on individuals and organisations working at this interface.[55] There are also different questions being asked. These differences need to be recognised by both sides.

10.3 Working within the legal environment, it is rarely the science that is disputed in court (unless it is new or "novel"); rather it is usually the operational aspects of the testing or examination process that receive the heaviest scrutiny, the focus of the examination is generally put on the most vulnerable aspects of testing with the aim to discredit the

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54 For further information on Forensic Foundations™, see: https://www.forensicfoundations.com.au/.

55 (a) The disconnect between scientific and legal method; A. Tompkins; Paper presented at the Legal Research Foundations Conference: The Role and Use of Expert Witnesses in Trials, November 2002. (b) Forensic culture as epistemic culture: The sociology of forensic science; S. A. Cole; *The Sociology of Forensic Science. Studies in History and Philosophy of Biological and Biomedical Sciences*; 2013; *44*, 36-46.

scientific results. Although forensic science experts have been giving expert evidence in courts for hundreds of years, issues still arise, both with the science itself and with the level of communication between the parties.[56]

10.4 Moving to current issues, Ms Davey noted that there are a number of recently published critical reviews of forensic science,[57] which have resulted in increased scrutiny and improvements in many areas. Issues can include technical requirements (e.g. validation and verification, standards and controls, and reliability) and/or personnel requirements (e.g. training and authorisation, ongoing competency/proficiency testing, legal literacy for experts, and scientific literacy for lawyers).

10.5 Ms Davey provided information for the TWG on available forensic resources that they might consider for relevance to the work of the OPCW. These include crime scene benchmarks;[58] ISO standards (17025 and 17020); and forensic standards,[59,60,61] and resources available from ANZPPA/NIFS,[62,63] the UK Forensic Regulator[64,65] and the National Clearing House of Science, Technology and Law.[66]

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56 *Australian Magistrates' Perspective on Expert Evidence: A Comparative Study*, I. Freckelton, P. Reddy H. Selby. The Australian Institute of Judicial Administration; 2001.

57 (a) National Research Council. Strengthening Forensic Science in the United States; A Path Forward. National Research Council; 2009; https://www.ncjrs.gov/pdffiles1/nij/grants/228091.pdf; (b) The Law Commission. Expert Evidence in Criminal Proceedings in England and Wales. The Law Commission; 2011; https://www.lawcom.gov.uk/project/expert-evidence-in-criminal-proceedings/; and (c) President's Council of Advisors on Science and Technology. Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature - Comparison Methods. Executive Office of the President; 2016; https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_forensic_science_report_final.pdf.

58 Quality Management in the Forensic Sciences. Expert Evidence; A. Ross, A. Davey; Thomson Lawbook Co.; 2017.

59 The Development of a Core Forensic Standards Framework for Australia; J. Robertson, K. Kent, L. Wilson-Wilde; *Forensic Science Policy & Management: An International Journal*; 2013, *4(3-4)*, 59-67. DOI: 10.1080/19409044.2013.858797.

60 For example: AS 5388.1 Recognition, recording, recovery, transport and storage of material; AS 5388.2 Analysis and examination of material, AS 5388.3 Interpretation, AS 5388.4 Reporting, ISO/FDIS 21043-1 – Forensic Sciences - Terms, definitions and framework.

61 From the International Organization for Standardization: ISO/FDIS 21043-2 – Forensic Sciences -Recognition, recording, recovering, transport and storage of items; ISO/WD 21043-3 – Forensic Sciences – Analysis; ISO/WD 21043-4 – Forensic Sciences – Interpretation; ISO/WD 21043-5 -Forensic Sciences – Reporting; https://www.iso.org/committee/4395817.html.

62 ANZPAA/NIFS = Australia New Zealand Police Advisory Agency/National Institute of Forensic Science Australia New Zealand. For further information see: https://www.anzpaa.org.au/forensic-science/our-work/products/publications.

63 For example: (a) Australia and New Zealand Guidelines for Digital Imaging Processes; http://www.anzpaa.org.au/about/general-publications/guidelines-for-digital-imaging-processes; and (b) The Intelligent Use of Forensic Data: An Introductory Guide to Evaluative Reporting; http://www.anzpaa.org.au/about/general-publications/forensic-data.

64 For further information on the UK Forensic Regulator, see: https://www.gov.uk/government/collections/forensic-science-providers-codes-of-practice-and-conduct.

65 For example: (a) Digital forensic services: codes of practice for forensic service providers; https://www.gov.uk/government/publications/digital-forensic-services-codes-of-practice-for-forensic-service-providers;

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

(a) When discussing standards, the purpose these standards would be applied to must be considered: investigation, intelligence, or use in a courtroom.

(b) Ms Davey noted that there are forensic modules that sit on top of ISO17025 that could be of interest.

(c) CBRN incident statistical analysis is often difficult due to limited data. Bayesian statistical models may help, but need good statistical expertise to fully understand limitations and where appropriate to use.

11. AGENDA ITEM ELEVEN – Crime scene management and forensic analysis

Subitem 11(a): CBRN Crime scene management and forensic analysis in Serbia

11.1 Mr Marko Milivojevic (Regional Forensic Division, Ministry of Interior of the Republic of Serbia, guest speaker) briefed the TWG on the work of the National Criminalistic-Technical Centre (NCTC or National Forensic Centre),[67] which resides within the Criminal Investigation Department of the General Police Directorate of the Ministry of Interior of the Republic of Serbia. In regard to chemicals, Serbia is sometimes used as a transit country for illegal drug traffic, with clandestine labs for illegal drug production found within the national boundaries. While the drug related chemicals may not be scheduled under the Convention, they can also be very toxic. Illegal dumping of chemical wastes is another problem that has been encountered. This can be a challenging issue for developing governmental capacities for the regulation of chemicals and chemical related activities.

11.2 The NCTC performs integrated forensic expertise in almost all fields of investigations fulfilling the needs of police departments, prosecutors' offices and courts in the Republic of Serbia. NCTC maintains its headquarters in Belgrade with regional forensic centres in Novi Sad, Niš and Užice. There are 152 employees with a broad range of educational backgrounds and relevant expertise. The NCTC is a member of the European Network of Forensic Science Institutes (ENFSI),[68] and regularly takes part in ENFSI (and other) expert working groups. Forensic competencies are developed, and maintained through accreditation to international standards (notably ISO/IEC 17025). This has required that NCTC develop a series of Standard Operative Procedures (SOPs) and training manuals, making it a qualified institution for education and improvement across forensic disciplines.

(b) Method validation in digital forensics; https://www.gov.uk/government/publications/method-validation-in-digital-forensics; (c) Cognitive bias effects relevant to forensic science examinations; https://www.gov.uk/government/publications/cognitive-bias-effects-relevant-to-forensic-science-examinations.

66 For further information on the National Clearing House of Science, Technology and Law, see: http://www.ncstl.org.

67 For additional information see: http://arhiva.mup.gov.rs/cms_eng/home.nsf/NFC.h.

68 For additional information on ENSI, see: http://enfsi.eu/.

11.3 Serbia has acquired skills in CBRN forensics through the European Union Centre of Excellence (CoE) initiative for CBRN risk mitigation,[69,70] participating in projects that have included the Generic Integrated Forensic Toolbox for CBRN incidents (GIFT).[71] The NCTC Training Centre for criminal processing and dismantling of clandestine drug laboratories is a unique training centre on Goč Mountain, where the United States Drug Enforcement Agency (DEA) and EUROPOL operational staff hold training exercises for chemical crime scene and laboratory Investigations. NCTC continues to build capabilities (learning from others) and provide training.

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

(a) The Goč Mountain training centre could offer opportunities to engage with forensic experts.

(b) SOPs and ROPs for working in chemically-contaminated environments are valuable and of interest to many forensic laboratories and police forces. The Secretariat's expertise in this area could be valuable to share.

Subitem 11(b): The collection, preservation and analysis of trace evidence in explosion cases

11.5 Dr Zhenwen Sun (guest speaker, Institute of Forensic Science, Beijing, China) presented an overview of the steps involved in explosion scene investigations. He described how a crime scene is secured, ensuring it is safe for investigators to enter, and the methods of collection, preservation and analysis[72] of explosive residues and improvised explosive device (IED) components. He concluded with examples of the development of scene investigation and evidence examination procedures in China. The approaches to these crime scenes may prove useful in investigations involving Convention related incidents.

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

(a) Examples of the application of tools useful for on-site guidance on sample collection (e.g. hand held analysis tools, or UAV systems for site surveillance and mapping) were described. The Secretariat might consider how and when such tools might be applied to Convention-related investigations.

(b) On-site prioritisation of where to, and which, samples to collect is an important consideration. Experienced investigators who are able to recognise

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69 For additional information on the EU CoE CBRN initiative, see: http://www.cbrn-coe.eu/.

70 A place to stand to move the Earth; M. Milivojevic; *CBRNe World*, April 2017, 25-28; http://www.cbrneworld.com/_uploads/download_magazines/A_place_to_stand.pdf.

71 For additional information on GIFT, see: https://cordis.europa.eu/project/rcn/192217_en.html.

72 (a) Application of Spectra Accuracy for Analysis of Organic Explosive: 2,4,6-trinitrotoluene by AccuTOF-DART; Z. Liu, Z. Sun, G. Zhang, J. Zhu, H. Mei, H. Li, B. Li, J. Xu, H. Zhou.; *J Forensic Sci Med*, 2016, *2*, 190-194. (b) Identification of Nitro Explosives by Direct Analysis in Real-Time Time-of-Flight Mass Spectrometry; Z.-F. Liu, B. Xu, Z.-W. Sun, Y.-Y. Sun, H. Zhou, J. Zhu, J.-Z. Xu, X.-K. Duan, C. C. Liu; Analytical Letters, 2017, 50(14), 2234-2245. DOI: 10.1080/00032719.2017.1282503.

the important signatures of forensic interest relating to an incident are invaluable for guiding the work of investigation teams.

Subitem 11(c): An overview of forensic techniques

11.7 Dr Ed van Zalen discussed forensic techniques and methods using the experience of the Netherlands Forensic Institute (NFI).[73] NFI, an agency of the Dutch Ministry of Justice and Security, is an impartial supplier of forensic investigation for law enforcement in the Netherlands and also for international organisations such as the United Nations, the International Atomic Energy Agency (IAEA),[74] The International Criminal Police Organization (INTERPOL),[75] the International Criminal Court (ICC)[76] and the OPCW. The NFI has 40 expertise areas and employs an integrated approach in its casework, innovation and outreach activities.

11.8 The 40 expertise areas include a range of instruments and methods such as polymerase chain reaction (PCR) for human and non-human DNA analysis, GC-MS, LC-MS/MS, X-ray diffraction (XRD) and X-ray fluorescence (XRF) for analysing and identifying chemicals and particles in complex matrices of human sources, gunshot residues, environmental samples, explosives and chemicals. Laser ablation isotope ratio mass spectrometry (LA-IRMS) and scanning electron microscopy (SEM)-XRF methods have been developed for attribution analysis of chemicals, explosives, tape and glass. Microscopy is of great importance for the comparison of ammunition, tool marks and fibres. Digital forensics focusses on hardware, investigating cell phones, data carriers, software, and encryption; requiring accessing and structuring large amounts of data.

11.9 To start the investigation of a chemical, biological, radiological, and/or nuclear (CBRN) crime scene, an action plan is prepared based upon the questions asked by the investigative authority, reconnaissance of the crime scene, intelligence, tactical information and a hazards risk assessment. The crime scene investigation is elaborated with on scene analysis, sampling traditional forensic traces and sampling the CBRN agents. The samples are registered, packaged and transported to a laboratory facility where the triage of the evidence takes place. The questions being asked and the materials collected will guide the determination of which laboratory will do the forensic investigation based on its capabilities. This could be a forensic laboratory for the traditional forensic work, a CBRN laboratory for identification and characterisation of the agents, or a combined CBRN/forensics laboratory.

11.10 Dr van Zalen reminded the TWG that, in support of forensic investigations, additional requirements are needed: chain of custody, preservation of evidence, care to avoid cross contamination, case reports, the role of the expert, validated forensic methods, and training and education of experts.

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

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

74 For further information on the IAEA, see: https://www.iaea.org/.

75 For further information on INTERPOL, see: https://www.interpol.int/.

76 For further information on the ICC, see: https://www.icc-cpi.int/.

(a) NFI has helped develop SOPs for CBRN crime scene investigations through the GIFT project.

(b) There is great value in obtaining fieldable miniaturised equipment as this allows the "laboratory" to be brought to the crime scene.

(c) ENFSI was noted as a resource to identify accredited expertise in forensic capabilities.

(d) Effective reachback from the field was recognised as a means to enhance capabilities of the investigative team.

12. AGENDA ITEM TWELVE – Chemical warfare agent analysis

Subitem 12(a): Chemical Forensics International Technical Working Group: objectives, gaps and collaboration

12.1 Dr Carlos Fraga briefed the TWG on the Chemical Forensics International Technical Working Group (CFITWG), which was created in April 2017 to address science and capability gaps in methods for performing chemical forensics on weaponised chemicals.[77] He explained that provenancing can tell how and where a weaponised chemical was made to help find perpetrators or facilitators of chemical attacks, and/or detect the illicit proliferation of chemical weapon precursors. Dr Fraga highlighted the need for testing protocols across as many laboratories as possible to refine and validate the robustness of approaches and protocols; to gain access to more representative samples, methods and approaches developed from case studies of chemical warfare agent use; and for the establishment of international scientific credibility of methods in the event results from these methods are taken into a court. In regard to scientific credibility, Dr Fraga noted the importance of publication of analytical chemistry and forensic methods in peer-reviewed scientific credibility, Dr Fraga noted the importance of publication in peer-reviewed scientific literature.[78,79]

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77 Chemical Forensics International Working Group, Inaugural Workshop Report, 5 April 2017.

78 Some representative examples: (a) Toxicological analysis of victims' blood and crime scene evidence samples in the sarin gas attack caused by the Aum Shinrikyo Cult; Y. Seto, N. Tsunoda, M. Kataoka, K. Tsuge, T. Nagano; *ACS Symposium Series*; 1999, *745*, 318-332. DOI: 10.1021/bk-2000-0745.ch021. (b) Impurity profiling to match a nerve agent to its precursor source for chemical forensics applications. C. G. Fraga, G. A. Pérez Acosta, M. D. Crenshaw, K. Wallace, G. M. Mong, H. A Colburn; *Anal. Chem.*; 2011, *83(24)*, 9564–9572. DOI: 10.1021/ac202340u. (c) Preliminary effects of real-world factors on the recovery and exploitation of forensic impurity profiles of a nerve-agent simulant; C. G. Fraga, L. H. Sego, J. C. Hoggard, G. A. Pérez Acosta, E. A. Viglino, Jon H. Wahl, R. E. Synovec; *Journal of Chromatography A*; 2012, *1270*, 269-282. DOI: 10.1016/j.chroma.2012.10.053. (d) Profiling of volatile impurities in tetramethylenedisulfotetramine (TETS) for synthetic-route determination, C. G. Fraga, J. H. Wahl, S. P. Núñez; *Forensic Science International*; 2011, *210*, 164-169. DOI: 10.1016/j.forsciint.2011.02.025. (e) Stable carbon and nitrogen isotope ratios of sodium and potassium cyanide as a forensic signature; H. W. Kreuzer, J. Horita, J. J. Moran, B. A. Tomkins, D. B. Janszen, A. Carman; *Journal of Forensic Sciences*, 2012, *57(1)*, 75-79. DOI: 10.1111/j.1556-4029.2011.01946.x. (f) Comparative evaluation of preprocessing freeware on chromatography/mass spectrometry data for signature discovery; J. B. Coble, C. G. Fraga; Journal of chromatography A; 2014, 1358, 155-164. DOI: 10.1016/j.chroma.2014.06.100. (g) Source Attribution of Cyanides Using Anionic Impurity Profiling, Stable Isotope Ratios, Trace Elemental Analysis and Chemometrics; N. S. Mirjankar C. G. Fraga, A. J. Carman, J. J. Moran; *Anal. Chem.*; 2015, *88(3)*, 1827-1834. DOI: 10.1021/acs.analchem.5b04126.

He also discussed some of the current collaboration efforts on chemical analysis and chemical forensics that involve OPCW designated laboratories.

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

(a) The CFITWG is proposing to develop a toxic chemical and pre-cursor impurity profiling database and to discover other toxic chemical forensic signatures.

(b) There are many years of stockpile destruction analytical data that could be compiled into a database for informing method development. This could include data for old and abandoned chemical weapons too. Furthermore, unpublished data from Schedule 1 facilities and designated laboratories could be used to augment published data. Modalities of how to make such data available to relevant laboratories are important to consider, as the unpublished data may need to be kept confidential.

(c) The CFITWG would benefit from collaboration with law enforcement laboratories.

Subitem 12(b): Fatal sarin poisoning in the Syrian Arab Republic 2013: forensic verification within an international laboratory network

12.3 Dr Daan Noort presented the results of an analysis of tissues collected from a deceased female victim, who had displayed symptoms of cholinergic crisis, during the United Nations led mission in the Syrian Arab Republic in 2013.[80] Two laboratories, located in the Netherlands and Germany, were authorised for forensic analysis of these samples. A number of validated analytical methods with sufficient sensitivity to analyse the biomarkers in the sub-nanomolar range were applied by both laboratories to identify signatures of nerve agents, with a special focus on sarin. These methods detected sarin signatures in various tissues, including hydrolysis products, a synthesis by-product and covalent protein adducts to human butyrylcholinesterase and albumin. These results provided unambiguous evidence for a systemic intoxication, unequivocally proving one of the first uses of sarin in the ongoing conflict in the Syrian Arab Republic. This scenario underlines the additional value of biomedical samples compared to environmental samples for investigations of alleged use of chemical warfare agents, and emphasises the requirement for qualified OPCW designated laboratories to carry out their analysis. It should also be stressed that the applied methods can also have great value for unequivocal diagnosis of exposure to other types of chemical warfare agents.

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

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79 A collection of papers from a chemical forensics symposia held in conjunction with the initial meeting of the CFITWG will be published in a special edition of the peer-reviewed scientific journal *Talanta*, (the International Journal of Pure and Applied Analytical Chemistry; https://www.journals.elsevier.com/talanta). This collection will include contributions from members of the OPCW SAB and the temporary working group on investigative science and technology.

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

(a) The TNO group had limited experience with organ materials as samples; Dr Noort noted that some of the tissue samples supplied for the study were easier to work with than others. Understanding the suitability of various human tissues and body fluids for post-mortem biomarker analysis would be valuable for any subsequent biomedical investigations involving suspected exposure to toxic chemicals.

(b) Blood samples were preferable for ease of analysis, with good analytical results obtained even from coagulated blood. It might be possible to use dried blood spots (such as those in hospital collections) for biomedical analysis.

(c) Chemical warfare agents can form addition products (adducts) with a large variety of biomolecules in the body, for which there is limited data available.[81] This must be borne in mind when searching for characteristic biomarkers for proof of retrospective poisoning by toxic chemicals.

(d) Biomedical chemical forensics is a new field of research and lags behind the more straightforward field of environmental chemical forensics. Impurity profiles arising from exposure to a toxic chemical are, at present, more difficult to obtain through biomedical sample analysis than through environmental sample analysis. However, as the pioneering study by Dr Noort and colleagues showed, biomedical analysis of the tissues of a deceased person did reveal the presence of sarin plus a chemical carried over from its production. This shows that biomedical chemical forensics can provide additional clues pertaining to the origin of the toxic chemical used.

(e) In reference to United Nations owned data discussed in subparagraph 9.11(h), it was noted that the publication described in Dr Noort's presentation included data that was approved for publication by the United Nations. Approval was facilitated through the OPCW. Additionally, when permission was requested, the two laboratories who had performed the analysis were put in contact with one another (when samples are split and sent to two designated laboratories for analysis, the identities of the laboratories are not shared between them).

13. AGENDA ITEM THIRTEEN – Data management

13.1 Dr Ed van Zalen presented an overview of how data is managed in forensic work, using the example of the EU Frame Work 7 GIFT (Generic Integrated Forensic Toolbox) project. Within GIFT, a system was developed to register the incident scene; gather and store data by sensors and detectors from the incident scene; and include laboratory results. The knowledge database provides SOPs for the investigator for use of personal protective equipment (PPE), sampling, risk assessment, and information about identified hazards. All the information is made available for the Command and Control Centre, the site commander and the investigator.

13.2 As data is collected, it is sent to, and stored at, the toolbox using encryption and following chain of custody requirements appropriate for data. Investigations can

81 Activity based protein profiling leads to identification of novel protein targets for nerve agent VX; D. Carmany, A. J. Walz, F.-L. Hsu, B. Benton, D. Burnett, J. Gibbons, D. Noort, T. Glaros, J. W. Sekowski; *Chem. Res. Toxicol.*; 2017, *30(4)*, 1076–1084. DOI: 10.1021/acs.chemrestox.6b00438.

quickly generate terabytes of data in the form of documents, video clips, photos, and more. Furthermore, raw data, including metadata associated with image files, must be captured and retained to allow for validation and authentication. To handle the huge amount of data, the NFI developed Hansken;[82] a software tool that stores, indexes and analyses data, making it accessible with specially developed tools available to case investigators.

14. AGENDA ITEM FOURTEEN – Engagement with forensic science experts

14.1 Dr Christopher Timperley briefed the TWG on his attendance as an observer at the 4th annual meeting of the Scientific Advisory Board of the Office of the Prosecutor (OTP SAB) of the ICC from 22 to 23 June 2017.[83] Dr Timperley had briefed the OTP SAB in June on the role and scientific accomplishments of the OPCW's SAB and the planned formation of the TWG (which had not yet been formed at the time).

14.2 The OTP SAB was established in 2014 to make recommendations to the ICC Prosecutor on the most recent developments in new and emerging technologies and scientific methods and procedures that could reinforce the capabilities of the Office in the collection, management and analysis of scientific evidence relating to the investigation and prosecution of genocide, crimes against humanity, and war crimes. Adapting the Office's investigative and prosecutorial capabilities and networks to the rapidly changing scientific and technological environment in which it operates is a strategic goal set by the Prosecutor. The contribution of the OTP SAB is crucial to the work of the Office in honing scientific standards governing operations and to the Office's duty to guaranteeing that the evidence presented to the Court's judges is credible and reliable.

14.3 Up to June 2017, the OTP-SAB had reviewed and certified five Standard Operating Procedures (SOPs) of the Office relating to, amongst others, human remains recovery, autopsies, forensic clinical examinations, as well as crime scene examination. During the meeting of the OTP SAB, two additional procedures for the handling of medical information and the use of remote sensing evidence were reviewed and another four SOPs were currently under examination by this Board. During the meeting, the OTP SAB had concluded that it should continue to promote the forensic work already done through its respective organisations and networks; it intended to publish its SOPs in international scientific journals in the future.

14.4 Eighteen forensics organisations were represented on the OTP SAB: the Academia Ibero-americana de Criminalística y Estudios Forenses: the African Society of Forensic Medicine; the Australian and New Zealand Forensic Science Society;[84] the European Council of Legal Medicine;[85] the European Network of Forensic Science

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

83 Dr Timperley had previously briefed the SAB on this meeting, see paragraphs 11.4 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/fileadmin/OPCW/SAB/en/sab-26-01_e_.pdf.

84 For additional information on the Australian and New Zealand Forensic Science Society, see: http://anzfss.org/.

85 For additional information on the European Council of Legal Medicine, see: http://www.eclm.info/.

Institutes;[86] the Ibero-american Network of Forensic Medicine and Forensic Science Institutions; the International Association of Law and Forensic Sciences; [87] EUROPOL/European Cybercrime Centre;[88] the International Academy of Legal Medicine;[89] International Forensic Strategy Alliance;[90] INTERPOL/Global Complex for Innovation;[91] INTERPOL/International Forensic Science Managers Symposium;[92] the Indo-Pacific Association of Law, Medicine and Science;[93] the New Mediterranean Academy of Forensic Sciences; the Arab Union of Forensics and Toxicology;[94] the Southern Africa Regional Forensic Science Network; the United Nations Institute for Training and Research (UNITAR/UNOSAT);[95] and the World Association for Medical Law.[96]

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

The TWG would benefit from continued engagement with the CFITWG and forensic organisations such as those represented within the OTP SAB.

15. AGENDA ITEM FIFTEEN – Discussion, establishment of sub-groups and the way forward

Subitem 15(a): Agreement of topics and establishment of sub-groups. 15(b): Identification of key areas for intersessional work, and gaps that may need further clarification. And 15(c): Plan of work for sub-groups and their leads; milestones and timelines

15.1 Paragraphs 4 and 5 of the TOR (see Annex 1 of this report) were reviewed and six sub-groups established to address the questions posed. The sub-group members moved into breakout sessions to identify areas of focus and priority for taking the TWG forward.

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86 For additional information on the European Network of Forensic Science Institutes, see: http://enfsi.eu/.

87 For additional information on the International Association of Law and Forensic Sciences, see: http://ialfs.org/.

88 For additional information on EUROPOL/European Cybercrime Centre, see: https://www.europol.europa.eu/about-europol/european-cybercrime-centre-ec3.

89 For additional information on the International Academy of Legal Medicine, see: http://www.ialm.info/.

90 For additional information on the International Forensic Strategy Alliance, see: http://www.ifsa-forensics.org/.

91 For additional information on INTERPOL/Global Complex for Innovation, see: https://www.interpol.int/About-INTERPOL/The-INTERPOL-Global-Complex-for-Innovation.

92 For additional information on INTERPOL/International Forensic Science Managers Symposium, see: https://www.interpol.int/INTERPOL-expertise/Forensics/Forensic-Symposium.

93 For additional information on the Indo-Pacific Association of Law, Medicine and Science, see: http://inpalms.tripod.com/.

94 For additional information on the Arab Union of Forensics and Toxicology, see: http://auft-arab.org/.

95 For additional information on UNITAR/UNOSAT, see: https://unitar.org/unosat/.

96 For additional information on the World Association for Medical Law, see: http://wafml.memberlodge.org/.

15.2 **Sub-group A** will address forensic methods and capabilities, with focus on questions from subparagraphs 4(a) and 4(k) of the TWG TOR. These questions are:

(a) Which methods and capabilities used in the forensic sciences could usefully be developed and/or adopted for Chemical Weapons Convention-based investigations?

(b) Are there stakeholders that the Secretariat could usefully engage with to leverage their capabilities on investigative matters?

15.3 The following priority areas were identified for Sub-group A, further consideration to these and other possible topics of relevance will be made during the intersessional period before the TWG's Second Meeting.

(a) Explore the range of forensic resources and their accessibility.

(b) Consider opportunities to involve Designated Laboratories and forensic laboratories to explore areas of common interest.

(c) Engage with forensic science networks, building on existing relationships.

15.4 **Sub-group B** will address data collection and management, with focus on questions from subparagraphs 4(b) and 4(c) of the TWG TOR. These questions are:

(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?

(b) What are the best practices for management of data collected in investigations, including compilation, curation, and analytics?

15.5 The following priority areas were identified for Sub-group B, further consideration to these and other possible topics of relevance will be made during the intersessional period before the TWG's Second Meeting.

(a) Explorer chain-of-custody best practices and technologies that are in use.

(b) Explore best practices for data management (including data analytics) and how these can be applied while maintaining appropriate confidentiality.

15.6 **Sub-group C** will address sampling, detection and analysis with focus on questions from subparagraphs 4(e) and 4(g) of the TWG TOR. These questions are:

(a) Which technologies and methodologies (whether established or new) allow point-of-care and non-destructive measurements at an investigation site to help guide evidence collection?

(b) Which methods are available (or are being developed) for the sampling and analysis of environmental and biomedical materials and can be used in the detection of toxic industrial chemicals relevant to the Convention?

15.7 The following priority areas were identified for Sub-group C, further consideration to these and other possible topics of relevance will be made during the intersessional period before the TWG's Second Meeting.

(a) Explore available tools for specific categories of chemicals of relevance (not limited to scheduled chemicals).

(b) Explore inputs from industry, first responders and environmental monitoring on the tools and approaches that may be available (this could be especially relevant for toxic industrial chemicals).

(c) For detection of toxic industrial chemicals in biomedical samples, gather published materials about environmental and occupational exposure (some older science is quite relevant). Engagement with forensic toxicologists can also be explored.

(d) Consider available remote monitoring and/or portable systems. Including consideration of evaluation reports of available technologies.

15.8 **Sub-group D** will address data collection and manage integrity of scene, evidence and evidence collection, with focus on questions from subparagraphs 4(d), 4(h) and 4(i) of the TWG TOR. These questions are:

(a) What are the best practices for the collection, handling, curation and storage, and annotation of evidence?

(b) Which technologies and methodologies (whether established or new) can be used in ensuring chain of custody and verifying authenticity (especially in regard to digital images and video recordings)?

(c) Which technologies and methodologies (whether established or new) can be used to ensure the integrity of an investigation site?

15.9 The following priority areas were identified for Sub-group D, further consideration to these and other possible topics of relevance will be made during the intersessional period before the TWG's Second Meeting:

(a) Evaluate current procedures and compare to forensic best practices from collection through to archiving and curation. This could include tracking of associated metadata.

(b) The sub-group noted that sample transport should also be considered.

(c) Review best practices used in field investigations. Consider the best approach to the development of guidelines.

(d) Explore how others approach the reconstruction of past events and physical locations.

15.10 **Sub-group E** will address provenance, with focus on questions from subparagraphs 4(f) and 4(j) of the TWG TOR. These questions are:

(a) Which technologies and methodologies (whether established or new) can be used in provenancing of chemical and/or material samples collected in an investigation?

(b) Do collections of physical objects, samples, and other information for chemical weapons-related analysis exist and can they be made available to investigators for retrospective review? How might these collections be used to support investigations?

15.11 The following priority areas were identified for Sub-group E, further consideration to these and other possible topics of relevance will be made during the intersessional period before the TWG's Second Meeting:

(a) Coordination with and encouragement of laboratories to be more actively engaged with the CFITWG.

(b) Identify others whose work relies heavily on provenancing (for example, scientists involved in food authentication and in oil spill forensics).

(c) Review protocols of others, including the tools and methods used (IRMS, SNIF-NMR, and inorganic analysis, for example).

(d) Chemical forensic analysis in biological samples (including human, animal, and plants).

(e) Explore feasibility of access to data from past chemical weapon investigations for the review of the scientific approaches and results.

15.12 **Sub-group F** will address additional considerations, with focus on paragraph of the TWG TOR, providing advice on Secretariat proposals for methodologies, procedures, technologies and equipment for investigative purposes.

15.13 The following priority areas were identified for Sub-group F, further consideration to these and other possible topics of relevance will be made during the intersessional period before the TWG's Second Meeting:

(a) Consider non-traditional options for data collection.

(b) Consider where traditional best practices may not fit the situational needs in the environments, and under the scenarios, where inspectors may be operating.

(c) Consider how to increase and improve sustainability of field missions.

(d) Understand issues related to technical investigative assistance, including possible legal issues.

Subitem 15(d): Agenda for the second meeting

15.14 The TWG agreed to hold its Second Meeting from 14 to 16 November 2018 (tentative). The programme for the meeting will be developed during the intersessional period.

16. AGENDA ITEM SIXTEEN – Adoption of the report

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

17. AGENDA ITEM SEVENTEEN – Closure of meeting

The Chairperson closed the meeting at 16:17 on 14 February 2018.

ACKNOWLEDGEMENT

The TWG members thank all of the guest speakers and staff of the Secretariat who gave presentations at their first meeting: Mr Nihad Alihodzic, Dr Marc-Michael Blum, Ms Anna Davey, Ms Katarina Grolmusova, Mr Ian Henderson, Dr Murty Mamidanna, Mr Marko Milivojevic, Mr Stefan Mogl, Mr Lennie Phillips, Mr Aamir Shouket, Dr Zhenwen Sun, Mr Steven Wallis and Dr Gareth Williams. The TWG also thanks Ms Marlene Payva, Ms Siqing Sun and Ms Pei Yang of the OPCW Office of Strategy and Policy, for their support of, and contributions to, the meeting and its preparations.

Annex 1: Terms of Reference for the Temporary Working Group on Investigative Science and Technology

Annex 2: List of Participants at the First Meeting of the Scientific Advisory Board's Temporary Working Group on Investigative Science and Technology

Annex 1

TERMS OF REFERENCE FOR THE TEMPORARY WORKING GROUP ON INVESTIGATIVE SCIENCE AND TECHNOLOGY

1. The Technical Secretariat's (hereinafter "the Secretariat") on-going contingency operations have increasingly involved investigations and fact-finding, with collection and evaluation of oral, material and digital evidence of the use of chemical agents; activities that are not part of routine Chemical Weapons Convention inspection and verification. The Director-General has decided that an in-depth review of how and when methods and technologies used in investigative work would be relevant to the Secretariat. He has asked the Scientific Advisory Board (SAB) to conduct this review. Further to his response to the report from the Twenty-Fourth Session of the SAB (SAB-24/1 dated 28 October 2016), and in accordance with paragraph 9 of the terms of reference of the SAB, the Director-General has therefore established a Temporary Working Group (TWG) on Investigative Science and Technology and has appointed Dr Veronica Borrett as the Chairperson of the group.

2. The objective of the TWG is to review science and technology relevant to investigative work, especially for the validation and provenancing (determining the chronology of ownership, custody and/or location) of evidence, and the integration of multiple and diverse inputs to reconstruct a past event. This would also include further considerations of topics in the recommendations from the SAB's 2016 chemical forensics workshop (SAB-24/WP.1, dated 14 July 2016), and topics falling under subparagraphs 2(e)[97] and 2(g)[98] of the SAB's terms of reference. The work of this TWG is intended to identify capabilities, skill sets and equipment that would augment and strengthen the Secretariat's investigative capabilities. The findings will be considered by the SAB and recommendations provided to the Director-General.

3. The TWG will consist of individuals who collectively have expertise in theory and practice of investigative work; including but not limited to investigational chemical analysis, evidence collection, forensic sciences, informatics, crime scene reconstruction, toxicology, inspection or experience of implementation of the Chemical Weapons Convention. Qualified members of the SAB may join the TWG. Members of relevant scientific organisations and international organisations may also be invited to join the TWG. Guest speakers may be invited from time to time. The TWG may also, when necessary, draw upon the expertise of the Secretariat; in particular the OPCW Laboratory, Inspectorate, and the Assistance and Protection Branch.

4. Reporting to the SAB, the TWG will in particular consider the following questions:

   (a) Which methods and capabilities used in the forensic sciences could usefully be developed and/or adopted for Chemical Weapons Convention-based investigations?

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97 "… assess the scientific and technological merit of a present, or proposed, methodology for use by the Technical Secretariat in verification under the Convention".

98 "... assess and report on emerging technologies and new equipment which could be used on verification activities".

(b) 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?

(c) What are the best practices for management of data collected in investigations, including compilation, curation, and analytics?

(d) What are the best practices for the collection, handling, curation and storage, and annotation of evidence?

(e) Which technologies and methodologies (whether established or new) allow point-of-care and non-destructive measurements at an investigation site to help guide evidence collection?

(f) Which technologies and methodologies (whether established or new) can be used in provenancing of chemical and/or material samples collected in an investigation?

(g) Which methods are available (or are being developed) for the sampling and analysis of environmental and biomedical materials that can be used in the detection of toxic industrial chemicals relevant to the Convention?

(h) Which technologies and methodologies (whether established or new) can be used in ensuring chain of custody and verifying authenticity (especially in regard to digital images and video recordings)?

(i) Which technologies and methodologies (whether established or new) can be used to ensure the integrity of an investigation site?

(j) Do collections of physical objects, samples, and other information for chemical weapons relevant analysis exist that can be made available to investigators for retrospective review? And how might these collections be used to support investigations?

(k) Are there stakeholders that the Secretariat could usefully engage with, to leverage their capabilities on investigative matters?

5. In addition, the TWG will provide advice on Secretariat's proposals for methodologies, procedures, technologies, and equipment for investigative purposes.

6. The Director-General might pose other relevant questions to the TWG, through the SAB.

7. The TWG will exist for a period of two years from the date of its first meeting. Thereafter its work will be reviewed by the SAB and the Director-General, and a decision will be made as to whether it should continue its work, and, if so, whether the terms of reference should be revised.

Annex 2

LIST OF PARTICIPANTS AT THE FIRST MEETING OF THE SCIENTIFIC ADVISORY BOARD'S TEMPORARY WORKING GROUP ON INVESTIGATIVE SCIENCE AND TECHNOLOGY[99]

	Participant	Institution
1.	Dr Crister Åstot	Swedish Defence Research Agency (FOI), Umeå, Sweden
2.	Dr Augustin Baulig	Secrétariat général de la défense et de la sécurité nationale, Paris, France
3.	Dr Veronica Borrett*[100]	BAI Scientific and Honorary Fellow, University of Melbourne, Australia
4.	Dr Brigitte Dorner	Robert Koch Institute, Berlin, Germany
5.	Dr Carlos Fraga	Pacific Northwest National Laboratory, Richland, Washington, United States of America
6.	Professor David Gonzalez*	Department of Chemistry, University of the Republic of Uruguay and Ministry of Education, Montevideo, Uruguay
7.	Dr Robert Mikulak*	Department of State, Washington, DC, United States of America
8.	Dr Daan Noort*	TNO, Rijswijk, the Netherlands
9.	Dr Syed K. Raza*	Institute of Pesticide Formulation Technology (IPFT), India
10.	Mr Valentin Rubaylo*	State Scientific Research Institute of Organic Chemistry and Technology, Moscow, Russian Federation
11.	Mr Cheng Tang*[101]	Office for the Disposal of Japanese Abandoned Chemical Weapons, Ministry of National Defence, China
12.	Dr Christopher Timperley*[102]	Defence Science and Technology Laboratory (Dstl), Porton Down, United Kingdom of Great Britain and Northern Ireland
13.	Mr Francois Mauritz van Straten*	Chemical Weapons Working Committee, South Africa
14.	Dr Ed van Zalen[103]	Netherlands Forensic Institute (NFI), the Netherlands
15.	Professor Paula Vanninen	University of Helsinki and VERIFIN, Helsinki, Finland
16.	Ms Farhat Waqar*	Pakistan Atomic Energy Commission
17.	Ms Anna Davey (guest speaker)	Forensic Foundations™, Australia
18.	Mr Marko Milivojevic (guest speaker)	Regional Forensic Division, Ministry of Interior, Novi Sad, Republic of Serbia
19.	Mr Stefan Mogl (guest speaker)	Spiez Laboratory, Switzerland

99 Dr Christophe Curty, having sent his apologies, was unable to attend the First Meeting of the TWG.
100 Chairperson of the TWG.
101 Vice-Chairperson of the SAB.
102 Chairperson of the SAB.
103 Vice-Chairperson of the TWG.

	Participant	Institution
20.	Mr Lennie Phillips (guest speaker)	Consultant
21.	Dr Zhenwen Sun (guest speaker)	Institute of Forensic Science, Beijing, China
22.	Mr Steven Wallis (guest speaker)	Consultant
23.	Dr Jonathan Forman (Secretary to the SAB, Technical Secretariat)	Organisation for the Prohibition of Chemical Weapons, The Hague, the Netherlands

*Member of the Scientific Advisory Board

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