


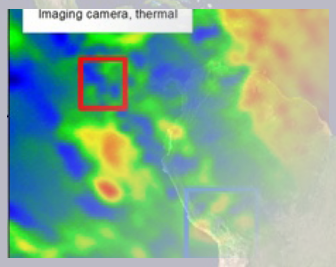




VERIFICATION

REPORT OF THE SCIENTIFIC ADVISORY BOARD'S TEMPORARY WORKING GROUP

June 2015

ORGANISATION FOR THE PROHIBITION
OF CHEMICAL WEAPONS

The **Organisation for the Prohibition of Chemical Weapons** (OPCW) is the implementing body of the Chemical Weapons Convention (the Convention), which entered into force in 1997. The OPCW has 190 Member States, who are working together to achieve a world free of chemical weapons.

The **Scientific Advisory Board** (SAB) is a subsidiary body of the OPCW established in accordance with the Convention to enable the Director-General to render specialised advice in science and technology to OPCW Member States. For more information on the SAB and to download other SAB reports, please visit www.opcw.org/subsidiary-bodies/scientific-advisory-board

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Verification

Report of the Scientific Advisory Board's Temporary Working Group

June 2015

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Endorsed by the Scientific Advisory Board at its Twenty-Second Session

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ORGANISATION FOR THE PROHIBITION
OF CHEMICAL WEAPONS

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Executive summary

Verification-related issues with scientific and technological dimensions have arisen over recent years. The Director-General of the Organisation for the Prohibition of Chemical Weapons (OPCW) requested the Scientific Advisory Board (SAB) to undertake an in-depth study of certain aspects of verification. He established the SAB Temporary Working Group on Verification (TWG), which was convened on 19 March 2013 (see Annex 1 for terms of reference and Annex 2 for membership). The TWG held six meetings[1] and presented four interim reports[2] to the SAB at the Board's Twentieth, Twenty-First, and Twenty-Second Sessions[3].

The TWG received briefings from experts from other international organisations (see Annex 3) and staff members of the OPCW's Technical Secretariat (the Secretariat) on current practices and future plans. The TWG also carried out a gap analysis by conducting interviews with Secretariat staff members.

Experience from other international organisations emphasised the value of evaluating all relevant data available, combined with appropriate information technology tools. The information utilised by these organisations is not limited to that submitted in accordance with treaty obligations but spans a wide range of additional sources. Information collected from open sources can provide insights into trends and developments that would not be picked up through the formal information flow. However, use of open-source information requires adequate resources, including specialised staff and expert tools. Stringent procedures must be in place to evaluate and validate information, while managing information overload. The TWG considered how a systematic use of open sources by the Secretariat could be valuable for, e.g., providing assistance to States Parties to the Chemical Weapons Convention (the Convention) in identifying declarable activities, and assisting the Secretariat in following global trends relevant to verification.

[1] 19 – 20 March 2013, 23 – 25 September 2013, 7 – 9 April 2014, 29 September – 1 October 2014, 28 – 29 January 2015, and 6 – 7 May 2015.

[2] www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/reports

[3] See SAB-20/WP.2*, SAB-21/WP.1, SAB-21/WP.6, and SAB-22/WP.1

The TWG reviewed the analysis of verification-related data in the Secretariat and recommends that it should no longer be compartmentalised in organisational units. The Secretariat should move towards a comprehensive, systems-based approach where all the separate elements of information are combined and analysed in a systematic and collaborative manner within the organisation. Currently, information management support to the verification process is insufficient: there is a lack of analytical tools and the Verification Information System (VIS) has shortcomings in certain areas. The Secretariat should take steps to implement an information management structure that can support the needs of the verification process.

As a complement to on-site inspections, the Secretariat should seek closer cooperation with the National Authorities, including visits to review their data collection and other declaration-related activities. The information obtained through such visits could enhance the assurance of the correctness and completeness of the declaration and be a factor in determining inspection frequency.

There have been inconsistencies in how States Parties declare plant sites which produce discrete organic chemicals (DOCs). The main inconsistencies relate to declarations of plant sites that produce chemical mixtures containing DOCs, and/or plant sites that produce DOCs via bio-mediated processes. Different interpretations by States Parties of declaration obligations have led to non-declaration of certain types of facility by some States Parties. The Convention does not exempt facilities producing mixtures containing low concentrations of DOCs from declaration requirements, nor does it define purity levels for DOCs. All facilities that produce DOCs at any concentration in amounts above the thresholds defined in Part IX of the Annex on Implementation and Verification to the Convention (Verification Annex) should be declared, provided that they do not fall within any OPCW exemption.

Today, DOCs are produced by a wide range of production methods: through chemical reaction, a biological process, or a mixture of both. The SAB has recommended that any process designed for the formation of a chemical substance, irrespective of the technology used, meet the term “produced by synthesis” as used the Verification Annex. Considering the large number of other chemical production facilities (OCPFs), the TWG discussed their relevance to the object and purpose of the Convention and is of the view, that OCPFs that are highly flexible, and thus convertible to the production

of scheduled chemicals, have greater relevance. To optimise the use of verification resources, certain industries and product types could be excluded from declaration of OCPFs (in line with a risk-benefit approach as applied to facilities producing exclusively hydrocarbons, explosives, oligomers, and polymers).

The TWG also considered the increasing number of facilities that produce DOCs at low production volumes. Products such as highly active pharmaceutical ingredients (HAPI), e.g. powerful opioids used in anaesthesia and toxins used in cancer therapy, may be highly relevant to the purpose of the Convention. This aspect requires further consideration.

The TWG reviewed the sampling and analysis capabilities of the OPCW. Through the proficiency test (PT) and designated laboratory (DL) programmes for analysis of environmental samples, the Secretariat has developed a robust network of off-site laboratories. The DL network has focused on the type of environmental analysis anticipated for a challenge inspection (CI). Investigations of alleged use (IAUs) may require analytical methods that are different from those regularly used in PTs. There is a need for PTs to prepare laboratories for IAU-type scenarios. The TWG furthermore discussed attribution analysis (also referred to as chemical forensics), which attempts to attribute a chemical weapon agent or precursor to its source or to a particular production route. Once the methodology has been developed further, and shown to be robust, it could complement other OPCW verification tools, particularly in IAUs and related fact-finding activities.

The TWG received briefings on the Secretariat's activities in the Syrian Arab Republic. Lessons must be identified and documented for all activities pertaining to the missions to the Syrian Arab Republic. As all relevant units within the Secretariat have been involved in the planning and conduct of these missions, the Secretariat must commission an independent review.

The OPCW support to the 2013 United Nations Mission to Investigate Allegations of the Use of Chemical Weapons in the Syrian Arab Republic underlined the need for an additional network of DLs, or an expansion of the capabilities of current DLs, for the analysis of biomedical samples. Towards this goal, the Secretariat has held five biomedical sample exercises (from November 2009 to May 2015), which have resulted in an impressive expansion of expertise across Member States. It is anticipated that the

exercises will transition to proficiency testing in 2016. The declaration of a ricin facility by the Syrian Arab Republic has reinforced the need for a verification capability for Schedule 1A toxins (ricin and saxitoxin).

The TWG considered new technologies for verification, and is of the view that particular attention should be given to remote/automated monitoring equipment, and to satellite imagery and new types of publicly available information (e.g. geospatial data). The Secretariat needs to stay abreast of developments in the chemical industry relevant to the implementation of the Convention, and in verification technology including chemical sampling and analysis where recent developments in instrument portability and miniaturisation may have relevance to on-site analysis. This is critical to be able to adapt the verification strategies to the changing conditions of the chemical industry, ensure that staff have the correct competence, and that appropriate tools are used.

Recommendations

For the verification regime to stay relevant, it must be able to evolve with time, which requires the adoption of improved methodologies and introduction of new technologies. This necessitates the availability of adequate resources, both in terms of staff and equipment. In this context, it is crucial to maintain the competence of staff and to ensure that the Secretariat remains an attractive workplace. Highly qualified staff members with initiative are required to ensure that verification can adapt to changing circumstances. In light of the above, the TWG makes the following recommendations to answer the terms of reference.

What are the technologies/methodologies used for verification purposes in other international treaties that could benefit the Convention verification regime?

Recommendation 1: The Secretariat should consider adopting a comprehensive, more analytical approach to verification utilising all available and verifiable information.

- *Effective verification is not the assessment of an individual data point as the outcome of an inspection, but rather all relevant data points pertaining to e.g. a State Party. To be able to better understand the effectiveness and completeness of the implementation of the Convention, the Secretariat must move towards a comprehensive systems-based approach where all the separate elements of information are combined and analysed systematically.*
- *Adopting a more analytical approach to verification would require adjustments in the management and handling of information. It would also have organisational implications, as the collaborative analysis of information will require a more transverse or matrix-based organisation throughout the Secretariat to enhance potential synergies and make the best use of competences and expertise.*

Which methodologies (whether existing or new) could assist States Parties in ensuring that all declarable plant sites are identified for declaration?

Recommendation 2: The Secretariat should acquire the capability to use open-source information on a routine basis.

- *Thus far, use of open-source information to support the activities of the Secretariat has been very limited. The experience gained has, however, demonstrated that this can be a supporting measure to assist States Parties in identifying declarable activities and to support clarification of discrepancies in declaration of the trade in scheduled chemicals. Through effective use of open-source information, the Secretariat could identify and understand the wider development and trends of the chemical industry; this would help the OPCW to be prepared to address future developments and evolving challenges.*

Which new or emerging technologies may add value to existing capabilities for verification purposes (such as data analysis/ data mining, statistical analysis, attribution analysis)?

Recommendation 3: The Secretariat should put in place an information management structure that can provide the support required for the verification process.

- *A more analytical approach to verification, using all available information (declarations, inspection results, satellite imagery, open sources, et cetera.), would require improved information management support. As part of this effort, the Secretariat should undertake a review of the Verification Information System (VIS), develop new templates for Article VI inspection reports that would allow the uploading of the entire report as a searchable document to the VIS, and explore possibilities for the application of secure electronic transmission of documents and data between the inspection site and the Headquarters.*

Recommendation 4: Remote/automated monitoring technologies should be added to the list of approved inspection equipment.

- *The experience gained from the missions to the Syrian Arab Republic demonstrated the value of remote/automated monitoring technologies. Where conditions make physical access difficult, and to optimise the use of resources, equipment such as seals, cameras with remote data transmission capability, and other sensor platforms for on-site monitoring purposes should be available to the Secretariat.*

Recommendation 5: The Secretariat should look into the option of using satellite imagery for the planning of non-routine missions, in particular for IAU and CI.

- *The Secretariat should practise in a first step the utilisation of satellite imagery during CI and IAU exercises. Satellite imagery technology could also be used for routine inspections, where access to the site is difficult due to security reasons, for example. The Secretariat may consider cooperating with other international organisations/specialist agencies.*

Recommendation 6: The Secretariat should visit the National Authorities to obtain assurance on the accuracy and completeness of declarations. The outcome of such visits may impact on the inspection frequency.

- *As a complement to on-site inspections, the OPCW should consider visits to the National Authorities to undertake a review of their data collection and other declaration-related activities. The result of such visits could provide the basis for targeted support from the Secretariat to the National Authority.*
- *With time this would develop into more formal audit-type visits. The frequency and duration of such visits could be a function of the number and types of Article VI facilities declared. The assurance provided through the increased information exchange with the National Authorities could eventually lead to a reduction of the frequency of on-site inspections of declared facilities.*

Recommendation 7: The Secretariat must commission an independent review of all activities pertaining to the missions carried out in the Syrian Arab Republic.

- *The review should include proposals to ensure that the experience gained during the missions to the Syrian Arab Republic is not lost.*
- *The review should also propose an implementation plan for the lessons identified*.

What are the key technical components of a consistent approach to declaring complex mixtures of discrete organic chemicals?

Recommendation 8: The list of declarable OCPFs submitted by States Parties should include all facilities which fall under the definition/requirement of paragraph 1 of Part IX of the Verification Annex, regardless of the purity level of a DOC or DOC mixtures produced.

- *Part IX of the Verification Annex puts the focus on the plant sites that produce DOCs,*[4] *rather than on the chemicals. The Convention does not exempt facilities producing mixtures containing low concentrations of DOCs from declaration requirements, nor does it define a purity level for DOCs.*

What are the verification aspects of the meaning of "produced by synthesis"?

Recommendation 9: Not all facilities that fall under Part IX of the Verification Annex should be considered of the same relevance to the object and purpose of the Convention. The TWG recommends a practical approach for enhancing the utilisation of verification resources for OCPF declaration and on-site inspection processes.

a. The OPCW policy-making organs should exempt certain OCPFs from declaration requirements.
   - *The Secretariat should explore whether such an exemption could be product- or industry-based. These could include facilities producing methanol, urea, formaldehyde, MTBE, soap produced by saponification of*

[4] C-I/DEC.39, dated 16 May 1997

a fatty acid, and human food and beverage production. Exempted facilities that begin the production of non-exempted chemicals would have a subsequent declaration responsibility. All OCPF facilities not so exempted should be declared, regardless of production of mixtures of DOCs or bio-mediated manufacturing route.

b. The Secretariat should reassess which product group codes are highly relevant to the Convention. Facilities declared with these product group codes should be subject to a higher probability to be selected for inspection.

- *This is consistent with the approach used in the A15 site selection algorithm, under which certain product group codes are more heavily weighted based on relevance.*

c. For facilities in product group codes that are considered less relevant, the Secretariat should identify appropriate mechanisms to augment the declared information with validated and credible sources to allow for an assessment regarding the need for on-site inspection.

- *This information must be validated and from credible sources to make a preliminary assessment regarding the relevance of the facility for on-site inspection.*
- *Less relevant facilities may include inter alia facilities producing oils, perfumes, cosmetics, starches, gluten, glues, and prepared additives for mineral oils.*

Recommendation 10: The verification thresholds for OCPFs producing highly relevant chemicals, and the possibility of revision of the product group codes, should be addressed by the SAB as well as the industry cluster.

- *An increasing number of facilities produce DOCs at low production volumes. Products such as highly active pharmaceutical ingredients (HAPI), e.g. powerful opioids used in anaesthesia and toxins used in cancer therapy, may be highly relevant to the purpose of the Convention.*

How can sampling and analysis most effectively be utilised for verification purposes?

Recommendation 11: The OPCW should increase the staff of the OPCW Laboratory to cope with various aspects of IAU, biomedical samples, trace environmental analysis, toxins, and on-site analysis. Establishing a network of DLs for biomedical sample analysis should be a high priority.

- *The resources of the OPCW Laboratory are already being stretched before accommodating aspirations for additional analytical capabilities.*

Recommendation 12: Lessons on chemical sampling and analysis from the OPCW's support to the 2013 United Nations Mission to Investigate the Use of Chemical Weapons in the Syrian Arab Republic, and all subsequent OPCW activities in relation to the Syrian Arab Republic must be identified and implemented.

- *Analytical support to the 2013 UN Mission demonstrated that real investigations, particularly IAU, may differ substantially from OPCW PTs. Sample numbers were much higher, many contained the same analytes, and laboratories were under pressure to report results. Protocols that are more flexible than those used in PTs are required, provided that standards of identification and reporting are not compromised.*
- *Analytical procedures and protocols should be reviewed to ensure flexibility to handle different sample types, large sample numbers, and to accommodate short time frames whilst ensuring robust analysis and reporting. Sampling strategies should be established.*

Recommendation 13: PTs should incorporate a broader range of chemicals, and at a wider range of concentrations, to prepare laboratories for IAU-type scenarios.

- *All 37 PTs to date have focused on scenarios anticipated for a CI, and have been restricted to scheduled chemicals and their degradation products at concentrations that allow the acquisition of full spectral data. IAU may involve non-scheduled chemicals (e.g. riot control agents, incapacitants), and low concentrations that may require different analytical methods than those used routinely in PTs.*

Recommendation 14: The Secretariat should expedite toxin identification exercises.

- *Identification criteria for the Schedule 1A toxins saxitoxin and ricin were recommended by the SAB TWG on Sampling and Analysis (S&A). The declaration of a ricin facility by the Syrian Arab Republic has reinforced the need for toxin verification procedures.*

Recommendation 15: Continuous additions to the OPCW Central Analytical Database (OCAD) are recommended to allow the OPCW to meet all its mandated inspection aims, including IAU.

- *Some non-scheduled degradation products and derivatives of scheduled chemicals are not in the OCAD; IAU may involve non-scheduled chemicals (see Recommendation 13)*

Recommendation 16: Developments in analytical instrument portability, miniaturisation and disposable biosensors should be periodically reviewed by the Secretariat and the SAB for potential applicability to on-site analysis.

- *These were last reviewed by the SAB TWG on S&A and the SAB TWG on the Convergence of Chemistry and Biology. As with other technology, instruments are becoming smaller, more portable, and in the case of some biosensors, disposable. At some stage, some of these developments might help reduce the logistic burden of on-site analysis.*

Recommendation 17: The Secretariat should monitor developments in attribution analysis/chemical forensics.

- *At present, the technical basis for attribution analysis in a chemical weapon context is not sufficiently developed to be considered by the Secretariat as a verification tool. Once the methodology has been developed further, and shown to be robust, it could complement other OPCW verification tools, particularly in investigations of alleged use and related fact-finding activities.*

Which methodologies might be helpful for the Secretariat to keep abreast of developments in science and technology of relevance to the Convention verification regime?

Recommendation 18: The Secretariat should augment its capability to monitor and forecast developments in science and technology of relevance to the Convention and its verification regime.

- *The Secretariat needs to stay abreast of developments in the chemical industry relevant to the implementation of the Convention, and in verification technology, including chemical sampling and analysis. This is critical to be able to adapt the verification strategies to the changing conditions of the chemical industry, ensure that staff have the correct competence and that appropriate tools are used. The ability of the Secretariat to meet this requirement is dependent on three main elements; specialised staff with competence to extract information from large amounts of data, information tools for handling these large amounts of data and maintaining close contacts with relevant international organisations, academia and other entities.*
- *The dedication of one post to monitor the development in science and technology has resulted in increased interaction between the Secretariat and the SAB in this area, including briefings to and informal contacts with the SAB by the Secretariat on recent developments. This interaction between the SAB and the Secretariat could trigger action on specific issues by the SAB, the Secretariat, or jointly by the SAB and the Secretariat, and with the possible involvement of external experts.*

Objectives of the Temporary Working Group on Verification

Verification-related issues with scientific and technological dimensions have arisen over recent years. The Director-General decided in 2012 that an in-depth study by the SAB was necessary and requested the SAB to establish a TWG on Verification for a period of up to three years (see Annex 1). The objective of the TWG was to consider questions relating to verification, in particular those which fall under paragraphs 2(e)[5] and 2(g)[6] of the SAB's terms of reference. Reporting to the SAB, the TWG was asked in particular to answer the following questions:

a. What are the technologies/methodologies used for verification purposes in other international treaties that could benefit the Convention verification regime?
b. Which methodologies (whether existing or new) could assist States Parties in ensuring that all declarable plant sites are identified for declaration?
c. What are the key technical components of a consistent approach to declaring complex mixtures of discrete organic chemicals?
d. How can sampling and analysis most effectively be utilised for verification purposes?
e. Which new or emerging technologies may add value to existing capabilities for verification purposes (such as data analysis/data mining, statistical analysis, attribution analysis)?
f. Which methodologies might be helpful for the Secretariat to keep abreast of developments in science and technology of relevance to the Convention verification regime?

The SAB recommended to the Director-General that the term "produced by synthesis" in subparagraph 1(a) of Part IX of the Convention should cover any process designed for the formation of a chemical substance (see SAB-19/1, dated 12 September 2012 and RC-

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

[6] "assess and report on emerging technologies and new equipment which could be used on verification activities"

3/DG.1, dated 29 October 2012[7]). The SAB further recommended in the report of the TWG on the convergence of chemistry and biology that the TWG on verification should consider relevant implications for verification from this recommendation (see page 28 of SAB/REP/1/14, dated 26 June 2014[8]). The TWG on verification deliberated on this question under paragraph 6 of its terms of reference[9].

The TWG was briefed by the Secretariat on verification activities undertaken by the OPCW during 2013 – 2015. Challenges posed in relation to verification activities conducted in the Syrian Arab Republic were addressed under the appropriate sections of this report.

The TWG consisted of individuals who collectively had expertise in the theory and practice of verification, in the chemical weapons and industry dimensions of verification, or experience with the implementation of the Convention (see Annex 2).

[7] www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/reports

[8] www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/reports

[9] "The Director-General might pose other relevant questions to the TWG, through the SAB"; see Annex 1 of this report.

Findings

What are the technologies/methodologies used for verification purposes in other international treaties that could benefit the Convention verification regime?

Which methodologies (whether existing or new) could assist States Parties in ensuring that all declarable plant sites are identified for declaration?

Which new or emerging technologies may add value to existing capabilities for verification purposes (such as data analysis/ data mining, statistical analysis, attribution analysis)?

Considerations

1. In order to address the questions posed to the group, TWG members clarified two key terms referred to in their terms of reference (TOR). “Verification methodology” is understood as the methodological approach taken with respect to verification and includes aspects related to the gathering, processing, analysis, sharing, and storage of information. “Verification technology” refers to the technological solutions and equipment used to implement the methodological approach.

2. In its considerations on verification technologies and methodologies, the TWG looked at the entire cycle of the verification process. Accordingly, specific findings, recommendations and conclusions made by the group relate to the various stages of this process, starting from the preparation and receipt of declarations, the validation of information, the conduct of inspections, data monitoring and conduct of clarification procedures up to the analysis, and eventual reporting of information.

3. Measures aimed at improving the effectiveness of verification need to consider all stakeholders engaged in the process, i.e., the Secretariat, chemical industry, and the National Authorities charged with the implementation of verification-related responsibilities in the Member States. As such, recommendations emerging from this TWG relate to the various target groups.

4. The TWG also noted the fact that, in general terms, arms-control verification is no longer exclusively an intergovernmental issue between states. Non–state, civil society actors such as non-governmental organisations (NGOs), scientific communities or informed individuals have increasingly engaged over the last years on the issues of verification. Taking into account the ever-increasing potential of information and communication technologies available to each citizen, societal contribution to verification has the potential to play an increasingly important role in future arms-control and non-proliferation-related verification efforts.

5. A number of the recommendations by the TWG are linked to the availability of adequate resources and expertise for their implementation. Additionally, and in view of tenure policy implemented in the organisation, sound knowledge management and transfer and retention of rare expertise are considered crucial in support of sustaining or enhancing verification capabilities.

6. TWG members emphasised that when considering new verification methodologies and technologies for the organisation, their deliberations must be guided by the provisions of the Convention. These provisions provide the basis for the verification regime and the foundation for all verification-related actions. Any recommendations aimed at improving the effectiveness of verification by adopting new verification technology and methodology must be guided by the relevant provisions.

7. Information on the technologies/methodologies used for verification purposes in other international treaties, new or emerging technologies that may add value to existing capabilities for verification purposes, was provided by members of the TWG and through briefings by invited speakers representing a wide range of international organisations (see Annex 3).

8. To allow for the identification of areas for possible application of experience and methodologies from other international organisations, and/or for the adoption of new and emerging technologies, the TWG was briefed extensively by the Secretariat on current verification practices and areas for potential improvement. The TWG also undertook a gap analysis of the verification practices through interviews with Secretariat staff members involved in the verification process.

Findings

9. A general observation of the TWG during the briefings provided by other international organisations was the emphasis on evaluation and analysis of all available data and the IT tools required for that purpose. The information accessed is not limited to that submitted in accordance with treaty obligations but spans the whole spectra of information available from a wide range of sources.

10. Using these additional sources of information can provide insights into trends and developments that would not be picked up through the formal information flow. At the same time, the large amount of information now available through a multitude of sources requires stringent procedures for evaluation and validation by experts.

A comprehensive systems-based approach to verification

11. The International Atomic Energy Agency (IAEA) has adopted an approach to verification in which information relevant to its safeguards system, collected from a number of complementary sources, is used to enhance knowledge about States' nuclear programmes. That enhanced knowledge allows the organisation to better focus on-site verification activities and draw sound and credible conclusions on the absence of undeclared activities. This improves the cost-effectiveness of verification activities and contributes to the enhanced productivity of the organisation.

12. The Secretariat seems to have adopted a more compartmentalised approach vis-à-vis management and analysis of information relevant to, and emanating from, the verification process. This approach largely reflects the responsibilities of the different units of the Secretariat and limits the ability to understand and evaluate the full scope

of a State's chemical activities relevant for the assessment of the implementation of the Convention. In order to allow for an effective use of a wide range of information sources, the TWG has identified potential benefits for the Secretariat to modify its approach to the evaluation of available information and to enhance its capability for data analysis. The analysis to be performed by the Secretariat must provide information on the effectiveness of the implementation of the verification system and the data generated should serve the purpose of assessing compliance by States Parties with the Convention.

13. Effective verification is not the assessment of an individual data point as the outcome of an inspection, but rather all relevant data points pertaining to e.g. a State Party. For a better understanding of the effectiveness and completeness of the implementation of the Convention, the Secretariat should move towards a comprehensive, systems-based, approach in which all the separate elements of information are combined and analysed in a systematic and collaborative manner within the organisation. Such information will come from a number of sources. The verification system will provide data from declarations, other submissions, and on-site verification activities. In addition to data generated by the verification activities, sources such as the reporting on the implementation of legislative obligations by States Parties and a balanced use of information from open sources will contribute to the overall analysis and evaluation.

14. A major limitation is that the verification regime of the Convention has no provisions for assessing the completeness of declarations; it is only possible to assess the correctness of declarations, in other words whether what has been declared has been correctly declared, and not whether all that should have been declared has indeed been declared. Without supplementing the information from verification activities with relevant data from open sources on completeness of declarations, any analysis of the effectiveness of the implementation of the verification regime of the Convention cannot be described as comprehensive.

15. Adopting a more analytical approach to verification would require adjustments in the management and handling of information. It would also have organisational implications, as the collaborative analysis of information will require a more transverse or matrix-based organisation throughout the Secretariat to enhance potential synergies

and make the best use of competences and expertise. The group acknowledged the importance of developing effective processes for analysing, validating, and evaluating information for verification purposes.

16. In implementing the verification regime of the Convention, a comprehensive quality management system (QMS), which provides assurances to all stakeholders that the verification system applies the right processes and that the outcomes of such processes are achieving the objectives of the organisation, is critical. The Secretariat has already implemented a strong QMS that is in part accredited and audited.[10] The adoption of a more comprehensive systems approach to verification would require a significant update to parts of the QMS documents to reflect the new processes as they are being implemented.

17. The adoption of the proposed new approach to verification would allow the Secretariat to provide much more substantive reporting to the States Parties on the effectiveness of the implementation of the verification regime and the fulfilment by States Parties of their obligations under the Convention. This increased transparency would greatly support the States Parties in their assessment of compliance with the Convention and, as required, identify areas where remedial action should be taken.

Possible use of open-source information

18. The TWG learned from presentations and discussions with staff members from the IAEA about the utility of information from open sources, which may provide important input into the process of establishing a complete picture of States' nuclear programmes. Presentations by staff members of the World Health Organization (WHO) further demonstrated the utility of the use of open-source information in detecting events that are critical for its ability to provide an early response and seek further information from the States concerned. Both organisations demonstrated the benefits of efficient and effective use of open-source information.

[10] Certain parts of the Secretariat's QMS are accredited under ISO 17025 and regularly audited by the Dutch accreditation body (RvA), e.g. conducting proficiency tests, certifying the OCAD for missions, et cetera.

19. Open sources provide information that is not classified or proprietary information; it is accessible through publicly available documentation and media, such as specialist trade publications, scientific and technical literature, academic reports and studies by relevant NGOs, company websites, news media, trade and patent data, government reports, reports from regulatory bodies, satellite imagery, et cetera.

20. While the scope and purpose of the use of open-source information by the IAEA and the WHO is different from what could be anticipated for the OPCW, valuable lessons could be drawn. It should be noted that the effective utilisation of open-source information always requires adequate resources, including specialist staff and expert tools. Well-defined methodologies and procedures must also be put in place to evaluate and validate the information collected before it is used, while managing information overload.

21. The TWG also noted that civil society plays an increasing role in arms-control verification by collecting and sharing vast amounts of data. Paired with the steadily improving information and communication technology and its expanding use across the globe, open-source information offers the potential to serve as another means to supplement other verification efforts.

22. Open-source information is not used by other organisations, such as the IAEA and the WHO, as a primary input for drawing conclusions. It would represent only one component of the various sources of relevant information to be considered by the OPCW. Any conclusions would have to be based on the organisation's own findings.

23. The TWG identified potential benefit from the use of open-source information by the Secretariat. Thus far, use of open-source information to support the activities of the Secretariat has been very limited. The experience gained has, however, demonstrated that this can be a supporting measure to assist States Parties in identifying declarable activities, for the Secretariat to identify potentially as yet undeclared activities, and to support the resolution of a situation where trade of scheduled chemicals does not fit the pattern of declared activities. Through an effective use of open sources, the Secretariat could also identify and understand the wider development and trends of the chemical industry; this would help the OPCW to be prepared to address future developments

and evolving challenges. The Report of the Advisory Panel on Future Priorities of the OPCW also considered the experience of other international organisations in their use of open-source information and found it difficult to comprehend why the Secretariat did not make better use of such information.[11]

24. It is important that the Secretariat establish a transparent process for the way in which it utilises open-source information. The use by the Secretariat of open-source information should not imply utilising information other than that submitted in declarations for verification purposes and for drawing of conclusions. However, using information from open sources would give context and would help to assure the completeness of States Parties' declarations under the Convention. The use of open-source material would then indeed be a service provided by the Secretariat to State Parties. In addition, information from open sources could improve accuracy and understanding of trade and help in resolving discrepancies between shipper and receiver in the framework of exports and imports.

Enhanced information management capabilities .

Information management structure

25. Information management plays a key role in the entire verification process and covers the transmission of declarations, their processing and reporting, analysis of data and information sharing. The findings of the TWG points to the need for the Secretariat to adopt a more analytical approach to implementing the verification regime of the Convention. This is highlighted by the recommendation from the group to adopt a comprehensive systems-based approach to verification and to establish professional capability to use open-source information to support the verification process. This will put additional demands on the information management support for the verification process. To achieve this, it is essential to have in place a sound information management structure that can provide the necessary tools and which has the ability to adapt to changing circumstances. The presentation by the Secretariat to the TWG and the gap analysis undertaken by the TWG has pointed to a general impression of a lack

[11] Paragraph 48 of S/951/2011 (dated 25 July 2011), www.opcw.org/index.php?eID=dam_frontend_push&docID=15031

of information management support to the verification process and insufficient analytical tools.

26. The Secretariat has in the last ten years put in place software developed in house , the Verification Information System (VIS). The VIS provides the central verification information management capability, including declaration processing, validation and analysis, inspection planning, and reporting. A key function of the VIS is to serve as the central repository for such verification-related information. The development of the VIS is an ongoing process and efforts are under way to implement further elements.

27. The information provided to the group indicated that the VIS had significant shortcomings in its current form. These shortcomings include limited reporting capabilities, that the system is not user-friendly, and that results from inspections cannot be uploaded directly to the VIS but require retyping. As a consequence, critical verification information is still maintained outside the VIS, resulting in double accounting of data, a situation that the VIS was originally designed to avoid.

28. Effective information management in the verification process is complicated by the fact that the current document management systems (including the Electronic Document Management System (EDMS) and the Correspondence Management System (CMS)) do not provide for adequate search capabilities. Consequently, finding documents related to a specific topic is extremely time-consuming, and replacement with a modern document management system that meets the requirement of the Verification Division is long overdue. According to the information provided to the TWG, steps have been taken to replace the current document management systems.

29. Taking into account the central role of the VIS, a general review of the VIS should be considered. This review should include current status, ongoing development and future enhancement, and it should clarify the need for additional tools for data analysis. It should further consider how the VIS would have to be developed to fulfil the requirements that the move towards a new approach to verification and the use of open-source information will pose. The review process should include all users of the VIS, provide the basis for a clear prioritisation of the work of the VIS, and reinforce ownership of the VIS among all concerned users. A comprehensive and consolidated

review, resulting in clear priorities, would also be an effective tool for the dialogue on future support for the VIS.

30. To ensure that inspection results are available on the VIS, the Secretariat should develop new templates for the Article VI inspection reports (S1, S2, S3 and OCPF) that would allow the uploading of the entire report to the VIS as a searchable document. The new template would also provide for the applicable information from declarations to be uploaded to the report during the preparation of the inspection. A strict template would also serve to further improve the consistency in inspection reporting, reduce the time spent on reporting on-site, and increase the predictability of the report content and structure.[12]

31. Information management also relates to the sharing of relevant information among the stakeholders engaged in the verification process. While recognising the requirements of the OPCW confidentiality regime of the "need-to-know" basis for access to confidential information, current practices should be reconsidered with a view to facilitating cooperation within the Secretariat and to providing the necessary exchange of relevant information between all units involved in the verification process. One area that could be considered is the division of labour, and access to information, between the unit planning Article VI inspections (the Industry Verification Branch (IVB) of the Verification Division) and the inspection team. IVB holds the entire set of inspection data from previous inspections, whereas the inspection team primarily has access only to information relevant for the specific site to be inspected. Consideration should be given to whether this situation is optimal for ensuring consistency in inspections and providing the required understanding of policy issues that have arisen at compatible sites previously inspected. Further, with the proposed move towards a more analytical approach in verification, the division of responsibility for the planning, conduct, and evaluation of inspections between the Inspectorate and Verification Divisions could be reconsidered.

[12] The TWG is aware of the new reporting templates that have been introduced and that were announced by the Director-General in his opening statement to EC-78 (EC-78/DG.13, 17 March 2015). These modified templates do not address the issue of uploading the inspection report to the VIS.

Secure electronic communication

32. The availability of secure electronic communication is a prerequisite for the electronic transmission of confidential information between States Parties and the Secretariat. While the requirements for encryption and confidentiality vary across States Parties, any solution must meet the requirements of the OPCW confidentiality regime. The Secretariat is now putting in place a system for the electronic submission of declarations (Secure Information Exchange (SIX)). This is a natural continuation of the capability of the VIS to upload electronic declarations and the provision of the tool for States Parties to submit electronic declarations (electronic declarations tool for National Authorities (EDNA)).

33. The TWG recommends that the Secretariat explore the possibilities for the use of capabilities provided by SIX for secure electronic communication with States Parties for other types of document, such as clarification letters and inspection reports, including comments from the State Party to such reports. The capabilities of SIX could also be exploited by the Secretariat for communication with inspection teams, including the submission of situation reports, supplementary information that can be requested by the inspection team, preliminary findings, and possibly inspection reports. The latter could be one means to meet the timelines for the submission of the inspection report during sequential inspections.

Application of new technologies

34. In its consideration of new technologies and approaches that are applied for non-proliferation and disarmament verification, the TWG noted the requirement of looking to commercially available methods of securing and transmitting information, and harnessing research and development (R&D) from other fields applicable to arms-control activities. In particular, attention should be given to remote/automated monitoring equipment, satellite imagery and new types of publicly available information (e.g. geospatial data).

35. The TWG considers that the application of these technologies and capabilities may have potential value for the non-routine verification activities of the Convention, such as investigations of alleged use of chemical weapons and challenge inspections.

Experience from the Syrian missions, where new technologies were used for the first time, further confirmed the necessity for the OPCW to routinely monitor emerging technologies in order to better respond to challenges. Such technologies may also enhance the efficiency of normal, low-risk, routine inspections.

36. Remote/automated monitoring equipment has emerged in recent years as a new means for the purpose of, inter alia, remotely collecting information. Experience from other international organisations, such as the IAEA, has shown the benefit of use of special seals with remote data transmission capability, which could possibly be used for on-site monitoring purposes in accordance with the Convention provisions. The application of these new technologies may reduce the need for on-site presence of inspectors and increase the efficiency and cost-effectiveness of verification activities.

37. Satellite images are now commercially available with high resolution, multispectral, hyperspectral, and thermal infrared capabilities. Temporal information can be augmented to satellite images using publicly available geospatial data collected in real time from social media (e.g. volunteered geographic information from ”tweeted” photographs), making these images more detailed and informative. Analysis of new (social) media may also support compliance monitoring. In particular, satellite imagery analysis capabilities could facilitate inspection-planning activities for investigations of alleged use of chemical weapons and challenge inspections.

38. The TWG also notes that three-dimensional (3D) modelling and virtual reality gaming applications have been widely introduced for the training of law enforcement units and armed forces. In this respect, the OPCW may consider exploring the possibility of introducing tailored applications for the training of inspectors.

39. All these technologies have in common that they generate increasing magnitudes of different types of data. In order to integrate visual, temporal, analytical, and geospatial data from diverse sources, one needs to recognise the need for specialised equipment, such as integrated information management solutions, and trained staff to produce meaningful data summaries. In this respect, the Organisation may consider cooperating with other international organisations/specialist agencies to make the best use of existing capabilities and/or expertise.

Visits to National Authorities

40. The National Authority is the focal point for contacts between the Organisation and the State Party. The tasks of the National Authority include, among other things, the data collection for the submission of declarations. A complement to on-site inspections could be visits by the Secretariat to the National Authorities to review their data collection and other declaration-related activities. The results of such a visit could, as required, provide the basis for assistance from the Secretariat to the National Authority to improve its data collection system. As a follow-up, the visits to the National Authorities could be coupled with extended data reporting from the National Authority to the OPCW on the activities undertaken to meet the declaration obligations. With time, the visits could evolve into a formal audit of the National Authorities data collection for declaration purposes. The frequency and duration of such audit visits could be a function of the number and types of Article VI facilities declared.

41. This idea of visits by the Secretariat to National Authorities is not new. It was included in the Director-General's address to the 14th Session of the Conference of States Parties (the Conference) and in the Secretariat note "The OPCW in 2025: Ensuring a world free of chemical weapons".[13]

42. Experience can be drawn from the IAEA, which performs visits at the request of a State. This is called the IAEA State System of Accounting for and Control of Nuclear Material Advisory Service (ISSAS). It results in a confidential report to the State with detailed recommendations on how any shortcomings identified in the performance of the state system could be rectified, and how further cooperation with the IAEA could be implemented to enhance the effective and efficient implementation of IAEA safeguards.

43. As an alternative to increasing the number and frequency of inspections at the declared sites, and devising more elaborate selection mechanisms, it could in the long run be valuable to look at alternative approaches for providing assurance of compliance with the Convention. A closer relation and an increased information exchange between the Secretariat and the National Authority could be a key element in this.

[13] S/1252/2015 (dated 6 March 2015)

44. A routine on-site inspection is frequently seen as just a facility inspection where information is collected on how well the actual activities conform to the data submitted in declarations. In reality, it could provide significant additional information on how well the State Party is meeting its obligations under the Convention. Discrepancies between declared data and the findings of the inspection team can be an indication of a number of situations, such as one in which the facility has not been made aware of its obligations, the National Authority does not have an appropriate system for data collection or lacks quality control, legislation does not provide sufficient authority for the required data collection, et cetera. However, even taking these considerations into account, at a routine on-site inspection of a facility only a limited portion of the obligations of the State Party are scrutinised. Consequently, one could question the real value of the current frequency of on-site inspections in providing overall assurance of compliance with the Convention by the State Party. Instead of increasing the number of on-site inspections, it could be more effective to supplement the routine inspections by other complementary means for data collection.

45. In addition to the above, the skewed distribution of Schedule 3 facilities and OCPFs between States Parties, combined with the constraints on inspection numbers per State Party, creates a situation in which it is difficult to describe the distribution of Schedule 3 and OCPF inspections in terms of equitable numbers of inspections and equitable geographic distribution. Tweaking the Schedule 3 and OCPF site selection algorithms can only partly correct this situation, and the skewed distribution of inspections will become more pronounced with time.

46. To introduce audit-type visits to the National Authority would be a significant departure from the current practices, but the implementation of the verification regime of the Convention must, like other regimes, evolve with time. These types of visits are not prescribed in the provisions of the Convention, but there is nothing preventing the introduction of such a system. These visits could be a very effective tool for providing assurance that the State Party is indeed meeting its complex obligations under the Convention, and this is at the very core of the objectives of the verifications system.

47. The introduction of National Authority visits would have to be agreed, but adherence could be on a voluntary basis. The benefit and trade-off for the State Party would be a reduction in Article VI inspection frequency. The gain for the OPCW would be an overall reduction in the resources required particularly for Schedule 3 and OCPF routine inspections and an increased focus on monitoring and data analysis.

48. The concept is that the information provided to the Secretariat through the audits of the National Authorities could reduce the inspection frequency, and could be accommodated within the provisions of the Convention. The selection algorithms to be used for selecting Schedule 3 facilities and OCPFs for inspection both have as one component "information on the plant sites available to the Secretariat".[14] The increased assurance that the plant sites that have been correctly declared could be obtained through the audit of the National Authority could be one factor that reduces the probability for a plant site to be selected for inspection.

Lessons from the missions to the Syrian Arab Republic

49. The OPCW support to the 2013 United Nations Missions to The Syrian Arab Republic and the subsequent OPCW missions did in many ways represent a first for the Secretariat. This includes operating in an environment with very significant safety and security threats, cooperation with the United Nations during an on-site mission, being subject to extreme political pressure, being the focus of media attention, complying with very short time frames, and utilising a range of new technologies and procedures for verification purposes.

50. While specific aspects of these missions are addressed within the sections on "Application of new technologies" and "Lessons from OPCW analytical support to the United Nations Mission to investigate the use of chemical weapons in the Syrian Arab Republic", the TWG considers that lessons learned must be identified and documented for all activities pertaining to the missions to the Syrian Arab Republic. As virtually all relevant units within the Secretariat have been involved in the planning and conduct of the mission to the Syrian Arab Republic, the TWG is of the view that the Secretariat

[14] Verification Annex Part VII paragraph 14 (b) and Part IX paragraph 11 (b) respectively.

must undertake a broad independent review of all activities pertaining to these missions.

51. The review should also address what steps can be taken to ensure that the experience gained during the missions to Syrian Arab Republic can be preserved. This is because the majority of staff directly involved in these operation will leave the Secretariat by the end of 2015 or soon thereafter.

52. The missions to the Syrian Arab Republic and the cooperation with the United Nations highlighted the need for prepared plans for interaction with the media, and that guidance has been developed for the contacts with media for all involved, including the designated laboratories, for example.

What are the key technical components of a consistent approach to declaring complex mixtures of discrete organic chemicals?

What are the verification aspects of the meaning of "produced by synthesis"?

Considerations

53. The regime for OCPFs under Part IX of the Verification Annex puts under verification those facilities that are capable of producing scheduled as well as non-scheduled toxic chemicals. Under this regime, the OPCW can monitor the relevant facilities in the chemical industry. The burden of on-site inspections is geographically broadly distributed and does not significantly hamper the operations of the chemical industry. Furthermore, the regime offers sufficient flexibility to be improved and adapted to technological change.

54. Since entry into force, and as at 30 April 2015, a total number of 4,417 OCPFs have been declared by 80 States Parties. Following completion of initial inspections of Schedule 1, Schedule 2, and Schedule 3 facilities, as required by the Convention, an

increasing proportion of available inspection resources have been allocated to the OCPF verification regime, with approximately 1,400 sites having now been inspected.

55. The TWG agreed that a technically sound and consistent approach should be elaborated to the questions posed, and any recommendation should avoid imposing an unnecessary burden on the chemical industry.

56. A discrete organic chemical (DOC) is a molecule comprising a definite number of atoms bonded together by chemical bonds and weak intermolecular forces. A DOC can exist in a pure form or in either a mixture or a solution. The word "discrete" in the Convention definition does not imply that DOCs are produced in pure form.[15] The Convention defines the term discrete organic chemical[16] as "any chemical belonging to the class of chemical compounds consisting of all compounds of carbon except for its oxides, sulfides and metal carbonates, identifiable by chemical name, by structural formula, if known, and by Chemical Abstracts Service (CAS) registry number, if assigned". In this respect, the Convention defines "unscheduled discrete organic chemicals containing the elements phosphorus, sulfur or fluorine" as PSF chemicals.[17]

57. The OPCW Conference of States Parties further clarified and expanded upon the DOC definition by a decision[18] which elucidates the existing exemptions from the Convention definition:

a) ‘‘Oxides of carbon" refers to carbon monoxide and carbon dioxide;

b) "Sulfides of carbon" refers to carbon disulfide;

c) "Oxides and sulfides of carbon" together refer to carbonyl sulphide;

d) Oligomers[19] and polymers, whether or not containing phosphorus, sulfur or fluorine; and

[15] Paragraph 4, Part I of the Verification Annex to the Convention

[16] Paragraph 4, Part I of the Verification Annex to the Convention

[17] Paragraph 1(b), Part IX of the Verification Annex to the Convention

[18] C-I/DEC.39

e) Chemicals containing only carbon and a metal.

58. The final report of the TWG on the convergence of chemistry and biology concluded: "Bulk and fine chemicals are being produced increasingly using biologically mediated processes, e.g. by microbial fermentation or using enzymes as catalysts. It is estimated that approximately 10% of chemical production volume will use such processes by 2020. This trend is being driven by commercial and environmental factors, and particularly by competition for conventional feedstock. Key enabling technologies have resulted in a rapidly expanding capability to redesign or manipulate organisms for specific purposes, and the ability to design and engineer improved enzymes (such as through metabolic engineering, enzyme engineering, synthetic biology, or traditional recombinant DNA technology)."[20]

59. Bio-mediated production of chemicals has been available for decades and commercialised for products ranging from antibiotics to amino acids and peptides. The volume and number of chemicals being produced by bio-mediated synthesis continues to increase. Many of these chemicals meet the definition of a DOC.

60. Currently, there is a lack of consistency in how States Parties declare plant sites which produce DOCs. One inconsistency applies to the declaration of chemical mixtures containing DOCs, another applies to how States Parties declare plant sites that produce DOCs via bio-mediated production methods. Some States Parties have specific criteria or exemptions set out in their national Convention implementation legislation and/or guidelines to the chemical industry regarding the declaration or exemption of facilities producing mixtures containing DOCs or DOCs produced via bio-mediated synthesis. These exemptions or guidelines vary and are based on a wide variety of criteria. Due to the lack of consistency in declarations, the selection of facilities for inspection is inconsistent between States Parties.

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[19] "It is recommended that molecules generally made up of three or more repeating units should be considered as oligomer", OPCW Declarations Handbook 2013 (dated 10 June 2014) Section B, Chapter 3 (Declarations of "other chemical production facilities"), page 26.

[20] Page 3 of SAB/REP/1/14

Findings for mixtures of discrete organic chemicals

61. The Convention does not exempt facilities producing mixtures containing low concentrations of DOCs from declaration requirements, nor does it define purity levels for DOCs. By contrast, the exemption from declaration requirements of facilities producing, consuming and processing Schedule 2 chemicals and producing Schedule 3 chemicals in lower concentrations, has been explicitly indicated.[21] The TWG thus concludes that declarations would be required for all plant sites that produced by synthesis more than 200 tonnes of DOCs during the previous calendar year or plant sites that comprise one or more plants which produced by synthesis more than 30 tonnes of a PSF chemical during the previous calendar year.

62. Not all OCPFs have the same relevance for the object and purpose of the Convention in relation to verification. The technical characteristics of an OCPF determine its relevance. The TWG notes that there is a wide range of facilities producing DOCs, some of which are highly versatile and would be readily convertible to produce scheduled chemicals, and therefore of greater relevance (i.e., facilities producing insecticides or herbicides). Others offer limited possibilities for conversion, and may therefore be of low relevance (e.g. facilities producing urea or methanol).

63. In most cases, the technical capabilities of plants producing either mixtures of DOCs or DOCs in solutions at a lower concentration are similar to those plants producing DOCs of high purity or in concentrated solutions. The most common difference is the purification step. The result of a chemical reaction is usually a mixture of chemicals. In practice, no chemical reaction leads to a 100%-pure chemical. This is true, regardless of the type of catalyst used, mode of production, or the reaction conditions. In other words, OCPFs produce mixtures rather than a pure chemical. There are many examples of DOCs which are produced as mixtures: solutions of phosphoric esters of ethoxylated alcohols, fatty acid chlorides, fatty acid esters, linear alkylbenzenes, et cetera.

[21] Paragraph 5 of Part VII and paragraph 5 of Part VIII of the Verification Annex to the Convention

Findings for "produced by synthesis"

64. Regarding the interpretation of the term "produced by synthesis" in subparagraph 1(a) of Part IX of the Convention, the SAB recommended to the Director-General that any process designed for the formation of a chemical substance be covered by it (SAB-19/1 and RC-3/DG.1).[22] The SAB further recommended in the final report of its TWG on the convergence of chemistry and biology that the TWG on verification consider relevant implications for verification (page 28 of SAB/REP1/14).[23]

65. Today, DOCs can be produced by a wide range of different production methods. A DOC can be formed in a single-step chemical reaction; alternatively, it can be the product of a metabolic pathway of a microorganism followed by a chemical process-based purification step. Furthermore, a chemical reaction could contain biological entities, as catalysts, such as enzymes, and a biological metabolic pathway may have been genetically modified with the help of chemical methods in order to yield a desired DOC. A DOC may also be produced by a multistep synthesis, each step of which could be based on any of these methods. The boundaries of what constitutes classic chemistry and classic biology have become blurred.

66. Factors that influence the choice of a particular production route include economic, environmental, and other product-specific considerations. Predictions about the rate at which bio-based production will increase in comparison to classic chemical processes are difficult to make, but it is certain that the application of biological process steps to the production of DOCs will continue to increase for certain classes of chemicals, in particular for fine and specialty chemicals.

67. A further consideration may be that the number of facilities that produce DOCs at lower production volumes is increasing. Although such a facility may or may not be relevant, some of their products, such as highly active pharmaceutical ingredients (HAPI), including chemicals for anaesthetic purposes, toxins used in cancer therapy or facilities producing various alkaloids or powerful opioids, e.g. etorphine, may be highly relevant

[22] www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/reports

[23] www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board/documents/reports

to the purpose of the Convention. These DOC facilities may produce quantities below the declaration threshold set out in Part IX of the Verification Annex, and are therefore not covered under the current verification regime.

68. In order to optimise the use of verification resources, some DOC facilities producing particular categories of chemicals should be considered lower priority. The TWG could also envisage excluding certain product types altogether from declaration requirements, as was done for facilities producing exclusively hydrocarbons or explosives. Examples to consider for such exemptions could be facilities producing methanol, urea, formaldehyde, methyl-*tert*-butyl ether (MTBE), soap produced by saponification of a fatty acid, and certain human food and beverage production. This would be in line with a risk-versus-benefit approach in terms of effective utilisation of verification resources. Exempted facilities that begin the production of non-exempted chemicals would have a subsequent declaration responsibility.

69. Other facilities may be of higher relevance and should therefore have a higher probability to be selected for inspection. In order to assess the relevance of an OCPF, the Secretariat may require more information, which may be obtained in different ways. One approach would be to expand information provided in declarations (such as type of process, type of plant); another to better utilise existing information from declarations and augment it with information from validated and credible sources. The TWG notes that broad changes to declaration requirements may not be possible in the short term.

70. The current product group codes used in the A15 algorithm[24] could be used to categorise declared OCPFs in terms of relevance and priority for on-site inspection. Some product group codes may signal DOC facilities of lower relevance. For DOC facilities declared under product group codes of lower relevance, validated and credible sources may be consulted and reviewed by the Secretariat to assess whether a facility should be considered for re-inspection or on-site inspection, and the relative priority of a facility for on-site inspection.

[24] S/962/2011 (dated 8 September 2011)

71. In summary, the TWG recommends several practical approaches for enhancing the utilisation of verification resources for OCPF declaration and on-site inspection processes. The TWG believes this approach would address the intent of the terms of reference of the TWG on Verification:

    a. The OPCW policy-making organs should consider exempting certain OCPFs from declaration requirements. The Secretariat should explore whether such an exemption could be product- or industry-based. These could include facilities producing methanol, urea, formaldehyde, MTBE, soap produced by saponification of a fatty acid, and human food and beverage production. Exempted facilities that begin the production of non-exempted chemicals would have a subsequent declaration responsibility. All OCPFs not so exempted should be declared, regardless of production of mixtures of DOCs or bio-mediated manufacturing route.

    b. The Secretariat should identify the product group codes that are highly relevant to the Convention. Facilities in those product group codes should be subject to on-site verification activities. This is consistent with the approach used in site selection Algorithm A15, under which certain product group codes are more heavily weighted based on relevance.

    c. For facilities in product group codes that are considered less relevant, the Secretariat should consider identifying proper mechanisms to augment declaration information with validated and credible sources to make a preliminary assessment regarding the need for on-site inspection or re-inspection, and the relative priority of a facility for on-site verification. These include facilities producing oils, perfumes, cosmetics, starches, gluten, glues, and prepared additives for mineral oils. This is particularly important in the event of re-inspection.

72. The TWG notes that the technical and practical issues raised by the OCPF verification regime are complex. Other issues not addressed by this recommendation may warrant consideration in the future by the SAB as well as the industry cluster. These issues

include the verification threshold for OCPFs and the possibility of revision in the product group codes.

How can sampling and analysis be utilised most effectively for verification purposes?

Current status of sampling and analysis

Technical aspects

73. Technical aspects of sampling and analysis (S&A) were addressed in detail by the SAB TWG on Sampling and Analysis in seven meetings held from 2007 to 2011. In collaboration with the OPCW laboratory, important areas addressed by the TWG on S&A included:
    a. shortening of on-site analysis time and reducing the logistic burden;
    b. biomedical sample analysis for IAU;
    c. trace environmental analysis for IAU;
    d. criteria for identification when using trace analysis;
    e. toxin analysis and criteria for identification;
    f. additions to the OCAD;
    g. advances in technology and methodology.

74. During the period of the TWG on S&A, and in the three years since the TWG reported to the SAB, the Secretariat has made notable progress in improving on-site analysis time (aqueous sample preparation and gas chromatography (GC) run times), biomedical sample analysis, and criteria for identification using trace analysis.

Proficiency test and Designated Laboratory Programmes

75. The goal of the proficiency test (PT) and Designated Laboratory (DL) programmes has been to achieve expertise in Convention-related chemical analysis across a broad geopolitical distribution, with a robust network of OPCW-designated laboratories. This goal has been largely achieved for the generic, broad-range analysis for scheduled chemicals and their degradation products anticipated for a CI, and exercised in 36 PTs.

However, some geographical regions remain under-represented. As of January 2015, there were 21 DLs from 17 Member States, 8 of which were suspended for inadequate performance in recent PTs.

76. The OPCW goal has not yet been achieved with regard to IAU, where a broader range of sample types and toxic chemicals (including non-scheduled ones) may be relevant. Biomedical as well as environmental samples may be collected, and concentrations of analytes may range from low parts per billion upwards, rather than parts per million as used in PTs.

77. There is a need for PTs to incorporate a broader range of analyte concentrations and non-scheduled toxicants, such as riot control agents and incapacitants, in order to prepare laboratories for IAU-type scenarios. Very low concentrations require selective, targeted analytical techniques, particularly for biomedical samples. An additional problem in the case of IAU is that reference compounds (for biomedical samples and non-scheduled toxicants) may not be readily available or their spectra included in databases.

78. Methods for the verification of saxitoxin and ricin were recommended by the TWG on S&A,[25] but these have not yet been exercised by the Secretariat. However, criteria for saxitoxin have been adopted by the Secretariat.

79. In order to accommodate additional analytical capabilities into the DL system, the SAB, in its 2012 report to the Director-General on advances in science and technology,[26] recommended that a review of the PT and DL system be undertaken. A small review panel was appointed by the Director-General in January 2014, and it submitted its report to the Secretariat in December 2014.[27] The panel discussed strengths and weaknesses of the current PT system, sought to identify where economies of

[25] Annex 2 of the report of the Seventh Meeting of the SAB Temporary Working Group on Sampling & Analysis, SAB-19/1 (dated 5 September 2012)

[26] Report of the Scientific Advisory Board on Developments in Science and Technology for the Third Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention, RC-3/DG.1 (dated 29 October 2012)

[27] Report of the Panel Appointed to Review the OPCW Proficiency Testing Programme (dated 10 December 2014)

resources and costs could be achieved, and considered how aspirations for biomedical sample analysis, trace environmental analysis, and toxin analysis could be incorporated into the current system.

80. The panel recommended that the current format for PTs should be maintained, but with some modifications to reduce the demands on participating and evaluating laboratories. Furthermore, PTs should incorporate IAU-type scenarios and not just CI scenarios. An element of training should be introduced for inexperienced laboratories to reduce demands on evaluating laboratories. Trace environmental and toxin analysis should be introduced into PTs as optional samples. A programme for designating laboratories for biomedical sample analysis was also recommended (see below).

Capability gaps requiring further development

81. The main capability gaps in verification analysis relate to IAU and toxin analysis (both on- and off-site).

Analysis for investigations of alleged use

82. Following recommendations by the SAB,[28] and endorsed by the Director-General,[29] the OPCW laboratory, with assistance from expert laboratories, has held five biomedical sample exercises (to May 2015). These exercises have resulted in an impressive expansion of expertise across Member States. In addition to analytical methods, the exercises have trialled draft criteria for identification at trace levels. These need further refinement in response to participating laboratories' comments. It is anticipated that the 2015 exercise will be the last, to be replaced by formal proficiency testing from 2016, as announced by the Director-General in his opening statement to the 78th Session of the Executive Council.[30]

[28] Report of the Ninth Session of the Scientific Advisory Board, SAB-9/1 (dated 14 February 2007).

[29] Note by the Director-General, Announcement of a confidence-building exercise for the analysis of biomedical samples, S/776/2009 (dated 20 July 2009).

[30] The Director-General's opening statement to EC-78 (paragraph 69 of EC-78/DG.13)

83. The PT review panel has made recommendations regarding requirements for designation and accreditation of methods for biomedical samples. In order to expedite designation, the panel proposed that provisional designation could be on the basis of performance in the first biomedical PT. Trace analysis of environmental samples has yet to be addressed by the Secretariat, although, as already referred to, the inclusion of optional samples in PTs is proposed. To be fully prepared for an IAU, robust recommended operating procedures (ROPs) are required, and identification criteria and reporting requirements need to be agreed and documented in a concise format.

84. The identification of non-scheduled compounds (e.g. incapacitants and some riot-control agents), whose spectra are not in the OCAD, may also be important in an IAU. Further additions to the OCAD are recommended to allow the OPCW to meet all its mandated inspection aims. DLs do have access to the validation group working database, which now contains spectra of some relevant non-scheduled chemicals.

Lessons from OPCW analytical support to the United Nations Mission to Investigate the Use of Chemical Weapons in the Syrian Arab Republic

85. The OPCW analytical support to the 2013 United Nations Mission to Investigate the Use of Chemical Weapons in Syria[31] was the first use of DLs for the analysis of real samples. The nature of the investigation differed substantially from PTs in several aspects. It is therefore important that lessons learned from this investigation be noted and incorporated into Secretariat practices.

    a. The fact that the investigation was an IAU reinforces the need for the Secretariat to refocus PTs, all 37 of which have been directed at CI-type scenarios.

    b. A large number of samples were collected, amid political and media pressure for rapid disclosure of results. A mechanism or procedure should be sought whereby samples could be prioritised.

[31] "United Nations Mission to Investigate Allegations of the Use of Chemical Weapons in the Syrian Arab Republic", final report, www.un.org/disarmament/content/slideshow/Secretary_General_Report_of_CW_Investigation.pdf.

c. Prior knowledge and information gathered before and during the mission strongly implicated one particular agent (sarin). In an IAU, all relevant information on casualties, such as symptoms and medical treatment, should be disclosed to the laboratories, provided that the principle of blind controls is not compromised.

d. A large number of samples were positive for sarin, its degradation products, production impurities, and additives such as stabilisers. Procedures and protocols would benefit from review to ensure that there is flexibility to handle large sample numbers, sample types, and time frames, whilst still ensuring robust and accurate analysis and reporting. Additional ROPs as well as standard operating procedures (SOPs) are required and identification criteria and reporting requirements need to be re-evaluated, agreed, and documented.

e. Analytical results from biomedical samples from alleged casualties provided factual evidence of exposure, and corroborated other evidence for the use of chemical weapons. The fact that suitable methods were available in a number of laboratories resulted from very recent confidence-building exercises held by the Secretariat. Progression of these exercises to a scheme for testing and designating laboratories for biomedical samples should be expedited (see above). DNA testing (outsourced) was shown to be a useful forensic tool for linking biomedical samples to individuals.

f. Biomedical samples require special equipment and handling procedures (both within and outside a regulated environment) because of health and safety concerns. Protocols for handling samples should be reviewed by the Secretariat and individual laboratories.

g. Laboratories may have accreditation for specific types of samples only (depending on the accrediting body). If results are reported for analyses outside the scope of the accreditation, but within the quality system of the laboratory, this should be suitably noted and reported.

h. The exclusion of DLs, 7 in total, from the five permanent members of the United Nations Security Council (China (2), France, Russia, the United Kingdom and the United States (2)), from analysing samples collected by the United Nations mission underlines the need for a broad geopolitical distribution of DLs.

86. The importance of sampling strategies in relation to inspection scenarios, the selection of sampling points, and the selection of appropriate methodologies, was noted by the TWG. Although much of the focus of the TWG was on lessons from the analytical support by the OPCW to the 2013 United Nations mission to the Syrian Arab Republic, it is important to evaluate also the sampling and analysis during all the subsequent OPCW missions. These activities must be carefully reviewed and lessons learned compiled and implemented.

Toxin analysis

87. Verification methods (on-site and off-site) for the two Schedule 1 toxins, saxitoxin and ricin, also remain a capability gap, although there are plans to address this. Verification methods now in place for saxitoxin have not been exercised by DLs. The Syrian Arab Republic has declared a ricin facility, so the Secretariat should now be building a capability to analyse samples for this Schedule 1A chemical or alternatively procedures to confirm its absence.

88. The TWG on S&A made recommendations for toxin verification, based mainly on mass spectrometry, immunoassays and bioassays. Of the two Schedule 1 toxins, the protein ricin presents the greater challenge. Although the Secretariat has not yet had the resources to address toxin analysis, a European Union project, EQuATox (Establishment of Quality Assurances for the Detection of Biological Toxins of Potential Bioterrorism Risk), has organised proficiency tests involving ricin and saxitoxin.[32] This project has brought together expertise from the verification, health, and food sectors. Some OPCW DLs have participated in the EQuATox project and the results should greatly benefit the goals of the Secretariat. The OPCW laboratory participated in an

[32] http://equatox.net

EQuATox saxitoxin proficiency test, using two techniques (liquid chromatography-mass spectrometry (LC/MS) and LC fluorescence). The methods for toxin verification recommended by the TWG on S&A remain valid, although some updating may be appropriate.

89. ROPs will be required for toxin analysis, criteria for identification documented, and the Secretariat will need to consider how results, e.g. immunoassays and bioassays, should be reported. Sample preparation for the identification of toxins in difficult matrices also needs to be addressed if low detection limits for toxins are to be achieved. A lack of certified reference materials is hindering progress in some laboratories. Not all States Parties or DLs will have the capabilities for the identification of toxins and some form of supplementary designation should be considered (this was discussed by the PT review panel). Non-scheduled toxins could be relevant to an IAU. The Secretariat should consider requesting information from DLs on their analytical capabilities for other toxins.

Attribution analysis (chemical forensics)

90. Attribution analysis in a Convention context, also referred to as chemical forensics, is the attribution or linkage of a chemical weapons (CW) agent or precursor to its source, precursor, or at least to a particular production route. This type of analysis has been developed for several non-Convention-related applications (e.g. food/wine adulteration, counterfeit drugs, explosives), but has only relatively recently been studied in detail for attribution of CW agents. A number of OPCW-designated and other government-funded laboratories are known to be investigating attribution analysis in a Convention context. Attribution analysis would enhance IAU capabilities, for example by identifying the origin and/or production methods of chemicals identified in an IAU.

91. Attribution analysis relies primarily on impurity profiling, combined with statistical comparison of profiles, and/or on comparison of elemental stable isotope ratios as determined by isotope ratio mass spectrometry. Databases and/or an appropriate reference sample are critical for attribution, but suitable databases are currently limited. Inter-laboratory collaboration would therefore be essential for establishing a network of laboratories capable of undertaking such analysis. At present, because of the limited

experience of CW attribution analysis (at least available in the public domain), its reliability is uncertain and more research is necessary. The view of the TWG was that once the methodology has been developed further, and shown to be robust, it could complement other OPCW verification tools, particularly in investigations of alleged use and related fact-finding activities, and the Secretariat should monitor developments in this area.

Scientific developments that might improve verification capabilities

On-site analysis

92. The TWG on S&A reviewed the status of portable gas and liquid chromatography-mass spectrometry instrumentation, and direct sampling mass spectrometry (MS) techniques, such as desorption electrospray ionisation (DESI) and direct analysis in real time (DART), which minimise or eliminate the need for sample preparation. Non-GC-linked MS methods would extend the range of analytes that could be analysed on-site. At that time (2010), it was concluded that it would be several years before portable and rugged instrumentation would be commercially available that might be suitable for on-site analysis. DESI was already being used successfully for Convention-related analysis in some mobile laboratories.

93. There has been continuing development in the miniaturisation of mass spectrometers, with applications including defence and security, first responders, and the pharmaceutical industry. Various instruments have become commercially available or are under development, based on time-of-flight or ion trap technology, the latter offering the capability for tandem mass spectrometry. The small dimensions and low weight (<15 kg) allow for rapid transportation for on-site use, and some instruments may not need specially trained operators.[33]

94. Rugged hand-held instrumentation based on Raman spectroscopy is now available from several companies. One such instrument has been adopted by the Secretariat for on-site analysis and was used in the Syrian mission. Raman can be used in various

[33] For an overview of available instruments and developments, see J. M. Perkel, Miniaturizing mass spectrometry, Science, 2014, **343**, 6173.

scenarios, with the advantage of being able to point-and-shoot through semi-translucent sealed containers. It can also be applied directly to aqueous solutions, and white or light coloured powders. Similarly, portable Fourier transform infrared spectroscopy (FTIR) can be used for various purposes, including coloured and fluorescent substances, making it complementary to Raman. Commercial instruments contain libraries containing spectra of thousands of chemicals, which can easily be expanded by the user. Both Raman and FTIR can be applied to the identification of chemical warfare agents, precursors and other scheduled chemicals, although they have limitations for the analysis of mixtures other than simple ones.

95. The SAB TWG on the Convergence of Chemistry and Biology recommended that rapid developments in portable and disposable biosensors be monitored.[34] These may provide useful on-site and off-site tools and could possibly be used for screening and prioritising samples, depending on their sensitivity. Prototype devices for diagnosing nerve agent and sulfur mustard exposure have been described. Fluorescent disclosure sprays have also been developed for detecting CW agents.

96. Developments in instrument portability, miniaturisation and disposable biosensors that might be applicable to verification should be periodically reviewed by the Secretariat or SAB.

Off-site analysis

97. The most important development in MS instrumentation over the past decade has been the availability of routine high-resolution mass spectrometry (HRMS). HRMS is now available in several designated laboratories and provides substantial advantages for off-site analysis. It facilitates the determination of the molecular formula and structure of an ”unknown” analyte (e.g. one that is not in the OCAD or National Institute of Standards and Technology (NIST) database), and allows retrospective trace analysis by post-acquisition searching of full spectral data. Impressive results using HRMS have been demonstrated in OPCW confidence-building exercises on biomedical sample

[34] Convergence of Chemistry and Biology. Report of the Scientific Advisory Board’s Temporary Working Group. SAB/Rep/1/14 (June 2014)

analysis. Criteria are required for identification using high-resolution mass spectrometry.

Which methodologies might be helpful for the Secretariat to keep abreast of developments in science and technology of relevance to the Convention verification regime?

98. The Secretariat needs to stay abreast of developments in the chemical industry relevant to the implementation of the Convention and in verification technology, including chemical sampling and analysis. It is important that the Secretariat be able to adapt OPCW verification strategies to the changing conditions of the chemical industry, to ensure that staff have the appropriate competencies, and that applicable verification tools be used. The Secretariat must also closely follow development in areas that could pose a threat to the objectives and purposes of the Convention, such as incapacitants and other so-called non-lethal weapons.

99. The ability of the Secretariat to do this is dependent on three main elements – expertise, tools, and contacts. The first, and maybe most important, is staff with the expertise and experience in this area. It is not enough to have expertise in the subject area, e.g. process technology or biologically mediated processes for the production of chemicals, but expertise is also required in the processes for extracting the relevant data in the flow of information from many sources. To keep abreast of development in a number of relevant areas, the Secretariat must consequently employ analysts with the correct profile for the key areas to be covered. In addition to Secretariat staff, the expertise within the SAB can, on a continued basis, provide their assessment of the development in a number of areas.

100. The area of chemical sampling and analysis is a special case. There is close cooperation between the OPCW laboratory, the analytical chemistry inspectors, the SAB and support provided by a range of laboratories in States Parties. This has allowed the Secretariat to stay ahead of developments in this area and be in a position to move forward the methodologies used for verification purposes. It is more a question of reluctance from the side of States Parties to accept and fund new procedures,

reference data, and instrumentation that has slowed down development. See earlier paragraphs for more detailed technical considerations.

101. The tools required relate primarily to the management of large amounts of data, including means to extract the relevant information from the very large information flow – known colloquially as “big data”. The sources of information range from specialised publications relating to, e.g. the chemical industry, to analysis of information flow on social media. To handle the latter requires specialised IT tools and human expertise.

102. The Secretariat can never hope to have the expertise in all relevant areas; consequently it is vital to maintain close contacts with other relevant international organisations, academia and other entities analysing the development of the chemical sphere or methodologies and technologies applicable to the implementation of the verification regime.

103. The Secretariat has dedicated one post to the purpose of following developments in science and technology in areas relevant for the implementation of the Convention (resulting in progress in this area, e.g. the issue of the new monthly S&T Monitor available on the OPCW public website). While this post is a welcome development, the TWG believes that the OPCW should review whether staff with additional specialities are required to provide adequate and systematic coverage of the very wide area of relevance.

104. The TWG also noted that the dedication of one post to monitor the development in science and technology has resulted in increased interaction between the Secretariat and the SAB in this area, including briefings to and informal contacts with the SAB by the Secretariat on recent developments. This interaction between the SAB and the Secretariat could trigger action on specific issues by the SAB, the Secretariat, or jointly by the SAB and the Secretariat, and with the possible involvement of external experts.

Acronyms, abbreviations and glossary

Acronym or abbreviation	Full term	Explanation
A15	A15 algorithm	See "Initiative by the Director-General on a methodology for the selection of other chemical production facilities for inspection, S/962/2011[35])
-	Attribution analysis (also known as chemical forensics)	The attribution or linkage of a chemical weapon agent or precursor to its source, precursor, or a particular production route
-	Bio-mediated (production)	A term that refers to the production of a chemical that utilizes a biological process. The term was intended to apply to chemicals produced from whole cells (fermentation) or extraction from plants and animals vs. enzymatic processes which would be considered a biochemical production process. However, the OPCW SAB has noted that from a scientific standpoint it is no longer possible to make any clear distinction between "chemical" and "biological and biologically mediated" processes (SAB-II.1, paragraph 2.3).
-	Biomedical samples	Material of biological origin from a human or animals; most commonly blood or urine. Any sample of biological tissue or fluid taken from a victim of suspected chemical agent exposure would be considered a biomedical sample.
CAS	Chemical Abstracts Service	A division of the American Chemical Society, whose objective is to find, collect and organise all publicly disclosed substance information. CAS Registry Numbers (CAS RNs or CAS numbers) are intended to provide a unique, unmistakable identifier for chemical substances (providing an unambiguous way to identify a chemical substance or molecular structure when there are many possible systematic, generic, proprietary or trivial names).
CI	Challenge inspection	See Article IX of the Convention and Part X of the Verification Annex
-	Chemical Forensics	See "attribution analysis"
CMS	Correspondence management system	An OPCW Technical Secretariat tool
Convention / CWC	Chemical Weapons Convention	An international treaty: "Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction; www.opcw.org[36]
DL	Designated laboratory	Laboratories designated by the OPCW for the analysis of authentic samples (see for example S/1209/2014, 27 August 2014[37]). DLs must be able to perform off-site analysis of chemical

[35] www.opcw.org/index.php?eID=dam_frontend_push&docID=15392

[36] www.opcw.org/index.php?eID=dam_frontend_push&docID=6357

[37] www.opcw.org/index.php?eID=dam_frontend_push&docID=17582

		samples collected by OPCW inspectors from chemical production facilities, storage depots, and other installations, or from the site of an alleged use of chemical weapons, and provide forensic proof if a violation of the Convention has occurred.
DOC	Discrete organic chemical	"Any chemical belonging to the class of chemical compounds consisting of all compounds of carbon except for its oxides, sulphides and metal carbonates, identifiable by chemical name, by structural formula, if known, and by Chemical Abstracts Service (CAS) registry number, if assigned"[38]
EQuATox	Establishment of Quality Assurances for the Detection of Biological Toxins of Potential Bioterrorism Risk	A European Union project
EDMS	Electronic Document Management System	An OPCW Technical Secretariat tool
EDNA	Electronic Declarations Tool for National Authorities	An OPCW software application for use by all States Parties to the Convention to create and submit the declarations under Article VI of the Convention
-	Environmental samples	Any material collected from soil, water, air, inanimate surfaces and objects present in the environment, or vegetation
GC	Gas chromatography	Method used to identify presence of chemicals (often used together with mass spectrometry: GC-MS)
IAEA	International Atomic Energy Agency	www.iaea.org
IAU	Investigation of alleged use	See Article IX and X of the Convention and XI of the Verification Annex
-	Industry cluster	Informal meetings are held from time to time among states parties to the Chemical Weapons Convention to discuss issues relating to the chemical industry and Article VI of the Convention
ISSAS	IAEA State System of Accounting for and Control of Nuclear Material Advisory Service	www.iaea.org[39]
IT	Information technology	The technology (devices, tools, infrastructure and processes) that is used to create, process, store, secure and exchange electronic data

[38] Paragraph 4 of Part I of the Verification Annex

[39] www.iaea.org/safeguards/resources-for-states/advisory-service-missions.html

MS	Mass spectrometry	Method used to identify presence of chemicals (often used together with gas chromatography)
MTBE	methyl-*tert*-butyl ether	A chemical compound produced from methanol and isobutylene. That is used as a a fuel additive in gasoline. At room temperature, MTBE is a volatile, flammable and colorless liquid.
-	National Authority	The national focal point for contacts between an OPCW Member State and the Organisation
NGO	Non-governmental organisation	An organisation that is neither a part of a government nor a conventional for-profit business.
NIST	National Institute of Standards and Technology	A federal technology agency in the United States of America that works with industry to develop and apply technology, measurements, and standards; www.nist.gov
-	Non-scheduled (chemicals)	Chemicals not contained in the schedules of chemicals that are annexed to the Convention
OCAD	OPCW Central Analytical Database	A reference library of analytical data. It contains validated spectroscopic and chromatographic data of chemicals of relevance to the Convention. Its primary purpose is to enable on-site analysis during OPCW inspections
OCPF	Other chemical production facility	See Part IX of the Verification Annex
-	Oligomer	Molecules generally made up of three or more repeating unit (Declarations Handbook 2013[40], Section B, Chapter 3, p 26)
-	Open source	Open sources provide information that is not classified/confidential or proprietary. Synonymous with "publicly available information" (as used by the OPCW Technical Secretariat)
OPCW	Organisation for the Prohibition of Chemical Weapons	www.opcw.org
-	Preliminary findings	Findings made by an OPCW inspection team and recorded on site in a preliminary findings report
PGC	Product group code	A descriptor for the production activities that make a plant site declarable under the Convention (see the OPCW Declarations Handbook[41]). Standard International Trade Classification (SITC) codes are used as the basis for PGCs.
PT	Proficiency test	An OPCW programme to designate laboratories under the Convention. PTs are conducted on a twice-yearly basis and are open to all interested laboratories from OPCW Member States. Applicants need to achieve high scores on three consecutive tests to be awarded the status of designated laboratory.
PSF	Phosphorus, sulfur, fluorine	PSF chemicals are discrete organic chemicals (see DOC) containing the elements phosphorus, sulfur or fluorine

[40] www.opcw.org/index.php?eID=dam_frontend_push&docID=17374

[41] www.opcw.org/index.php?eID=dam_frontend_push&docID=17374

ROP	Recommended operating procedures	A recommended method to be followed for the performance of designated operations or in designated situations. This differs from a Standard Operating procedure (SOP) in that an SOP is an established or prescribed methods to be that is followed routinely for its designated purpose.
S&A	Sampling and analysis	The collection of samples for analysis and the subsequent chemical analysis related to OPCW's verification activities; for further explanation see:, www.opcw.org/index.php?eID=dam_frontend_push&docID=18443
S1	Schedule 1 chemical	Chemicals that have been or can be easily used as chemical weapons and which have very limited, if any, uses for peaceful purposes[42]
S2	Schedule 2 chemical	Chemicals that are precursors to, or that in some cases can themselves be used as, chemical weapons agents, but which have a number of other commercial uses (such as ingredients in resins, flame-retardants, additives, inks and dyes, insecticides, herbicides, lubricants, and some raw materials for pharmaceutical products)[43]
S3	Schedule 3 chemical	Chemicals that can be used to produce, or can be used as, chemical weapons, but which are widely used for peaceful purposes (including plastics, resins, mining chemicals, petroleum-refining fumigants, paints, coatings, anti-static agents and lubricants), for example phosgene and hydrogen cyanide, which have been used as chemical weapons, but are also utilised in the manufacture of polycarbonate resins and polyurethane plastics, as well as certain agricultural chemicals[44]
SAB	Scientific Advisory Board	A subsidiary body of the OPCW established in accordance with article VIII of the Convention to enable the Director-General of the OPCW to render specialised advice in science and technology to Member States. The SAB comprises 25 independent experts; www.opcw.org/about-opcw/subsidiary-bodies/scientific-advisory-board
SIX	Secure Information Exchange	An OPCW tool initiated in 2012 to establish an end-to-end solution enabling the secure exchange of information between States Parties and the Secretariat using the internet
-	State Party	Member State; a state which has acceded to the Convention
TS	Technical Secretariat (or Secretariat)	The Secretariat of the OPCW; www.opcw.org
-	Temporal	This relates to timeliness and is one of five key aspects that determine the credibility of a piece of information (besides relevance, accuracy, objectivity and coverage)

[42] www.opcw.org/our-work/non-proliferation/controlled-chemicals

[43] www.opcw.org/our-work/non-proliferation/controlled-chemicals

[44] www.opcw.org/our-work/non-proliferation/controlled-chemicals

-	Tenure policy	An OPCW policy that regulates the duration of service of OPCW staff members (essentially those in the P and D categories)[45]
-	Toxin	A poisonous substance that is a specific product of the metabolic activities of a living organism. Toxins can be small molecules, peptides, or proteins that exert their toxic effects through interaction with biological macromolecules such as enzymes or cellular receptors.
TWG	Temporary Working Group	TWGs are established under the SAB to consider issues in depth
VIS	Verification Information System	OPCW's electronic repository of information related to verification activities undertaken by the Technical Secretariat
WHO	World Health Organization	www.who.int

[45] www.opcw.org/index.php?eID=dam_frontend_push&docID=15218

Annexes

Annex 1: Terms of Reference[46]

1. Verification-related issues with scientific and technological dimensions have arisen over recent years. The Director-General has decided that in-depth study by the Scientific Advisory Board (SAB) is necessary. Further to his response to the report from the Nineteenth Session of the SAB, 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 Verification and has appointed Roberto Martinez Álvarez as the Chairperson of the group.

2. The objective of the TWG is to consider questions relating to verification, in particular those which fall under paragraphs 2(e)[47] and 2(g)[48] of the SAB's terms of reference, and to make recommendations to the SAB.

3. The TWG will consist of individuals who collectively have expertise in the theory and practice of verification, in the chemical weapons and industry dimensions of verification, or experience with the implementation of the Chemical Weapons Convention (the 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 Technical Secretariat

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

    a. What are the technologies/methodologies used for verification purposes in other international treaties that could benefit the Convention verification regime?
    b. Which methodologies (whether existing or new) could assist States Parties in ensuring that all declarable plant sites are identified for declaration?
    c. What are the key technical components of a consistent approach to declaring complex mixtures of discrete organic chemicals?
    d. How can sampling and analysis be utilised most effectively for verification purposes?
    e. Which new or emerging technologies may add value to existing capabilities for verification purposes (such as data analysis/data mining, statistical analysis, attribution analysis)?
    f. Which methodologies might be helpful for the Secretariat to keep abreast of developments in science and technology of relevance to Convention verification regime?

5. In addition, the TWG will provide advice on Secretariat proposals for technologies and equipment for verification purposes.

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

7. The temporary working group will exist for a period of three 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.

[46] Approved by the Director-General on 20 December 2012

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

[48] "assess and report on emerging technologies and new equipment which could be used on verification activities"

Annex 2: Members of the Temporary Working Group on Verification

Member	Institution
Professor Roberto Martinez-Alvarez*[49]	Universidad Complutense de Madrid, Spain
Dr Robin Black	Consultant (formerly of the Defence Science and Technology Laboratory/DSTL, Porton Down, UK)
Dr Hermann Lampalzer	Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO)
Mr Stefan Mogl[50]	SPIEZ Laboratory, Spiez, Switzerland
Dr Daan Noort	Netherlands Organisation for Applied Scientific Research (TNO), the Netherlands
Mr Eric Pujol	International Atomic Energy Agency (IAEA)
Dr Mehran Rouzbahani	Consultant (formerly of the Organisation for the Prohibition of Chemical Weapons; OPCW)
Mr Cheng Tang*	Office for the Disposal of Japanese Abandoned Chemical Weapons, Ministry of National Defence, China
Dr Per Runn	Consultant (formerly of the Organisation for the Prohibition of Chemical Weapons; OPCW)
Professor Alejandra Graciela Suárez*[51]	Universidad Nacional de Rosario. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina
Professor Paula Vanninen*	Finnish Institute for Verification of the Chemical Weapons Convention, Department of Chemistry, University of Helsinki, Finland
Mr Francois Mauritz van Straten*	South African Nuclear Energy Corporation SOC Ltd, Pretoria, South Africa
Mr Valentin Rubaylo*	State Scientific Research Institute of Organic Chemistry and Technology, Moscow, Russian Federation
Dr Rob Visser	Consultant (formerly of the Organisation for Economic Co-operation and Development; OECD)
Mr Michael Walls	American Chemistry Council
Dr Augustin Baulig*	Secrétariat général de la défense et de la sécurité nationale, Paris, France
Mr Bimal Mehta	Transpek Industry Ltd., Vadodora, India
Dr Nicia Maria Fusaro Mourão*	Associação Brasileira da Indústria Química (ABIQUIM; Brazilian Chemical Industry Association), Brazil
Dr Mui Tiang Sng	DSO Laboratories, Singapore

*Member of the Scientific Advisory Board

[49] Chairperson of the Temporary Working Group on Verification

[50] Chairperson of the Scientific Advisory Board until 14 June 2013

[51] Chairperson of the Scientific Advisory Board from 15 June 2013

Annex 3: Guest speakers at meetings of the Temporary Working Group on Verification

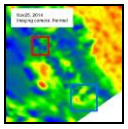
Speaker	Institution
Second Meeting	
Mr Christopher Eldridge	International Atomic Energy Agency (IAEA)
Dr Catherine Smallwood	World Health Organization (WHO)
Third Meeting	
Mr Wilhelm Mandl	International Atomic Energy Agency (IAEA)
Dr Piers Millet	Biological Weapons Convention Implementation Support Unit (BWC ISU)
Dr Tamara Patton Schell	Vienna Center for Disarmament and Non-Proliferation (VCDNP)
Fourth Meeting	
Dr Philipp Amann	European Union's Law Enforcement Agency (EUROPOL)
Dr Kavita Berger	Center for Science, Technology, and Security Policy, American Association for the Advancement of Science, Washington DC
Professor Åke Sellström	Consultant

Front cover:

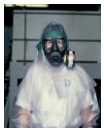
Map of the world. Copyright NASA (http://visibleearth.nasa.gov/useterms.php)

Inspectors during an Article VI inspection. From OPCW's collection of images

On-site verification. From OPCW's collection of images



Aerial surveillance with thermal imaging camera. Copyright CTBTO



Personal protective equipment. From OPCW's collection of images

Lightweight drone with visible imaging camera payload. Photograph by Wesam Alwan

Taking an environmental sample during a field exercise. From OPCW's collection of images

An industrial chemical plant. From OPCW's collection of images

Data. Licensed under CC0 Public Domain

Back cover:

A chemist taking samples of a chemical weapon for analysis. From OPCW's collection of images

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS
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