Three Decades of Positive Experience with Risk Based Safety Criteria in Ammunition and Explosives Handling in Switzerland

Major General Paul Müller
Head of the Committee for the Safety of Ammunition and Explosives
in the Forces and Military Administration
PL Controlling Army, General Staff
CH-3003 Bern, Switzerland
Tel: int-41-31-323 08 73
Fax: int-41-31-324 64 25

In Switzerland, the safety management of the handling of ammunition and explosives in the military field has been founded on a risk based safety assessment concept for almost 30 years. My presentation illuminates the needs for and the development of the risk based concept. I will show how its flexibility has allowed a reduction in the risks to a responsibly acceptable safety level with limited financial means and - in the same time - complying with the military requirements. I will also demonstrate how the investments for development, implementation, maintenance and updating of this concept have paid back more than a hundredfold.

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1. Introduction

Thank you, Mr. Chairman, for the kind introduction and the warm welcome. Thank you and your staff for inviting me to speak at this prominent occasion of the opening session of this seminar. It is a great honour for me to address this distinguished audience of experts and representatives of military and civilian authorities from all over the world. We meet at the greatest and most important symposium on explosives and ammunition safety in the world. As a representative of a small country my superiors, my experts and I are proud of your interest in our risk based concept for the safety assessment of ammunition and explosives handling in the military field. Our techniques have been successfully in force for nearly 30 years.

There were four very good reasons for accepting the invitation:

Firstly, we are aware of the increasing interest of the DDESB in Risk Based Criteria, nurtured by many presentations at former Safety Seminars, by the long-standing US contacts with Swiss officials and experts in such international bodies as the Klotz-Club and just recently the NATO AC/258 underground storage subgroup. A DDESB-study on this topic, which was performed two years ago by the Pacific Northwest National Laboratory and supported by our main private consultant in this field, came to a positive result. This study was followed by the work of the Risk Based Explosives Safety Criteria Team, the result of which will also be presented at this seminar. Perhaps my speech as well as the presentation by our Chief Safety Expert in the Risk Management Session on Wednesday morning will help to convince your superior authorities to support the DDESB in its efforts not only in spirit but with both financial means and action.

Secondly, you may know that Switzerland recently joined the NATO Partnership for Peace program. So my speech is absolutely to the liking of the head of our DoD and the Government, who would like to see Switzerland making active contributions to the PFP-community. In fact, risk based safety assessment is now being considered a long-term target in the NATO AC/258 too.

Thirdly, I took over as the head of the Committee for the Safety of Ammunition and Explosives only a couple of months ago. So, I simply can't afford not to attend this Seminar. And, last but not least, it is a particular pleasure to be here in Orlando in the middle of the Sunshine State.

This is not the occasion nor have I the expertise to enter into the details of risk based safety assessment methodology and data. I can refer you to quite a number of Swiss presentations to former seminars and draw your attention to the two more technical contributions on Wednesday morning and Thursday afternoon. Today I would rather concentrate at a more general level on the necessity for our risk based concept, its development and its proven benefit.

2. Description of Ammunition and Explosives Handling in Switzerland

Storage is, with respect to the quantity and allocation, the most important of all the activities. Most of the stored goods are reserves for the forces in war time. For availability reasons our storage sites are spread throughout our country (F 1). The storage plants usually stand alone, there are no facilities for maintenance and inspection, administration etc. These activities are centralised in our country.

A significant part of the ammunition is stored in underground rock caverns.(F 2) These sites contain several 1000 gross tons of ammunition in a couple of large storage chambers. It is this construction type which can be equipped with the famous automatically closing "Klotz" safety device. Another construction type is the shallow-buried store in soil, consisting of a couple of chambers, each capable of housing up to several hundred tons of ammunition. The advantages of both types are their good protection against enemy impact, the very small space required for the above-ground parts and the unobtrusive appearance in our landscape, something which has become a very important factor in our country.

The igloo-type earth-covered magazines are only used in small numbers mainly on our airfields. Finally, there are quite a number of above-ground free-standing magazines with a capacity of up to a few hundred tons. They usually contain basic load and are densely dispersed in our country. Their main advantage, the excellent availability of the ammunition, is countered by the fact that the wrong people also have equally good access. I have to mention that usually there are no permanent sentries on guard (of course there are technical security installations, and the alarms set off intervention). For this and other reasons we are currently reducing the number of above-ground magazines drastically.

The general safety problem of storage is mainly given by the catastrophic damage potential of the stored goods, fortunately compensated by the low probability of an explosion, and the activities of third persons in the endangered area like for example residents, farming, industry, traffic, leisure etc. (F 3). You may not realise that Switzerland is less than a quarter of the size of say Florida or only three-and-a-half times as big as the Everglades. Because we have inaccessible areas like mountains, lakes and rivers as well as urban areas there is very very little space left for ammunition magazines and safety distances.

A second sector of handling ammunition and explosives is manufacture, maintenance, demilitarisation and disposal. These processes are carried out in a couple of state-owned installations. Here, the safety problem is characterised by the numerous personnel working within the area of hazardous effects of many potential explosions, the probability of which can be much higher than that of a storage plant. Similar safety problems are generated in the field of research and devel-

opment as well as acceptance and quality control. These activities are done in laboratories as well as in in- and outside testing ranges.

In addition, all these hazardous goods have to be transported from the factory to the storage site, from storage to storage, from the factory to the test range etc. Here, the safety problem lies in the relevant probability of an explosion, which could produce catastrophic losses among third persons in busy surroundings. Consider an explosion of a truck caught in a traffic jam or a railway car within an urban area!

Finally, ammunition and explosives are stored, transported, handled and shot by the troops during their training. The characteristic safety problem is the protection of themselves as well as that of third persons around the storage sites, on the road and in the area surrounding the ranges etc.

3. The Necessity for and Development of the Risk Based Safety Assessment Concept

Until 1970 the storage safety concept had been fully deterministic and measure-oriented, following the principles of safety distances, hazard categories and compatibility groups. For the manufacture, detailed (but in fact unspecific) occupational health and safety standards were in force. However, these principles proved to be too inflexible to respond properly to the new problems as they evolved: Due to the political situation Switzerland had to upgrade its forces. Thus, the amount of ammunition to be stored and its explosive content steadily increased. Military readiness requirements called for additional storage space closer to populated areas. At the same time, however, a great number of residential, public and industrial buildings, leisure installations and roads were being built closer and closer to the existing storage installations. In addition, people made heavier and heavier demands for safety. Last, but by no means least, the financial funds in the DoD remained limited as always and everywhere.

The main shortcoming of the qualitative and measure-oriented safety concept was that there was no adequate definition of safety. Standards were inflexible and inconsistent. Because safety was not treated quantitatively the effectiveness of the safety precautions could be neither measured nor related to the cost.

The members of the former Ammunition Storage Board no longer wanted to stick their heads in the sand and increase the number of waivers. They therefore decided to investigate thoroughly the problem in all its dimensions, and to work out new regulations which really would help. The general direction was shown by the first experimental risk analyses performed already in 1970 for a few existing underground magazines. The board looked for DoD-external know-how sup-

port and obtained the necessary funds. Study groups made up of military and civilian officials and experts were established, as was a sub-committee responsible for conceptual decisions. In essence, the resultant organisation still exists today.

The problem was tackled along the whole front. There were the military requirements such as readiness and protection against enemy weapon effects, operational requirements, cost and, of course, safety aspects. Obviously all these aspects should have been met at the same time. However, solutions could not be found by setting absolute requirements but, instead, by weighing up all the aspects and uniting them in an optimum solution (F 4). Concerning safety there was no better way than to introduce the quantitative risk concept and risk/cost-criteria.

Fortunately, at that time the safety of ammunition and explosives in the military forces and administration was not focused by civilian laws and guidelines. The Swiss Explosives Law releases the military from its substantive contents, but commits the Government to issuing its own concepts and regulations. The Government assigned this duty to the Department of Defence, which designated its highest officer, the Chief of General Staff as the responsible authority.

4. State of Action

For many years, the methodological instruments have been operational. The safety criteria (that means accepted risks) are laid down. The first edition of the respective regulations date from 1975 and were updated in the mid-80s. The organisation has been established with a top level safety committee, safety executives and working parties on both decision and technical levels. Computer software for performing risk analyses have been developed. For more details I refer to two Swiss presentations to the 25th Seminar of 1992 in Anaheim (F 5).

Today, the risk based concept is mainly implemented in storage, manufacture and maintenance as well as in research and development. For reasons of financial priorities it has not yet been introduced in transport and in the forces where safety is dependent on a very dense net of detailed measure-oriented regulations.

At the moment we are updating the models and data for risk analyses in our storage safety regulation TLM 75/Part 2 with an effort of several man-years over a five-year period. Better and more refined models are required for assessing reality better in order to make better use of the existing infrastructure. On the other hand, today there is more and better know-how especially on the spreading of hazardous effects. In fact, although at the moment the ammunition reserves are being reduced due to the downsizing which has also gripped the Swiss forces, the obsolete ammunition does not disappear simply by the respective resolution of Government and Parliament, nor

have the safety problems of the remaining installations. Indeed, the whole storage concept has now to be adapted to the new operational and tactical requirements. In addition, obsolete installations will be overtaken or hired by private users and therefore create new safety problems.

I can add right now that we are supporting a study by the Swiss National Fund for Scientific Research entitled "Risk Based Regulation - a Suitable Instrument for the Safety Law?". This project is using our concept and the safety criteria as its main case study.

5. Advantages

We have achieved a precise definition of safety by using the notion of risk, taking into account both the frequency and the consequences of possible explosions. (F 6) Our risks have become visible and comparable. The people responsible can be shown what they are laying their heads on the chopping block for. We know for example, (F 7) that the total collective risk of our storage is about 70 % lower than that of manufacture or about 18 times higher than that of research and development. It is clearly shown that storage risks are certainly not the main safety problem in our country.

Safety can actually be managed today. We are able to express the cost-effectiveness of the precautions we take. We have left the solitary tactical or financial or safety thinking behind us, being now capable of optimising safety not only in relation to cost but also taking into consideration the military requirements even though those are not usually expressed quantitatively.

One of the most important results is that safety can be achieved economically. The systematic approach to safety also triggered the breaking up the decrepited thinking in standards. This allowed for example the development of new magazine constructions, the construction cost of which were factors lower than before (F 8).

One of my predecessors, Major General Bender, already presented to the 22nd Seminar 1986 in Anaheim the result of a comparison of NATO Safety Principles and Swiss Regulations applied to an actual Swiss above-ground storage system. (F 9) Our concept allowed the safe use of 19 of the 20 magazines with a certain storage capacity, whereas NATO Safety Principles accepted only 7 magazines with mere 25 % of that capacity and would have required the erection of 23 new magazines. Transferring that potential of saving to the whole storage system, very rough estimations say that the NATO principles would be hundreds of millions $ more expensive than our concept - always supposing new sites for the additional magazines could be found.

Other successful applications of our concept are new installations for manufacture, and research and development. In addition, risk based assessment has helped us find intelligent solutions in many other cases such as dud-safety, fuzes acceptance and anti-tank-missile test shooting, training shootings from artillery bunkers and the like. Generally, the risk based concept allows solutions where the conventional assessment has not offered any - within, I underline, safe limits.

6. Engagement and Expenditure

However, putting into practice the risk based safety concept is more sophisticated than the conventional deterministic system and, therefore, demands more from those applying it. Performing a risk analysis is more difficult as well as time- and money-consuming than just checking a catalogue of safety measures. For example the completely new detailed risk based safety assessment we require for the safe operation of an underground storage with a few chambers can easily generate 300 to 500 working hours.

The personnel responsible have to meet higher requirements, and they have to be trained accordingly. In addition, those on the higher ranks are concerned with more impact on their management processes. Safety can no longer be settled once and for all by simply obeying a number of detailed rules. In addition, their multiple target decisions can no longer hide behind safety. Finally, the top level decision makers setting the safety goals for the whole system are confronted with the explicit question: "How safe is safe enough?".

How much have the development and refinement of the risk based concept cost us until today? We would guess something around 7 to 10 million US $ in the last 28 years. A remarkable sum, at first sight. But don't forget that the development of a conventional assessment system also costs money. Consider the savings I just mentioned, and be aware that the replacement cost of the whole ammunition and explosives system is estimated at around 10 billion US $.

7. Concluding Remarks

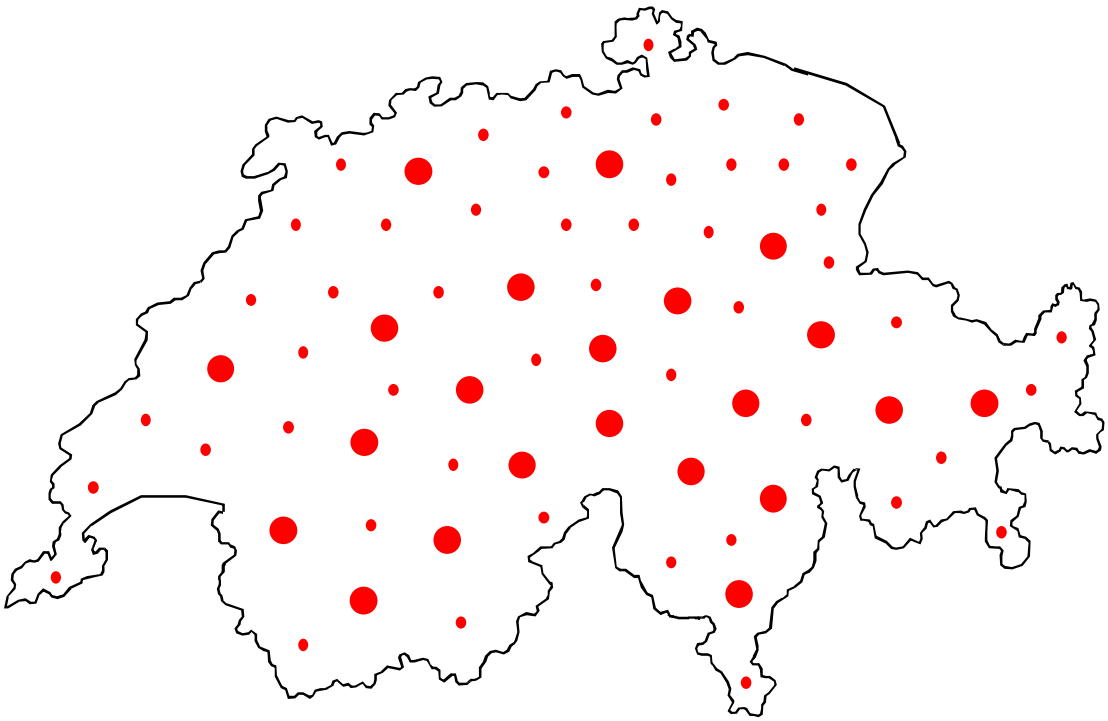
You can imagine that we are not only proud of what we have developed and put into practice. We just could not have afforded not to do it!

I hope that all the countries, confronted by the same problems we had, will have the courage to take the initiative. I call out to them: Do it! Risk based explosives safety methods, data and criteria exist and they have already been applied successfully for many years! Make the effort, it will pay back manifold!

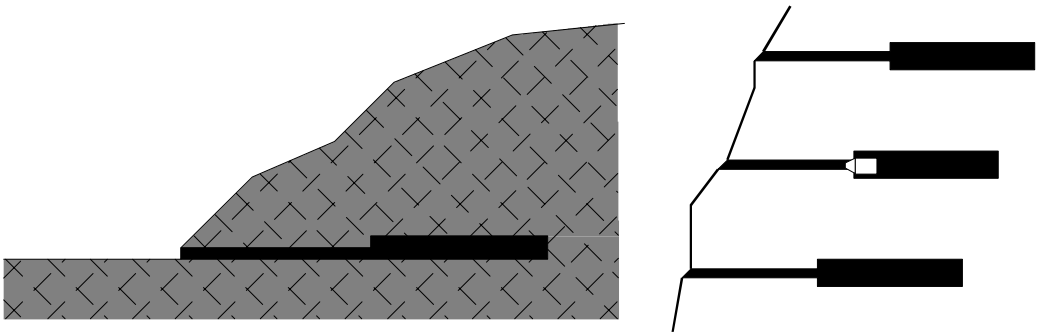
But changing from quantity-distance to risk based criteria is not an act but a process. Do not try to eat the ox in one gulp, proceed step by step.

At the end of my speech I would like to thank all the experts and authorities in many countries, especially from the US, Norway, Sweden, Germany and UK. Extensive, essential data - especially on the effects of explosion, came from them. We could not have afforded to carry out all the research ourselves.

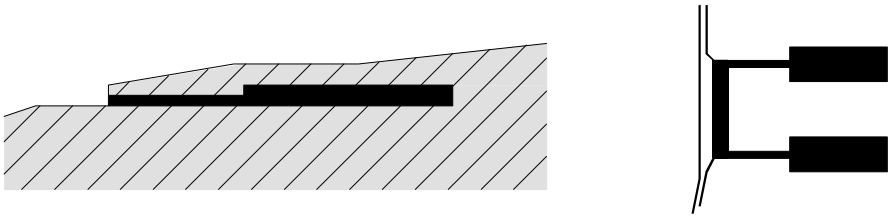
Thank you!



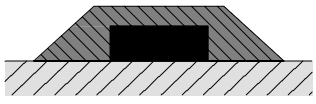
Underground / Rock (several 1000 tons)



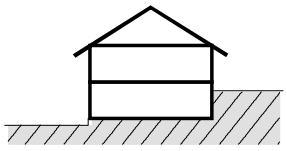
Shallow-buried / Soil (few 1000 tons)

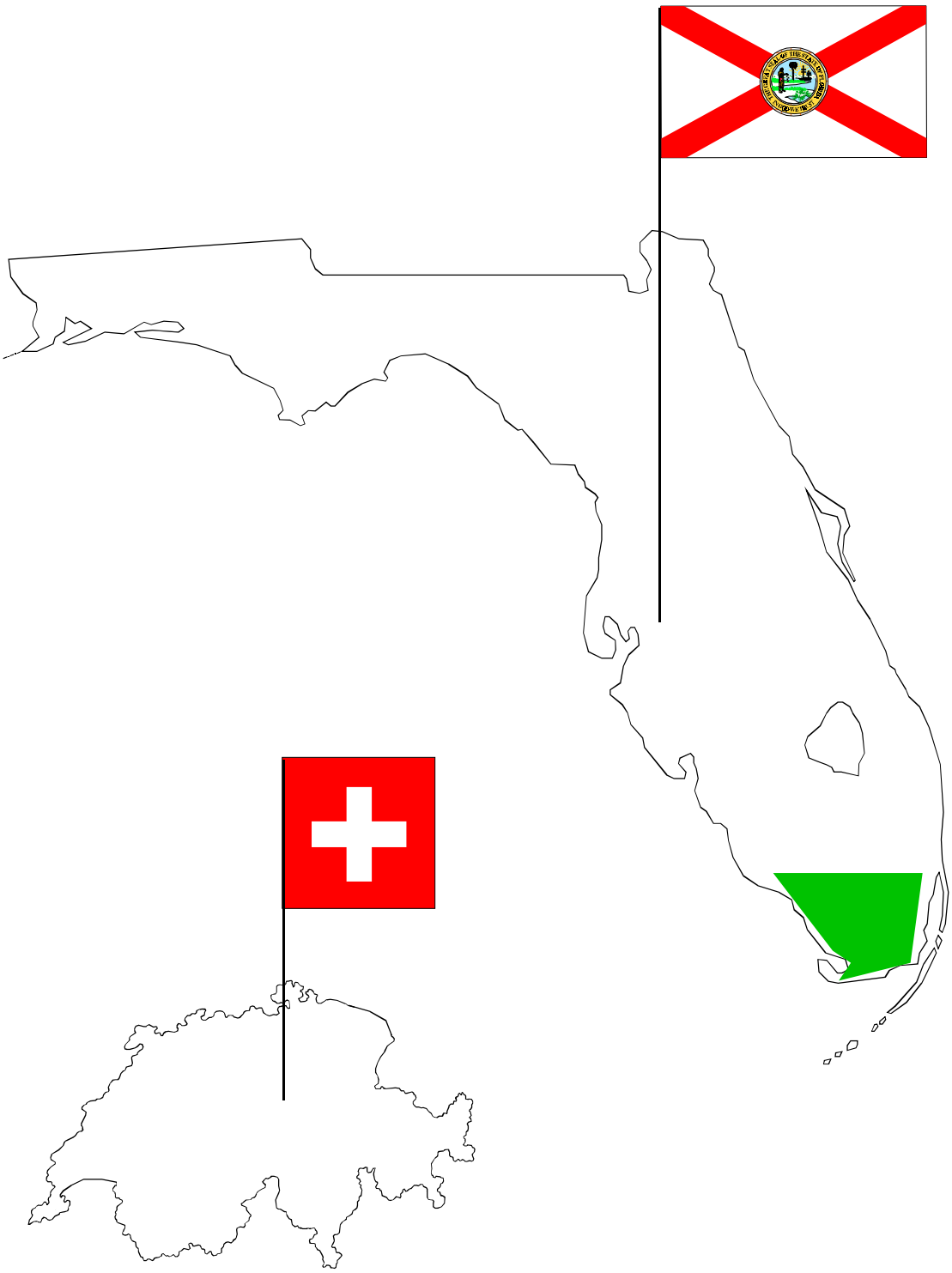


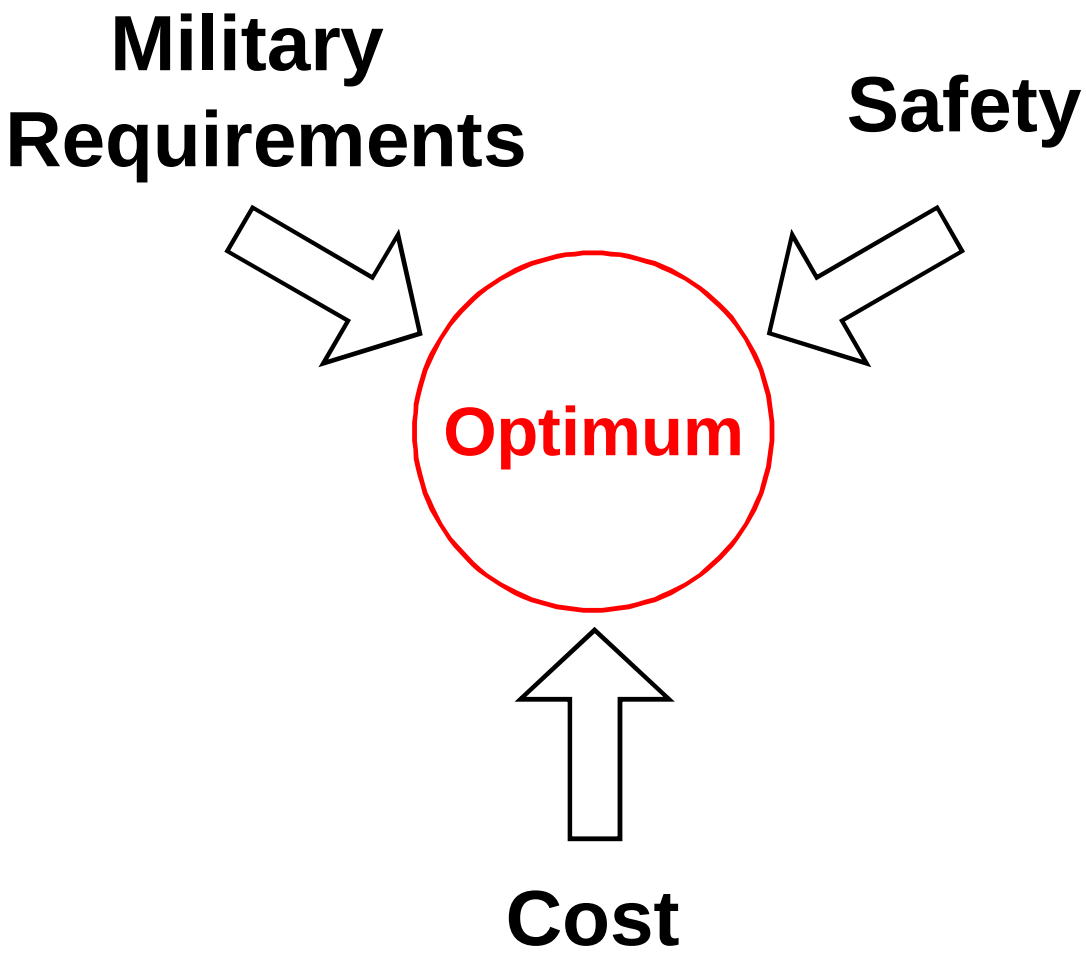
Earth-covered (few 100 tons)



Above-ground (few 100 tons)






Military Requirements
Safety
Optimum
Cost

25th DoD Explosives Safety Seminar
1992 Anaheim, CA

How the Safety of the Ammunition and Explosives Storage and Handling is Managed in Switzerland:

Part I: Safety Concept, Regulations and Organisation

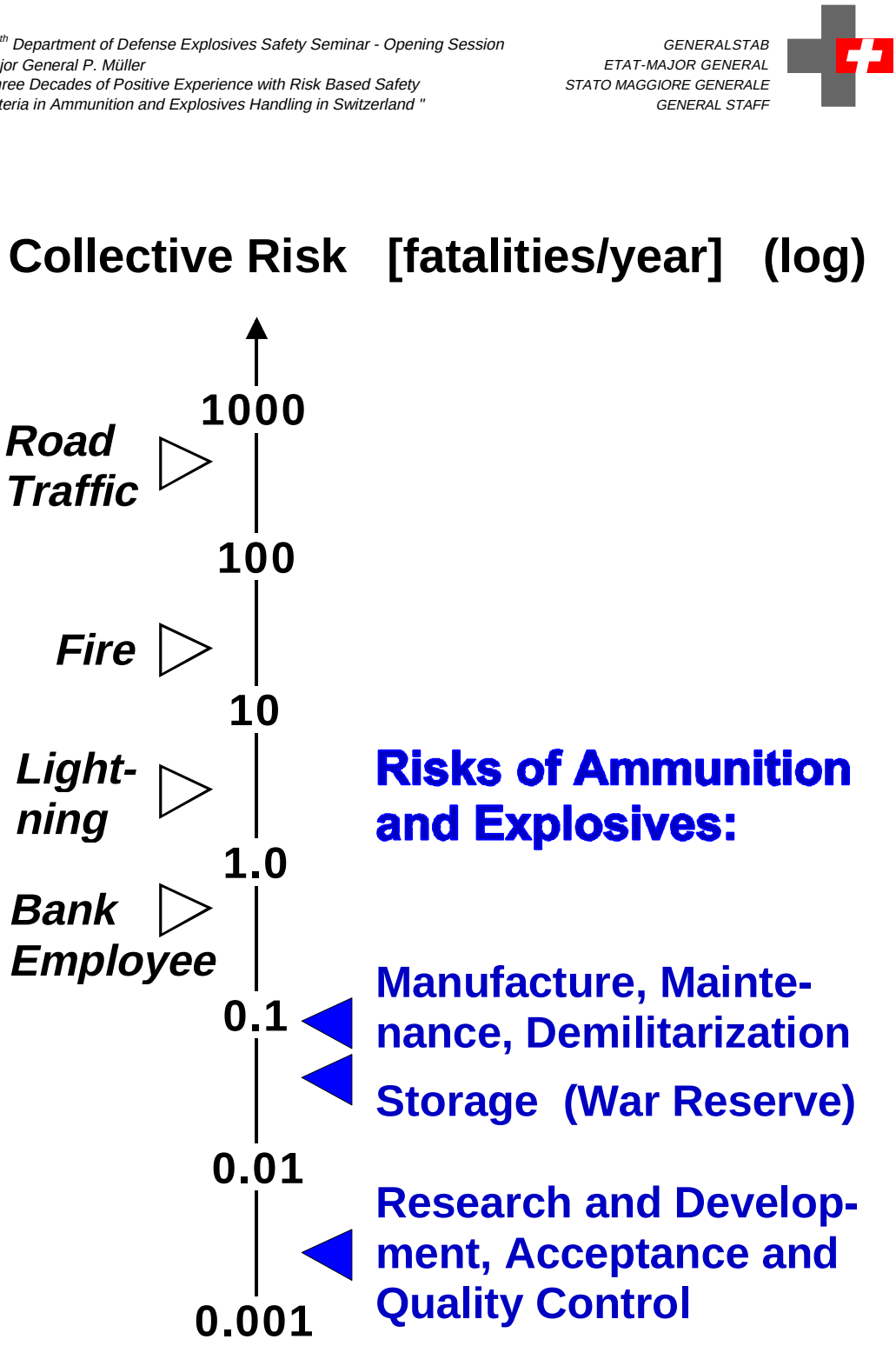
(Andreas F. Bienz)

Part II: Risk Analysis of Ammunition Magazines

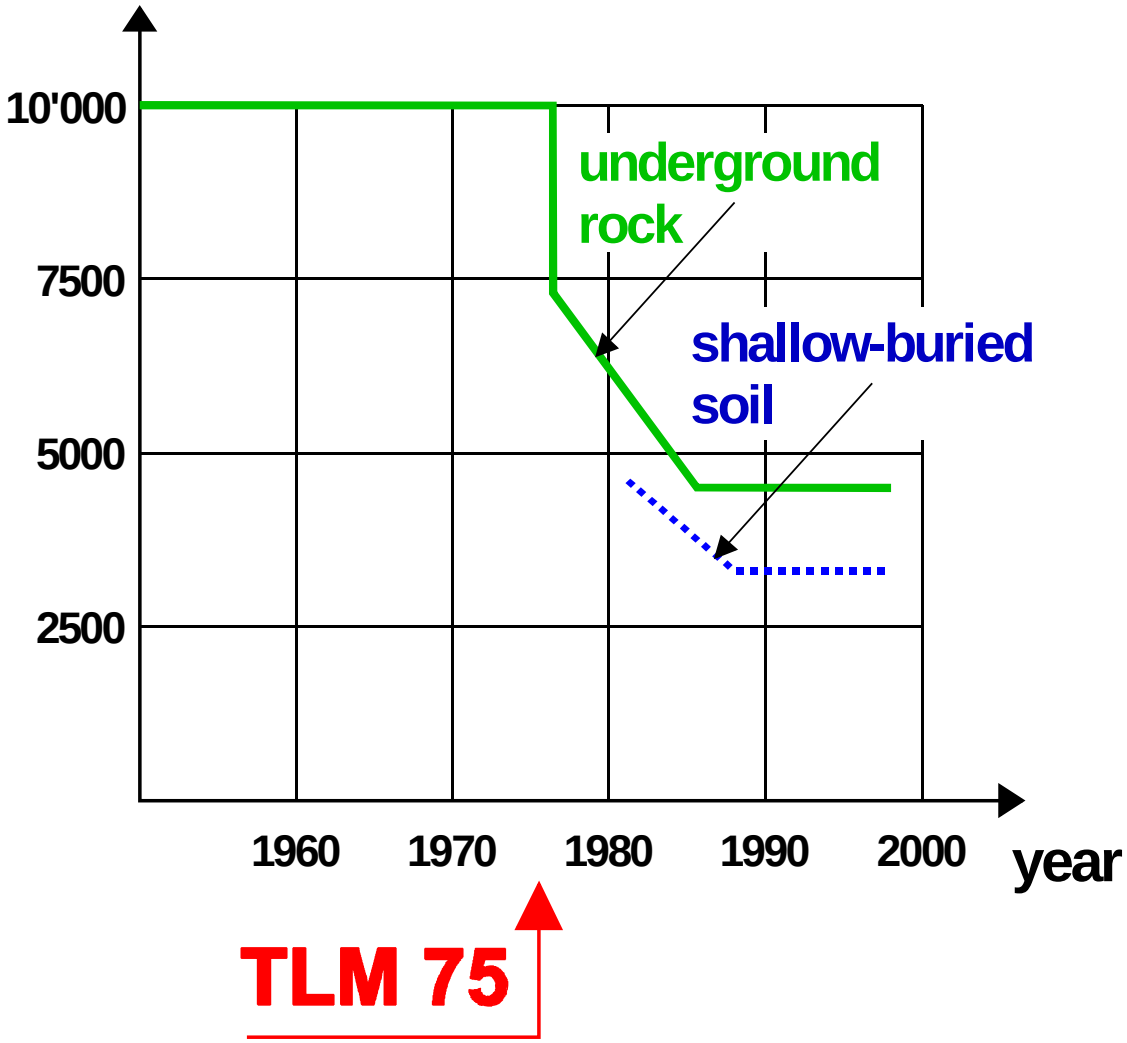
(Peter O. Kummer)

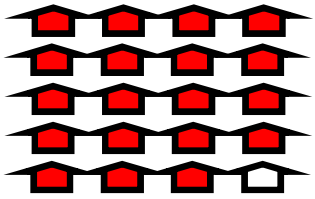
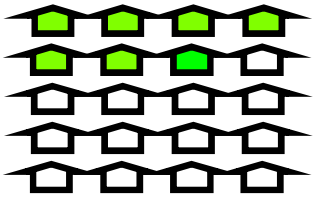
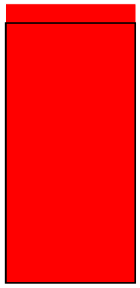
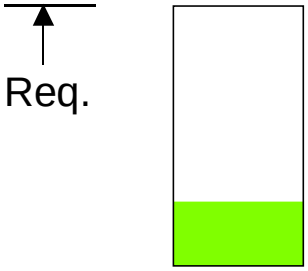
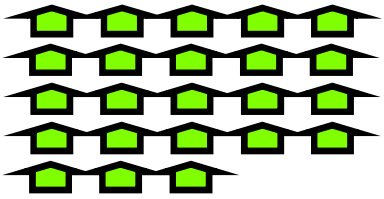
Risk =

Probability x Consequences


Collective Risk [fatalities/year] (log)
1000
Road Traffic
100
Fire
10
Light-ning
1.0
Bank Employee
0.1
0.01
0.001
Risks of Ammunition and Explosives:
Manufacture, Mainte-nance, Demilitarization
Storage (War Reserve)
Research and Develop-ment, Acceptance and Quality Control

Specific Construction Cost for Storage Installations [US $ / gross ton]



	TLM 75	NATO Safety Principles
Number of Complying Magazines		
Remaining Safe Storage Capacity		
Required New Magazines	None	
Construction Cost	None	7 mill. $