no 30

Indicators of State and Non-State Offensive Chemical and Biological Programmes

EDITED BY INGRID FÄNGMARK AND LENA NORLANDER

WMDC
THE WEAPONS OF MASS DESTRUCTION COMMISSION
www.wmdcommission.org

This paper has been commissioned by the Weapons of Mass Destruction Commission. Its purpose is to function as food-for-thought for the work of the Commission. The Commission is not responsible for views expressed in this paper.

Weapons of Mass Destruction Commission (WMDC)
The WMDC is an independent international commission initiated by the Swedish Government on a proposal from the United Nations. Its task is to present proposals aimed at the greatest possible reduction of the dangers of weapons of mass destruction, including both short-term and long-term approaches and both non-proliferation and disarmament aspects. The Commission will issue its report in early 2006.

The commissioners serve in their personal capacity. The Commission is supported by a Secretariat based in Stockholm, Sweden.

Weapons of Mass Destruction Commission
Postal address: SE-103 33 Stockholm, Sweden
Visitors' address: Regeringsgatan 30–32
E-mail: secretariat@wmdcommission.org
Website: www.wmdcommission.org

Indicators of state and non-state offensive chemical and biological programmes

Edited by
Ingrid Fängmark and Lena Norlander
Division of NBC Defence, Swedish Defence Research Agency (FOI)

Contributing experts:
Gudrun Cassel
Anna Holmström
Britt Karlsson
Per Lind
Magnus Normark
Tina Sehlstedt
Anna-Karin Tunemalm

Content

Executive summary

Means to reduce proliferation of chemical and biological weapons is of high priority for the international community and a number of measures have been taken already. The more complex threat picture after the end of the cold war era has accentuated the demand for measures to monitor the observance of the chemical and biological conventions, in particular for countries outside the treaties and also because the biological weapons convention lacks a verification regime. Simple criteria, indicators, to systematically gather information and track changes have previously been discussed as conceivable tools for this purpose. This report presents an analysis of suitable indicators of various strengths, representative for the different stages of the development of a state-funded offensive capability. It also contains a brief assessment of indicators for non-state actors.

Due to the dual-use nature of chemical and biological warfare (CBW) programmes, indicators for detection of illicit programmes are difficult to distinguish from those of permitted civilian activities. This is a particular problem at the early research stages of an offensive programme, but also in later stages some elements of the offensive activities can scarcely be distinguished from legal activities. As a result there is no single outstanding critical indicator for a state-funded chemical or biological weapons programme, rather multiple indicators or specific "signatures" of indicators, common for chemical and biological programmes, have to be used.

State programmes can be identified in various stages of development. Indicators for political will are early indicators. These are followed by indicators for research, building of know-how and weapon capability, i.e. infrastructure for an offensive programme. The political will is demonstrated through multiple observable indicators describing leadership and political outlook; and indicators, such as asymmetric conditions and rhetoric regarding weapons of mass destruction were found to play a vital role, with the lack of transparency being an aggravating circumstance.

Other indicators describe resources such as know-how, research and development capability, industrial capability and delivery systems. Some of these indicators are strong and others are of medium or low importance, but still contributing to the overall picture. Due to the dual-use nature of CBW programmes, infrastructural indicator signatures are seldom characteristic and have to be assessed in combination with indicators for political will. There are also indicators for the protective measures that have to be undertaken, i. e. to protect the resources from being revealed, and to protect troops from biological and chemical weapons, as well as for economic relations and funding of the programme. In general, an important indicator for a state funded offensive programme is equipment and know-how for up-scaling from laboratory to pilot and production scale. Another indicator is the lack of balance between declared production or education and funding and scientific output. Resources in terms of a civilian industrial capability can already exist when the decision to initiate an offensive programme is made, but certain indicative infrastructural changes have to be made.

Indicators of non-state actors are assessed to be weak and very few. It can be a person or a group with extreme political views, who have shown an interest in chemistry or biology and production technology. Other indicators are if the group has procured or searched for laboratory equipment of any kind together with primitive dissemination devices or simple protective equipment.

Altogether the combination of non-transparency, research facilities connected to defence establishment and financing is a strong indicator for offensive activities. The set of indicators presented in this report must be continuously validated and improved in order to be adapted to changing situations and provide flexibility in the assessment.

Introduction

The threat assessments during the cold war era had a fixed frame – there were no doubts about the presence of active programmes on biological and chemical warfare agents. The threat from biological and chemical warfare agents was a concern despite the fact that the first use of these weapons was forbidden according to the Geneva Protocol from 1925. Moreover, the development and production of biological weapons (BW) were prohibited by the Biological and Toxin Weapons Convention (BTWC), which came into force in 1975. A majority of the states of the world have signed and ratified this convention. In the cold war era there was no convention that prohibited the development, production and stockpiling of chemical weapons (CW) as the Chemical Weapons Convention (CWC) did not come into force until 1997. Chemical weapons have been used in various conflicts from the First World War to modern time. They were for instance used by Iraq in the war with Iran 1980-1988.

Several states have been accused of offensive activities in the 1980 – 1990s and also in recent years. During that time reports from intelligence organisations all over the world contained lists of agents, possible dissemination devices, research programmes, and estimated programme volumes. It is notable though that the use of biological weapons in conflicts has never been verified.

The end of the cold war brought with it a modified threat picture, which is more complicated to assess. In addition to state programmes, non-state actors show interest in unconventional weapons and the possible use of biological and chemical agents by terrorists is of great concern.

After the cessation of the cold war an increased dialog and trust between former antagonists changed the view. It was discovered that the threat from some nations had been exaggerated, and for others underestimated. In recent years the international community has gained insight in some of the nations, whose names were frequent on BW and CW lists. A representative example is Libya, which in 2003 invited the United Nations (UN) to inspect facilities involved in offensive activities. Libya also declared the content of the former programmes. The other recently "opened" state is Iraq whose offensive programmes have been scrutinized by the UN and later the Iraqi Survey Group. Thus two of the nations of concern have disappeared from the list of states suspected of offensive programmes.

The border between defensive and offensive activities is, however, difficult to define especially at the early stages of a programme. Research for the development of a new vaccine might easily be a cover for the development of a biological weapon. Scientists working on new pesticides have suitable resources at their disposal to develop chemical weapons. In both cases the equipment is of dual-use character and commonly found in civilian laboratories and factories. The same is true for much of the material used in the development of products for therapy or for the farming area.

Unfortunately, the appearance of terrorist groups as presumed actors in the biological and chemical offensive area had a negative effect on the international view on the threat from these agents. The world is now counting on an increased number of actors and, in contrast to states with offensive ambitions, these actors are very hard to pinpoint because they frequently act within scattered networks. As a result there is a worldwide concern about the threat from terrorists and a striving to develop means of protection against biological and chemical agents.

Taken together there is an apparent need for new tools to assess the current threat. We want to find the relevant indicators for a state-sponsored offensive programme as well as for nonpermitted low-scale terrorist activities. By nature it is, however, easier to define indicators for large-scale state-owned programmes than for non-state small-scale activities. In this paper we will discuss both issues.

The primary use of indicators is to characterise current status and to track or predict significant changes. Relevant indicators provide a systematic approach to identify changes to be followed up further, through for example gathering of additional information (intelligence) or, if possible, by on-site inspections.

Based on their different nature, indicators for BW and CW programmes can be divided into state policy orientated indicators and resources (i.e. know-how, raw material, production oriented and weapons oriented), respectively. State policy oriented indicators demonstrate the intent or the motive for a state to acquire capability. The most obvious example is when a military doctrine reflects an ability to deploy weapons of mass destruction (WMD). The most serious cases are those where perceived intent is combined with capability in terms of know-how and industrial resources. Indicators have to be focused on judgements of intent as well as capability, since most chemical and biological facilities are relatively simple and of multi-use. Particularly at the early stage of research and development, the only difference between offensive and defensive activities might be the one of intent.

The aim of the report

The overarching aim of this report is to provide the reader with an understanding of indicators of biological and chemical weapons programmes and how to use such indicators in the future approaches to prevent proliferation of WMD. The report deals with indicators for state-funded programmes as well as for non-state actors.

The material and the assessments presented in the report are collected from presentations by technical experts and analysts of biological and chemical weapons. Each of these scientists has a specific expertise in the area and thus, the result presented is reflecting various aspects on offensive programmes and indicators for such programmes.

State programme indicators

State policy orientated indicators

Unconventional weapons such as biological and chemical weapons are often regarded as the choice of the poor. Their use can be difficult to verify but antagonists may accuse each other of development and use of such weapons with the purpose to discredit one another. Saddam Hussein considered Iraq's chemical weapons as weapons of power and he used them both against oppositional groups domestically and as tactical weapons against Iran. They also served as strategic weapons against Israel. A country like the former Iraq with its undemocratic leadership, limited transparency and no public insight into internal affairs is the typical example of apt conditions for the acquisition of WMD. It is likely that the threshold for offensive research increases with the degree of openness and democracy in a country and thus it has a connection to the nature of leadership.

Dominance in the conventional weapon arena could be balanced by asymmetric means, and in this context biological and chemical weapons play a role. A country may try to counterbalance an asymmetric situation in the region by turning to a non-conventional weapons programme, especially if there is a perceived existential threat towards the state leadership, a fundamental dissatisfaction with the geopolitical status quo or if the state is engaged in a territorial conflict with significant implications. Examples of the latter are conflicts about natural resources or a conflict of geo-strategic importance. An experience including past WMD dynamics with consequences for the country's political outlook is also likely to contribute to a more prone attitude towards an offensive track.

In conclusion, our attention should be raised when a country expresses a state doctrine, which demonstrates a clear offensive or deterrent strategy, a non-democratic leadership and a limited transparency into its internal affairs.

Contributing signs, however, of a lower dignity, are if the country has expansionistic ambitions or is seeking regional hegemony, if it has a strong relation on a high political level with other states of concern or has a negative asymmetric position towards a threat. An additional indicator may be if highly ranked individuals with a strong scientific background exert an influence on state defence planning. The threshold for illicit activities will be raised if a country has a high degree of dependence on the international community (economic or trade relations) or on its immediate neighbours.

A weak indicator is the attitude the country displays and how it acts with respect to international conventions – reflecting an ambition to protect its interests or an underlying secret agenda. In these respects the degree of transparency is critical. The rhetoric of highly ranked officials regarding WMD and its impact on present or future security dilemmas including statements on sovereign states' rights to acquire any means to defend themselves is another weak indicator.

Given the sensitive character and military interest in state owned offensive programmes, important facilities and chemical and biotechnical industries would be under military or state influence. In a situation where defence projects have a high priority in state affairs, they would be funded over the state budget. The combination of a lack of transparency and an organisational connection to defence establishments and defence financing makes offensive ambitions in the chemical and biological area more likely, i.e. this is a strong indicator.

Altogether the will or intention to pursue an offensive programme is highly important and state policy oriented indicators therefore play a vital role. It can be argued that without will technical assets become less important. On the other hand, a strong chemical or biotechnical industry and research resources may facilitate the decision to use these assets for offensive purposes.

Resources

The evolution of a state-funded programme

State-funded chemical and biological weapons programmes follow similar evolutionary steps with an increasing degree of sophistication, as illustrated by the figure below. An initial period of assessment of the areas of interest and basic research is followed by the successive development of an infrastructure for offensive work. This is exemplified by the introduction of a pilot scale production of the agents simplest to handle and produce along with the development of simple delivery systems. In the next stage more complicated agents are introduced into the programme, such as simple nerve agents for a chemical programme or viruses in a biological programme. At the same time the technological level of delivery systems will increase from simple artillery bombs to cluster bombs and cruise missiles.

In later stages, the stability of the agents is an issue of concern. Various methods are developed with the purpose to increase the stability of biological agents as aerosol and later the interest is shifted from wet aerosol to dry aerosol dispersion techniques. At the top stages of the programmes, VX, binary chemical agents, new agents or genetically modified microorganisms (GMM) are found in the programmes and the actor has established know-how in aerosol production, optimal particle size and dispersion models.

The arrows between the chemical and the biological stairs indicate links in the form of information exchange between biological and chemical laboratories located at the same site or using the same supporting facilities. A review of past well-known programmes indicates that the chemical programme is initiated before the biological programme. In particular, the biological programme is believed to benefit from experience gained within the chemical programme.

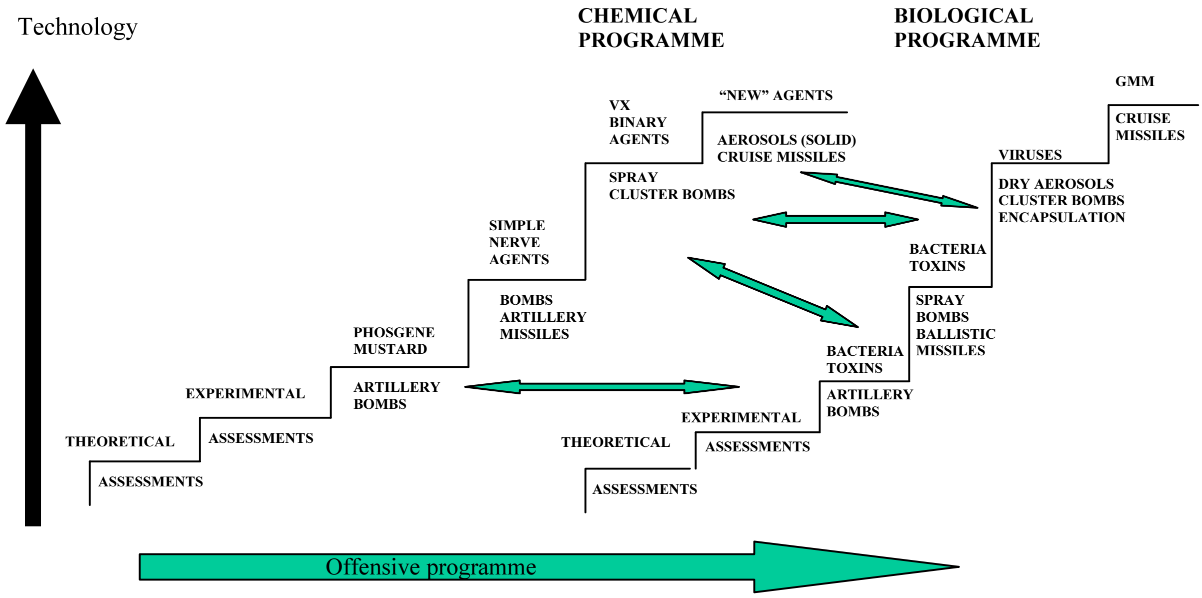

Figure 1. Result of a survey of the chronology of technological achievements of offensive chemical and biological programmes as pursued in past state programmes.

Know-how and infrastructure

Common for large-scale chemical and biological weapons programmes is the need for know-how and an industrial infrastructure. Production technologies for classical biological and chemical agents are well known and the bottleneck for acquiring a capability will be the acquisition of material and equipment. An appropriate capability supported by an advanced research and industrial profile is required if the intent is to develop and produce new agents. Many countries have, for perfectly legitimate reasons, a civilian chemical and biotechnological industrial profile of dual-use character that would serve to produce chemical and biological agents. Likewise, many components of a legitimate defence research programme and an offensive program are the same. The main difference is the large-scale dimension of an offensive programme.

A country with an offensive program will need to protect its assets from being revealed. Thus characteristic for a production or offensive research facility is a high level of secrecy, at least for part of the facility. It will have restricted access, high security and safety levels, guards, military personnel, fences, cameras, motion detectors etc.

A facility may be revealed by its effects on the environment and worker's health. Therefore other signs are if ventilation and waste handling systems are oversized and safety procedures elaborate. Typical for a chemical facility is that there will be access to excessive quantities of high quality personal protective equipment and specific decontamination material and equipment. A biological facility may have a vast laboratory area and a high safety level in order to produce highly contagious agents. States of concern may, however, be less conscious of the risk of personal exposure than the risk for a leakage which could reveal the site.

There may be reasons for locating a facility within a concealed programme in a remote area, but on the other hand a civilian site located in a city may attract less attention and serve as a cover for offensive activities. Altogether, within an offensive programme, safety and security measures as well as type and quantity of materials do not match declared or officially stated activities. In conclusion, a discrepancy in declared activities or production and the character of the site, i.e. location in combination with security/safety equipment is a critical factor.

A production facility may need support, such as laboratories for research and quality control and animal testing rooms, which could be equipped for aerosol dissemination tests. These indicators are of medium importance and the access to animal test facilities is more important for a biological programme than for a chemical programme. The presence of such supportive functions in combination with an interest in aerosol dissemination devices and aerobiology is, however, a strong indicator for an offensive activity.

Another characteristic for an offensive production facility is that dual-use production equipment and raw material is procured covertly or that the country has a capability for indigenous production to cover its needs. With respect to the need for raw material there is a fundamental difference between a chemical and biological programme. As biological agents occur naturally, a proliferator need not to go through complicated procedures such as concealing import or starting up indigenous production as is the case for a chemical programme for classical chemical agents. Import of raw material and capability for indigenous production of raw material are essential indicators for a chemical programme. Thus dual-use equipment becomes a conditional indicator in the chemical field as its importance depends on whether raw material is available or not. The production of biological warfare agents may, however, be uncovered by the consumption of a large quantity of growth media, which is not possible to explain by any legitimate production, for instance production of vaccines.

In the previous decade most states have introduced stronger export restrictions in order to make it more difficult to import equipment for offensive programmes. A help for these measures has been the lists first established in 1985 by the Australia Group. These lists, however, comprise large-scale equipment, i.e. production equipment, and do not cover small-scale ambitions. As a result of the expanded export restrictions and the subsequent problems to import equipment, a growing number of states strive to gain a national capacity for dual-use production equipment.

Key-personnel employed at an offensive site are educated and trained in relevant areas, abroad if the desired knowledge is not available domestically. They are well paid and the ethnic diversity is typically limited. An offensive site has a high level of research funding compared to civilian research institutes and funding exceeds what normally would be expected in terms of research output such as scientific publications.

An agent does not become a usable weapon until it has been integrated with some type of weapon system. Suitable munitions or delivery systems need to be procured, developed or modified and there must be equipment and procedures for the filling of weapons. Therefore an offensive production facility is preferably located in close proximity to a metal-machining factory, which is capable of manufacturing munitions or performs reverse engineering of conventional munitions. The filling operation, which is extremely hazardous, should ideally be performed inside a sealed building with a controlled atmosphere and the filling machines themselves being enclosed and sealed from the external environment. The presence of facilities of this type is an indicator for an offensive programme.

Development of delivery systems must be supported by a logistic system for the stockpiling, transport, handling and use of bulk agents and munitions (including explosives), and production and weaponisation must be complemented by dispersion trials to test prototypes. Here perfectly legitimate activities such as the dissemination of biopesticides on crops, or the use of conventional smoke bombs, might serve as a cover for weaponisation testing. An indicator of high importance is the accomplishment of large-scale military exercises, including dispersion trials and operational tests of battle plans, and this would also require test areas. BW and CW troop protection exercises may have legitimate reasons and cannot serve as a sole indicator.

In the table below indicators common for both chemical and biological weapons programmes are compiled and categorised according to their importance.

Table 1. Critical indicators for offensive state-funded chemical and biological programmes.

Type of indicator	**Critical indicator**	**Indicator of medium importance**	**Weak indicator**
State leadership	Authoritative regime Non-transparency	Scientific impact on defence planning Degree of independence from international community (trade relations, security policy issues)	
Political outlook	Past or present WMD dynamics in the region Doctrines (defensive, deterrence or offensive) Severe security dilemmas	Political ambitions (regional hegemony, domestic or foreign policy aspiration) Alliances and influences (relations to other states of concern) Asymmetric circumstances	Rhetoric (expression of an aggressive security policy) Attitude towards international conventions
Industrial capacity and profile	Import (covert) of dual-use equipment and raw material or indigenous production Capability for reconfiguration Raw material or growth media do not match output Oversized safety systems	Protective measures and materials relevant for officially stated activities Animal testing rooms Bunkers for storage	Industrial capacity (research and development, production)
Protective measures	Restricted areas A high level of secrecy (at least for part of the facility)	CBW troop protection exercises	
Research capability	Pilot plant for scaling up Under military influence	Laboratories for R&D and quality control	
Funding and resources	Highly educated personnel but low publication rate Military presence	Economy/defence expenditures (defence projects priority in state affairs)	Industrial chemical, biotechnological profile with military connection
Delivery systems	Research on delivery systems Exercises, dispersion and field trials Aerosol dissemination devices	Facility in close proximity to explosive handling and meta-machining factory	

These indicators were tested on a number of countries, signatory states as well as states of concern. It was found that by combining indicators from the table it is possible to find characteristic signatures with a more decisive power than that of a single indicator. The most decisive signature components were found to be state leadership and political outlook. Such characteristic signatures of indicators should raise our attention. There are also specific indicators for chemical programmes and others, which are more relevant for biological programmes. These are discussed under separate headlines below.

Critical indicators of a state-funded chemical weapons programme

Chemical programmes can vary significantly in technological level and size depending on user and strategy.

For major conflicts between states, large quantities (hundreds of tonnes) are required and, when producing for future use, storage stability will be of major concern. In such cases storage areas or bunkers, and the logistic systems connected to them are indicators of illicit activities, together with procurement or production of stabilizer chemicals. An advanced CW programme would encompass several agents with differing toxicities and physical properties, and different types of munitions. Within advanced programmes new agents can be developed in order to circumvent export/import control regimes. Such a programme requires research laboratories, sophisticated techniques and an industrial base on a high technological level. An operational capability requires the design of effective munitions, filling systems and a weapon system. An advanced user may prefer binary agents (two relatively non-toxic chemical components that, when mixed together, react to form a lethal agent) to avoid the risk of being revealed, because of improved storage stability and also for safety reasons, i.e. easier to produce and handle. Munitions development capability becomes even more important with binary systems. Common for advanced programmes are the access to first class chemical research and an advanced chemical and munitions development industry. Other characteristics are the need for support from pilot scale plants for scaling up and the access to testing and proving grounds for dispersal trials and troop training.

Smaller quantities (hundreds of kilos) may be sufficient for tactical requirements. In such cases a CW arsenal containing only one or two agents and a simple “off the shelf” delivery system, such as an agricultural sprayer, would suffice. If the agent is produced for immediate use, agent quality will be of minor concern and production can be done “just in time” using a temporarily converted civilian production plant. With equipment and raw material within reach, and infrastructure and safety procedures established beforehand, a multipurpose plant can be converted in less than a month. Conversion is facilitated if the country is willing to trade off safety of workers and environmental protection. The current trend in industrialised countries is towards smaller facilities that are able to switch production between various products at short notice to meet the demand of a more complex market. Such flexible facilities also, unfortunately, make it easier to switch to the production of CW or CW precursors. However, ceasing civilian production temporarily might create observable shortages of consumer goods, such as pesticides or drugs that may serve as indicators. Indicators that need to be followed up are import of dual-use equipment to states of concern, which have a capable chemical industry, access to important dual-use chemicals and well-equipped laboratories, but with a low transparency towards the outside world. This is particularly true if it occurs in combination with infrastructural signatures such as excess waste handling and ventilation systems, and also availability of inert gas-lines.

For terrorist use an even smaller scale production (kilogrammes) could be sufficient (see further under non-state actors).

Capability and know-how

The information age has facilitated proliferation of chemical know-how through various channels, primarily the Internet. The routes of production for the classical CW agents are generally known and relatively easy to find and use for someone with basic skills in chemical engineering and technology. Another useful educational background is a higher university level in organic chemistry complemented by analytical chemistry skills in order to assure proper quality control. Research for alternative synthetic routes for classic nerve agents, raw material or new agents can be conducted under the cover of for example pesticide or insecticide development. This generally requires a university degree or a higher education in chemistry and toxicology.

From a technological standpoint the scaling-up from laboratory to pilot to industrial scale is not trivial and therefore going from laboratory scale (kilogrammes) to pilot and production scale (tonnes) will be one of the choke points for a proliferator. Production equipment must be of a high quality and corrosion resistant. Such equipment is of dual-use nature and under international trade control. A more scrupulous producer in urgent need for a few batches of CW agents might, however, be willing to sacrifice equipment and use those of a lower quality. From a technological production standpoint a remotely controlled batch process would be easier to control than a continuous process and thus the existence of batch processes could contribute to the signature of an offensive programme.

Another important obstacle is the access to basic raw material for the production of CW agents, because of the international embargo on such chemicals. However, many of those chemicals have legitimate use in the civilian industry at quantities that makes control difficult. Millions of tonnes of phosphorus-based compounds, related to nerve agents, are traded globally for commercial purposes. Thus militarily significant quantities could be lost in the noise of international trade. Experiences from Iraq have demonstrated how difficult it is to track illegal procurement if a proliferant country takes care to set up elaborate networks of 'front' companies, paper subsidiaries, and middlemen to hide their purchases. Because the production of many basic commodity chemicals is shifting from the industrialised countries to the developing world, some precursor chemicals are produced at multiple locations in several countries.

In conclusion, a large number of countries have a technical capability to produce at least simple chemical weapons, especially if the country is self-supporting with raw material. Using an alternative synthesis route for chemical warfare agents, it may be possible to bypass embargoes on production equipment and raw material. However, this puts high demands on scientific skills and technological level.

Critical indicators of a state-funded biological programme

The use of biological weapons has not been verified, but there has been plans to use them both as strategic and tactical weapons. The main route for dissemination has been intended for aerosol delivery and large scale attacks. In comparison to chemical weapons, the term large-scale may be equivalent to dissemination of kilograms, not tonnes, of biological material. The reason is that many of the microorganisms, spread by air, cause infection after exposure to an infectious dose of a few organisms, 10-1000 bacteria or virus particles. As the organisms are very small, there are millions of infectious doses in a kilogram of purified bacteria or viruses.

Many of the components of a defence research programme – permitted activities according to BTWC – and an offensive programme are the same. There are well-equipped laboratories, for instance for cultivation and harvesting of microorganisms. However, in general, the offensive biological programme of a state is characterised by a more pronounced large-scale dimension compared to the defence research programme. The fermenters in the offensive laboratory are of pilot scale or even of large scale. There is a tremendous difference in growing highly pathogenic bacteria and viruses in small-scale and in large scale, respectively. The knowledge can, however, not be limited to the offensive programme as large-scale cultivation of microorganisms is performed also in pharmaceutical industries such as those producing antibiotics and vaccines. On the other hand, the industries do not handle highly pathogenic organisms. Vaccine strains of viruses and bacteria are for instance attenuated variants of the pathogens, i.e. variants with low degree of pathogenicity or recombinant strains expressing the critical components of the highly pathogenic strains.

Capability and know-how

An important indicator for a state-sponsored programme is the combination of the basic knowledge of the critical properties of infectious agents and the means to test and maintain these properties. There are a number of basic critical questions, which the scientist and technical staff have to be aware of, for instance:

- the optimal methods for propagation of viral or bacterial strains
- the proper methods for harvest and preparation of infectious material
- the maximal number of generations in artificial growth before loss of pathogenicity
- the infectious doses of the microorganisms of interest
- the relevant animal system(s) for testing pathogenic properties.

In addition, the offensive actor needs to know the average time from exposure to illness, the contagiousness, and very important, the physical stability of the organism. Taken together, the expert knowledge of all the basic properties of a pathogenic organism is crucial for the development of a biological weapon. Capability for large-scale cultivation, preparation of pathogenic material for aerosol dissemination and animal tests should always be assessed as an indicator of offensive activities if the state of concern is characterised by low transparency and/or hostile attitude towards neighbouring countries.

Vaccine development of today is often characterised by the design of recombinant constructions. Similar research efforts may also be performed with the intention to create a genetically modified organism for further weaponisation. But the development of agents for use as weapons does not necessarily require a high technological level in molecular biology or gene technology. A successful offensive work may include biological agents of natural origin (clinical isolates), which are suitable for weaponisation. Nature offers a tremendous amount of variants of naturally occurring pathogenic strains and there may be no obvious need for artificial modification of their properties. But a research facility with highly skilled scientists may use technology to optimise the warfare agents in order to obtain more efficient weapons, for instance by introducing antibiotic resistance genes. This is easily done by using standard procedures, known for decades. Moreover, single antibiotic resistance marker genes are commonly used in laboratories studying pathogenicity, and in defence programmes where vaccines are developed. In the initial phases of such vaccine development research is performed in laboratory scale with the emphasis on the immunogenic properties of the infectious organisms. Animal models are frequently used in the work.

Alternative genetic modifications of a BW agent may be performed in order to change the common pattern identified in routine diagnostics or to confer immunomodulating affect to the virus or bacterium. Compared to the original organism, similar genetic constructs have been shown to cause severe infections with partially new symptoms. The construction of organisms with enhanced virulence (including immuno supression), survival, host range etc. or with multiple antibiotic resistance is always a critical indicator for an offensive programme. Moreover, extensive tests in animals are required in order to verify that the genetically modified organisms retain their virulence and, thus, such activities may be identified by their large dimensions.

The test of a vaccine candidate is generally performed on small rodents such as mice or guinea pigs. Monkeys are used more seldom because these experiments are expensive and they also require more laboratory space. A few viral species have, however, very narrow host ranges and the tests therefore have to be made in monkeys. In an offensive programme the final tests of a weaponised agent is expected to be made in monkeys, because of their similarity to humans.

A crucial indicator is know-how in aerobiology, including generation of aerosols with optimal particle size, dispersion models, and physical and biological character of particles. It may be argued that this competence is needed also for aerosol challenges of pathogens in vaccine tests. However, the presence of aerosol generation equipment for large-scale exposure of animals is a critical indicator, exclusively of offensive ambitions.

Biotechnology has also brought more efficient methods for growth of microorganisms and the same knowledge is a benefit in an offensive programme. As a result of the more efficient methods developed for the production of pathogenic microorganisms, more species can be artificially grown in a laboratory. An apparent interest in developing and optimising systems for large-scale growth of pathogenic viruses and bacteria is an indicator of offensive activities. In contrast, only a small amount of material (i. e. gram quantities) is needed for general studies of pathogenic organisms or for the development of protective measures.

Import of equipment for large-scale production of microorganisms to states of concern is often regarded as attempts to equip a bioweapon facility. It is almost impossible to determine whether the equipment is intended for the specified legal purpose or not. An export licence for equipment for large-scale production of microorganisms should ideally be coupled to an inspection procedure, executed when the specified facility has been in use for a while.

Viruses and bacteria may be stored in freezers, but additives are needed in order to secure the survival. Freezers with strain collections and preparations of biological material are commonly found in all types of research facilities. However, the consequent search for optimal strains for weaponisations may be reflected by a large strain collection, which is an indicator of the programme. The fragility of biological agents restricts the possibilities of large-scale stockpiling of weaponised organisms. In an offensive biological programme the capability to start large-scale production in a few weeks is the critical factor, not the presence of stockpiles of biological agents.

Are there indicators for non-state actors?

In contrast to state actors, there are few examples of non-state actors trying to gain an arsenal of BW or CW agents. Thus the assessment of indicators for these actors is mainly based on a theoretical discussion. Non-state actors, just like state actors, could, however, be expected to have an identifiable intent of using biological or chemical agents which might stem from an interest in chemistry or biology. Just as with state actors there is an assessment and familiarisation phase starting with an interest in the subject of choice, followed by development of knowledge and capability. This is the primary phase where the activities of a group can be identified. However, a successful identification requires the autonomy of the group, i.e. that there is an established group and that it does not have an efficient cover. Covers could for instance be legal works performed at laboratories with the appropriate infrastructure available such as universities, research institutes, pharmaceutical industries etc. where dual-use material and equipment are available. The identifiable search for know-how, often materialised in the choice of education, could be an indicator of medium importance.

The actor or actors may be identified because of their divergence from society norms, with respect to religious or extreme political views. An indicator might for instance be a student with an outspoken extreme political view and an appropriate education who “disappears”, i.e. the student does not continue within his or her research field neither at a university nor in industries.

As a terrorist activity is expected to serve the purpose to create fear, chaos and distrust in society the ability to create such effects will be important when selecting the tools. Terrorists may carry out attacks that require years of planning just like the September 11 attack. Terrorists can also choose to utilize vulnerable points in the society such as transport or storage of toxic chemicals. Likewise it may be sufficient for a terrorist to portray a capability and even false threats may serve that purpose. It is thus expected that a terrorist would not spend time and money on producing the most sophisticated agents because more primitive threats could give the same effect. In that respect chemical programmes will approach biological programmes in the sense that a terrorist may use "naturally" occurring agents, such as industrial chemicals.

Terrorists are not expected to possess a well-equipped facility for production, rather a primitive and covered site. The production is of a limited or small scale and the technical standard will typically be low. At the same time a terrorist group may not be localised at a certain site but rather scattered, the various cells being located at different sites.

An indicator for chemical and bio-terrorism is attempts to buy critical equipment and raw material by persons who lack affiliation to research facilities or industry. As discussed in the previous chapters, the appropriate equipment is unfortunately of dual-use character and commonly found. Moreover, for terrorist purposes very simple equipment would be sufficient, such as equipment found in many types of laboratories. For instance, many technical university laboratories have a pilot plant, which is sufficient for the production of significant volumes of chemical or biological agents.

Export control measures, as implemented in most Western countries in the last century, include most of the common production equipment. Equipment for large-scale work is thus very hard to purchase on the open market, but laboratory items for small-scale and pilot scale experiments are not regulated. Another option is the black market where almost everything is available for a group with a strong financial backing or to steal equipment from places where they are easily accessible, such as universities. There is also a market for second hand laboratory equipments and many items are obtainable over the Internet without any complicated identification procedures. The identifiable search for equipment is assessed to be the most critical moment of the capacity building of a terrorist group and thus a useful indicator.

In comparison with state-funded actors the terrorists are assessed to lack or to have primitive safety and security standards and rarely any personal protective equipment. Nor could it be expected that a terrorist group has taken necessary steps to prevent release of agents.

Contrary to a state actor, a terrorist group is expected to choose simple commercial equipment for dissemination. The equipment may be built from simple available components or modified for the purposes. Means for efficient dispersion is one of the more important technical obstacles for a terrorist group and also one of the few valuable indicators.

Conclusion

The work in the recent decades on monitoring and analysing information gathering regarding states accused of having offensive programmes has demonstrated that the threat can easily be exaggerated. Without a systematic approach such analysis may result in a biased view. A more optimal and objective result will be achieved if the analysis is focusing on a set of critical indicators. By systematically organising, compiling and aggregating indicators, it is possible to observe indicator signatures that deviate from normal patterns. When deviations occur the analyst can use indicators as tools for identifying further questions. Thus indicators will assist both in the evaluation of existing information and gathering of complementary new information. In the gathering of indicators previous and well-known programmes are used as a model. Hence the selected set of indicators must be adapted to the current situation. Indicators need to be continuously validated and improved in order to provide the required flexibility.

The material presented in this report shows that there are many similarities between chemical and biological programmes, which can be utilised to establish common indicators. An example is the vital role played by state policy oriented indicators. There are also characteristic differences and for a more detailed analysis the basic indicators have to be complemented with more detailed programme specific indicators. Depending on the purpose of the analysis it is plausible that the indicators presented in this report are too imprecise and will need to be further broken down into “sub-indicators“. Even if some indicators are considered as critical, or of high importance, the analysis shows that there is no single indicator that would serve the purpose to unambiguously reflect offensive ambitions neither in the chemical nor biological area. There are, however, characteristic signatures of indicators.

It is much more difficult to identify indicators for non-state actors, mainly because of the limited scale of production and the fact that terrorist groups occur in various scattered cells. As a result very few indicators for non-state actors are identified and none of them could be categorised as critical or even of medium importance.

Even if we use signatures of multiple indicators they can seldom be decisive and serve as evidence for offensive activities. The reason is that actors - state and non-state - have obvious reasons to conceal their ambitions and that production facilities and equipment are of dual-use character. The most important use of indicator signatures is therefore to follow and track changes, and when significant changes are observed, serve as alarm signal for the gathering of additional information, for example from satellite sources or preferably from inside a suspected facility through intelligence or challenge inspections. With transparency and mutual trust being the most crucial ingredients of non-proliferation of chemical and biological weapons the international community needs a mechanism to initiate inspections in cases when multiple indicators and additional information clearly point in the same direction. The implementation of various measures of non-proliferation from former and active state programmes is the most efficient way to reduce the risk for terrorist groups to gain BW and CW capabilities.

Acknowledgements

We are grateful to Gertrud Puu and Anders Norqvist for valuable comments on the manuscript and also to Lars Rejnus who initiated the discussions on critical indicators. We are thankful for the linguistic corrections made by Marianne Olofsson.

List of published studies and papers

All papers and studies are available as pdf-files at the Commission's website: www.wmdcommission.org

No 1 "Review of Recent Literature on WMD Arms Control, Disarmament and Non-Proliferation" by Stockholm International Peace Research Institute, May 2004

No 2 "Improvised Nuclear Devices and Nuclear Terrorism" by Charles D. Ferguson and William C. Potter, June 2004

No 3 "The Nuclear Landscape in 2004: Past Present and Future" by John Simpson, June 2004

No 4 "Reviving the Non-Proliferation Regime" by Jonathan Dean, June 2004

No 5 "Article IV of the NPT: Background, Problems, Some Prospects" by Lawrence Scheinman, June 2004

No 6 "Nuclear-Weapon-Free Zones: Still a Useful Disarmament and Non-Proliferation Tool?" by Scott Parrish and Jean du Preez, June 2004

No 7 "Making the Non-Proliferation Regime Universal" by Sverre Lodgaard, June 2004

No 8 "Practical Measures to Reduce the Risks Presented by Non-Strategic Nuclear Weapons" by William C. Potter and Nikolai Sokov, June 2004

No 9 "The Future of a Treaty Banning Fissile Material for Weapons Purposes: Is It Still Relevant?" by Jean du Preez, June 2004

No 10 "A Global Assessment of Nuclear Proliferation Threats" by Joseph Cirincione, June 2004

No 11 "Assessing Proposals on the International Nuclear Fuel Cycle" by Jon B. Wolfsthal, June 2004

No 12 "The New Proliferation Game" by William C Potter, June 2004

No 13 "Needed: a Comprehensive Framework for Eliminating WMD" by Michael Krepon, September 2004

No 14 "Managing the Biological Weapons Problem: From the Individual to the International" by Jez Littlewood, August 2004

No 15 "Coping with the Possibility of Terrorist Use of WMD" by Jonathan Dean, June 2004

No 16 "Comparison of States vs. Non-State Actors in the Development of a BTW Capability" by Åke Sellström and Anders Norqvist, October 2004

No 17 "Deconflating 'WMD'" by George Perkovich, October 2004

No 18 "Global Governance of 'Contentious'" Science: The Case of the World Health Organization's Oversight of Small Pox Virus Research" by Jonathan B. Tucker and Stacy M. Okutani, October 2004

No 19 "WMD Verification and Compliance: The State of Play" submitted by Foreign Affairs Canada and prepared by Vertic, October 2004

No 20 "WMD Verification and Compliance: Challenges and Responses" submitted by Foreign Affairs Canada, October 2004

No 21 "Meeting Iran's Nuclear Challenge" by Gary Samore, October 2004

No 22 "Bioterrorism and Threat Assessment" by Gary A. Ackerman and Kevin S. Moran, November 2004

No 23 "Enhancing BWC Implementation: A Modular Approach" by Trevor Findlay and Angela Woodward, December 2004

No 24 "Controlling Missiles", by Jonathan Dean, December 2004

No 25 "On Not Confusing the Unfamiliar with the Improbable: Low-Technology Means of Delivering Weapons of Mass Destruction" by Dennis M. Gormley, December 2004

No 26 "A Verification and Transparency Concept for Technology Transfers under the BTWC" by Jean Pascal Zanders, February 2005

No 27 "Missing Piece and Gordian Knot: Missile Non-Proliferation" by Mark Smith, February 2005

No 28 "The Central Importance of Legally Binding Measures for the Strengthening of the Biological and Toxin Weapons Convention (BTWC)" by Graham S. Pearson, February 2005

No 29 "Russia in the PSI: The Modalities of Russian Participation in the Proliferation Security Initiative" by Alexandre Kaliadine, August 2005

No 30 "Indicators of State and Non-State Offensive Chemical and Biological Programmes" edited by Ingrid Fängmark and Lena Norlander, August 2005

No 31 "The 2005 NPT Review Conference: Reasons and Consequences of Failure and Options for Repair" by Harald Müller, August 2005

No 32 "National Measures to Implement WMD Treaties and Norms: the Need for International Standards and Technical Assistance" by Andreas Persbo and Angela Woodward, August 2005

No 33 "Russia and the Chemical Disarmament Process" by Sergey Oznobistchev and Alexander Saveliev, August 2005

No 34 "Transparency and Secrecy in Nuclear Weapons" by Annette Schaper, August 2005

WMDC

THE WEAPONS OF
MASS DESTRUCTION
COMMISSION

www.wmdcommission.org