Appendix

Examples of lessons learned in the course of the work on the compendium

Example 1 — Uncovering the scope of Iraq's work on the chemical warfare agent VX

1. In 1991, Iraq declared that it had carried out laboratory research on VX. By 1995, UNSCOM uncovered evidence that the scope of Iraq's activities on VX was much broader. Consequently, in 1996 Iraq declared the production of 3.9 metric tons of VX, the production of 60 metric tons of key VX precursors and the acquisition of some 650 metric tons of other precursors for the production of VX. Iraq also acknowledged that it had decided to conceal various aspects of its VX activities from UNSCOM and, in 1991, had unilaterally destroyed all VX and key precursors it had produced and some 150 metric tons of other precursors it had procured as well as documents and records relevant to VX.

2. Whether an earlier voluntary disclosure by Iraq of its work on VX could have contributed to fully clarifying this matter can only be the subject of speculation. However, it is obvious that the unilateral destruction, admitted by Iraq, prolonged the verification process, led to the elimination of physical evidence essential for complete verification and left serious uncertainties regarding the quantities of VX produced and its disposition. In 2002, due to these uncertainties, UNMOVIC identified the issue of VX as one of the remaining unresolved disarmament issues. In March 2003, it included this issue in the list of key remaining disarmament tasks (required under the terms of Security Council resolution 1284 (1999)). The Iraq Survey Group also reported that Iraq had not adequately explained and accounted for its VX production and weaponization.

3. The VX verification experience makes it clear that only a sophisticated verification system comprising various verification tools and techniques is capable of uncovering evidence of past undeclared activities. The verification of procurement data revealed the acquisition of large quantities of precursors by Iraq; document searches resulted in the discovery of some records on VX-related activities; interviews with Iraqi scientists and technicians helped to identify gaps in Iraq's declarations on VX; debriefings of defectors produced additional information on the weaponization of VX; information from former suppliers to Iraq helped to corroborate the procurement data; and sampling and analysis identified the presence of VX degradation products. All of the above in combination with on-site inspections led to the identification of the indisputable existence of undeclared activities related to VX.

4. The multidisciplinary verification approach also helped to uncover additional evidence on VX. In 1998, UNSCOM decided to re-examine through sampling and analysis unilaterally destroyed special warheads for Al Hussein missiles. This issue was important for all three verification areas, missile, chemical and biological, since it was linked to the determination of the total number of special missile warheads destroyed and their types and composition. Degradation products of VX were found on missile warhead fragments by one national laboratory. Iraq, however, disputed these analytical results. Later in 1998, other missile warhead fragments were sampled in Iraq. The samples were analysed by three national laboratories. All three laboratories reported the presence of a decontamination compound, and one

laboratory identified a possible degradation product of a nerve agent, but not necessarily VX.

5. Specific technical knowledge had been gained from the experience of sampling and analysis in the course of the VX investigation. One is that sampling and analysis should be performed at the earliest stages of verification and be considered as a routine procedure to collect more verification data rather than an extraordinary measure to verify specific concerns. It should be noted that traces of VX degradation products on chemical process equipment were found only in 1997, after VX production had been established and the specific production plant used by Iraq for that purpose had been identified. Special missile warhead fragments that had initially been verified in 1992 were finally subject to thorough sampling and analysis only in 1998. The following additional procedures for sampling and analysis were introduced by UNMOVIC in the light of this experience:

(a) Samples were to be independently analysed by at least two approved outside laboratories following existing chain-of-custody procedures;

(b) One portion of each sample was to be given to Iraq and another retained by UNMOVIC as a reference;

(c) All samples, as well as raw data and analytical results generated in the course of analyses by the outside laboratories, were to be the property of UNMOVIC;

(d) All conclusions and assessments of analytical results were to be the responsibility of UNMOVIC.

Example 2 — Missile monitoring

6. Under Security Council resolution 687 (1991), Iraq is prohibited from possessing ballistic missiles with a range greater than 150 kilometres. Thus, missiles remaining in Iraq that exceeded the limit set by the Security Council, as well as their major parts, repair and production facilities, were subject to destruction, removal or rendering harmless under international supervision. The plan for ongoing monitoring and verification approved by Security Council resolution 715 (1991) expanded the prohibition and applied it to any delivery system capable of a range greater than 150 kilometres regardless of payload and to any related major parts and components.

7. The possession and development of missile systems within the permitted range was not prohibited to Iraq but was subject to ongoing monitoring and verification. Consequently, in the period from 1992 to 2003, Iraq continued its work on solid and liquid propellant missile systems. The following are examples of what has been learned from the practical experience of the implementation of ongoing monitoring and verification in the missile area.

8. The range of a missile that is fully developed with a known standard payload can be determined on the basis of flight tests or technical documentation. The determination is easy if the missile clearly exceeds the allowable range by a large margin, as in the case of Scud-B and Al Hussein missiles (which have maximum ranges of about 300 and 600 kilometres, respectively). But if a missile's range is somewhere in the vicinity of the permitted value, then expert evaluation and judgement are required since the results of flight tests may depend on particular

environmental conditions. Such was the case when UNMOVIC determined the Al Samoud-2 missile, which was developed during the period from 1999 to 2002 in the absence of international inspectors, to be a proscribed missile. That determination was made on the basis of the assessment of an international panel of experts that judged the missile to be capable of exceeding the permitted range (see S/2003/580).

9. It is well understood that the range of a missile is affected by the payload. However, a payload may vary depending on military requirements. Thus, it is more complicated to establish the possible maximum range of a missile system under development or at the modification stage, since the results of flight tests would depend on multiple parameters, such as fuel load, payload and engine shut-off (burn time), that could be changed at a later stage and could thus affect the range value. Therefore, range alone is an insufficient criterion to make a judgement on a missile under development. Additional technical parameters applied in the course of ongoing monitoring and verification, that could be practicably verified with a minimal degree of ambiguity, have proven to be effective tools that prevented Iraq from developing proscribed missiles in the presence of international inspectors.

10. These parameters included a 600-millimetre limit for the diameter of the airframe of all liquid propellant missiles, the prohibition of any modifications of SA-2 missiles relevant to their conversion into a surface-to-surface mode, the prohibition of tests of SA-2 engines with shut-off valves or modified for extended flight duration and the prohibition of the use of original or modified parts and components of SA-2 missiles for use in a surface-to-surface role. While Iraq did not formally accept these restrictions, it refrained from the production of missile systems that would violate them in the presence of international inspectors until December 1998, when inspectors withdrew from Iraq.

11. After 1991, Iraq retained capabilities to develop indigenously or modify missiles with a range close to 150 kilometres and, due to the nature of missile technology, was technically able to produce missiles that could exceed the prohibited range. However, it did not do so while under ongoing monitoring and verification. The record of ongoing monitoring and verification in the missile area shows that monitoring goals can be achieved through an enhanced verification system comprising on-site inspections, static and flight test observation, use of remote cameras, documents and computer search, tagging of missile hardware in combination with an export/import monitoring mechanism and restrictions on the reuse of missile parts and components from other permitted-range missiles. The absence of international inspectors, the accessibility of critical foreign missile parts and components, and accumulated experience from past missile projects were crucial contributing factors in the resumption of proscribed missile activities by Iraq in the period from 1999 to 2002.

12. Therefore, the evaluation and research of all aspects of Iraq's past missile projects has proved to be a major condition and prerequisite for the development of an efficient monitoring system capable of identifying critical signs and indicators of proscribed activities.

13. The review of Iraq's missile projects demonstrates that liquid propellant missiles are the most likely candidates for modification aiming at the extension of the range of a missile through a payload reduction and increase of fuel capacity. Parts and components of liquid propellant surface-to-air missiles can also be reused in a surface-to-surface role, like the liquid propellant engines of the SA-2 missiles

used in the Samoud-2 surface-to-surface missiles. Accordingly, it is important to reach a full accounting of all SA-2 missiles and their components, especially engines and parts of guidance and control systems, remaining in Iraq. It should be noted that Iraq was not able to produce indigenously liquid propellant missile engines.

14. Conversely, the example of Iraq's development of the Al Fatah missile (see S/2003/580 and S/2003/1135) demonstrates that solid propellant missile technology is more easily attainable in-country for indigenous production.

Example 3 — Determination of biological warfare agent production facilities

15. In 1991, after the adoption of Security Council resolution 687 (1991), Iraq declared that only one facility at Salman Pak had been involved in biological warfare research. No other facilities were declared in connection with its biological warfare programme. Iraq had decided not to declare the full extent of its biological warfare programme and to remove any evidence of its previous existence, but at the same time to retain all remaining associated facilities, equipment and materials.

16. By 1995, in the course of its continuing verification, UNSCOM collected sufficient evidence suggesting that Iraq's biological warfare programme had not been limited to research activities but had also included the production of several bulk biological warfare agents and, possibly, their weaponization. Consequently, in July 1995, under pressure from the inspectors who had acquired procurement information related to the unexplained import of large quantities of growth media, Iraq finally admitted the past production of biological warfare agents at Al Hakam, a dedicated biological warfare facility. After the departure of Lieutenant-General Hussein Kamel from Iraq in August 1995, Iraq further admitted that biological warfare agents had also been produced at two other civilian facilities, the foot-and-mouth disease vaccine plant at Al Dawrah and the agricultural research and water resources centre at Fudaliyah.

17. The account of international verification in the period from 1991 to 1995 exemplifies that even the most clandestine biological warfare programme, such as the one in Iraq, cannot be hidden in its entirety from a comprehensive inspection regime. It also shows the complexity of the determination of past biological warfare activities and provides lessons that are important to consider in cases when concealment policies and practices are actively employed. Prior to the arrival of international inspectors, Iraq cleaned all sites involved in the production of biological warfare agents, removed evidence of past activities, including relevant documents and records, reconfigured equipment, decontaminated and renovated buildings and structures and prepared convincing cover stories.

18. In May 1991, Iraq first identified Al Hakam as a legitimate biological facility intended for the future production of vaccines or other materials produced by micro-organisms such as single-cell protein. The facility was inspected for the first time in September 1991. Several samples taken by the inspectors from different pieces of equipment at Al Hakam were analysed by one outside national laboratory and were reported as negative for the presence of biological warfare agents. Further inspections of this site took place in 1992, 1993 and 1994. The inspectors raised suspicions regarding the true nature of the site and noticed unusual features of the facility, such as the presence of multiple air defence units around its perimeter, the enhanced protection and bunker-style structures, the separation of different areas

within the facility, the rapid construction of the site, implying a strong sense of urgency, its isolation and secrecy, the presence of equipment that had been transferred from other sites, and the weak economic rationale for the purported production of single-cell protein. Although the inspectors believed that the facility could have been planned as the next stage in Iraq's biological warfare programme, no evidence of its actual involvement in Iraq's past biological warfare programme was found. It was assumed that the very low level of biological containment in the facility prevented it from being used for the production of pathogens and that its equipment was not suitable for such production.

19. It was established that timing was critical for Iraq to eliminate much of the evidence of past activities at Al Hakam. Thus, prompt commencement of verification activities at newly declared or identified facilities is essential, especially for biological inspections. The availability of inspectors for deployment at short notice and well-established analytical capabilities, both within the inspection team and in outside laboratories, are required to achieve this goal. Diversified inspection teams, comprising not only experts in the biological warfare field but also specialists in scientific and technical areas relevant to specific activities such as those declared by Iraq at Al Hakam, namely production of vaccines and single-cell protein, would be required to ascertain whether a facility like Al Hakam fits its declared status and purpose by its design, construction, equipment, staffing, budget, etc.

20. Additional experience gained relates to sampling and analysis, which always carry the notion of scientific argument and thus have a strong influence on a final judgement. While positive results of analysis may provide strong forensic evidence and proof, negative samples may easily lead to wrong conclusions and be exploited by the inspected side. In addition, a limited sampling strategy, focused on a few sampling points, risks missing relevant information and may even be counterproductive. An adequate sampling policy comprising environmental, background and investigation-related points in the vicinity of Al Hakam could have enhanced the chances of detecting proscribed materials in the vicinity. Likewise, the use of more than one laboratory for analysis has a reinforcing effect on the results given. To be effective, sampling and analysis require sufficient preparation as well as a constant update of analytical procedures. However, even extensive sampling and analysis could have produced limited results due to the technical limitations of analytical methods available at that time. Thus, it is desirable to keep samples for a sufficient period of time while new, more sensitive methods of analysis are developed.

21. Considerations related to the low level of biological containment were major factors in the initial perception of the unsuitability of Al Hakam for the production of pathogens. These considerations were drawn from microbiological practices and standards familiar to the United Nations biological inspectors, who were considered to be some of the best scientists and engineers in the biological warfare field. However, they were based on elevated expectations on the part of the inspectors regarding the degree of efficiency of Iraq's biological warfare programme, assuming possible production of viral agents and dried bacterial agents. As was subsequently learned, Iraq produced bacterial biological warfare agents at Al Hakam with a moderate risk of airborne contamination due to the generation of aerosols. Thus, by applying the biosafety standards of developed countries it is not always possible to reach conclusions on the type of biological activities being carried out elsewhere.

22. Unlike Al Hakam, which was built as a dedicated biological warfare facility, the foot-and-mouth disease vaccine plant at Al Dawrah was constructed as a legitimate turnkey facility by a foreign company in the late 1970s and early 1980s. The plant was designed for the production of vaccine for three foot-and-mouth disease strains endemic to Iraq. United Nations inspectors, who visited the plant from September 1991 to 1995, identified capabilities existing at the facility to produce biological warfare agents, but concluded that the site was a legitimate facility since no modifications to its original design had been made by Iraq. No evidence of its involvement in Iraq's biological warfare programme was found until Iraq declared its past involvement in 1995. Sampling at this facility was not performed prior to 1995.

23. The most important lesson learned with regard to the experience of the foot-and-mouth disease vaccine plant is that Iraq indeed carried out large-scale production of a biological warfare agent at a legitimate civilian facility. Conversion of a legitimate facility for biological warfare purposes is difficult to detect, especially when such activities take place only for a short period of time, and when the site requires only very minor adjustments for the production of a biological warfare agent. Similar experience was gained regarding another legitimate facility at Fudaliyah also utilized by Iraq's biological warfare programme.

24. It was also found that if a deception campaign is actively pursued, the probability of finding hard evidence of activities related to biological warfare is minimized. The major technical tool that could have helped to identify such facilities is extensive sampling and analysis. Other verification methods, such as the evaluation of documents and records and interviews with staff, are also important, but could be influenced by deception efforts.

25. It should also be noted that the first teams that inspected facilities at Al Hakam, Al Dawrah and Fudaliyah combined two functions simultaneously — site exploitation and site assessment. It has been determined from this inspection experience that a verification system could be more balanced and effective if it provides for a two-stage approach: verification and collection of facts in the course of inspection activities, and a separate evaluation and assessment in the broader scope of proscribed programmes.