SAFETY ASSESSMENT SOFTWARE (SAS)

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ABSTRACT

Safety Assessment Software (SAS) is a software tool that has been developed by MSIAC staff. The primary goal of SAS is to assist a safety advisor to produce a report which details all the testing requirements to carryout a comprehensive safety assessment of a munition before its introduction into service. However there are some additional uses of SAS which include:

- Life Cycle Representation;
- Threat Hazard Representation;
- Test Requirement Gap analysis between different nations;
- Up to date Library of associated test specifications;
- A common approach to testing requirements which may enable industry to do its own testing requirement development and therefore arrive at a position where costing analysis can take place.

This paper presents the methodology applied in SAS, the different screens and the data required for a Safety Assessment Report. Potential uses of SAS are also discussed.

1. INTRODUCTION

MSIAC, as NIMIC, developed THAMES (Threat Hazard Assessment MEthodology Software), which conceptually was good, but in use had some drawbacks and was not widely used. As a result of the MSIAC Cost Benefit Analysis Model (CBAM) it was seen that an associated tool sharing some of the same coding could be developed that would replace THAMES with a user-friendly versatile tool.

The primary goal of SAS is to assist a safety advisor/analyst to produce a report which details all the testing requirements to carryout a comprehensive safety assessment of a munition before its introduction into service. However, there are some additional potential usages of SAS version Beta 1.1 which include:

- Life Cycle Representation;
- Threat Hazard Representation;
- Test Requirement Gap analysis between different nations;
- Up to date Library of associated test specifications;
- A common approach to testing requirements which may enable industry to do its own testing requirement development and therefore arrive at a position where costing analysis can take place.

The need for a tool like SAS was recognised many years ago by the various national approving authorities. A new safety advisor coming into a safety organisation such as a national approving authority would be overwhelmed with the need to develop a testing specification that covered all the requirements. This task was traditionally done by taking the most recent assessment plan for a similar munition and using that as a template. The plan could then be reviewed by the various specialist sections to ensure that the latest references were being used. However, with staff turn-over and changing references it was always possible that assessments would at best be delayed and at worst not be comprehensive. There was also a risk that the new system to be tested may be required to be operable on additional platforms or in wider climatic conditions that were not envisaged and incorporated in an earlier munition.

In the past there was probably sufficient breadth and depth in the departments responsible for setting requirements combined with a considerable wealth of experience to ensure that shortfalls in testing requirements were not missed. Organisations are always under pressure to reduce costs and the largest cost is generally associated with staff. With staff reductions there will be less experience and corporate knowledge available and there will be an increasing risk that some requirement might be missed. Having a comprehensive tool that is kept up to date by one source, but can be reviewed by many, allows an organisation to be reasonably confident that an assessment that has been processed through the SAS tool, will have all the right references in place.

There will also be an auditable reference document to show how the output was generated.

2. DEVELOPMENT OF SAFETY ASSESSMENT SOFTWARE: SAS

MSIAC SAS is designed to aid a safety advisor/analyst to produce a report which details all the testing requirements to carry out a comprehensive safety assessment of a munition before its introduction into service. The first prototype of SAS was developed early 2004. SAS is a Delphi 5 application, (visual Pascal), that was designed primarily to represent a life cycle and link to a library of data and standards, that is included with the deliverable software as a comprehensive and up to date library. The current (Beta) version of SAS has been developed using the requirements defined by the MSIAC team and has been given limited distribution for comment by potential users. A number of reports have been received from several countries, which have given direction to SAS development.

3. SAS STATUS

SAS Beta version 1.1 developed by MSIAC is now being tested and is available to MSIAC Nations in accordance with the MSIAC procedures.

A specific programme of work has been set up to support the introduction and the use of SAS Beta 1.1:

a. Distributing SAS Beta 1.1 to MSIAC Nations (started in October 2005). The user manual has been created to assist the user in building a life cycle and explains all the SAS functions in detail. The electronic SAS user manual is embedded inside the program.

b. Soon to be available will be 2 examples:

   i. Example 1 will be a generic life cycle for a simple training Bomb
   ii. Example 2 will be a complete assessment of a 155mm shell.

4. SAS REQUIREMENTS

The most difficult part of the Safety Assessment Software remains the compilation of the essential requirements to be introduced into the model. The main problem lies in the production of a “fuzzy” requirement. A safety assessment will always have to be carried out on the worst case environment that is envisaged and there will normally need to be a safety margin as well. The consequence of this is that testing will sometimes exceed the capability of the munition to withstand the test specification. Consequently a safety analyst/advisor in conjunction with the acquisition Project Manager and the manufacturer will need to devise a plan which allows for adequate inspection and revision.

MSIAC SAS is firmly based on the requirements which are generated by AOP 15 Annex A, [1], which is a questionnaire that should be completed by the operational requirements branch in conjunction with the acquisition Project Manager. This reference document has been available for many years and, although currently under review, provides an excellent basis for the Safety Assessment. The whole life cycle of a munition should be analysed which encompasses the Manufacture to Target or Disposal Sequence (MTDS) or Cradle-to-Grave.

It is also recommended to conduct a Threat Hazard Assessment (THA, or MTA - Munition Threat Analysis) to enable the user to include the appropriate threats. To ensure that all hazards are considered a Hazard Log needs to be generated but the methodology for this is outside the scope of SAS. Five Hazard Analysis activities are identified in AOP15 [1].

5. METHODOLOGY

The SAS methodology requires the user to create a life cycle for the munition being assessed by the use of storage, transport and operational modules and the SAS's user manual embedded in the SAS software provides detailed explanations on creation and use of the modules. The life cycle should describe the situations, which the munition will encounter during its lifetime, for example storage in an igloo, transport by rail etc. Part of creating the life cycle is to assign the percentage of the lifetime a munition will be in a particular situation or scenario. (The life percentage assigned is selectable in the final report.)

The steps include the selection of the munition type, its service environment and its operational platform. The countries' documents which are to be used are then selected. Any number of countries documents can be selected but the length of the final report will be shorter if less are selected. In this case an air armament for a combat aircraft with all countries documentation has been selected.

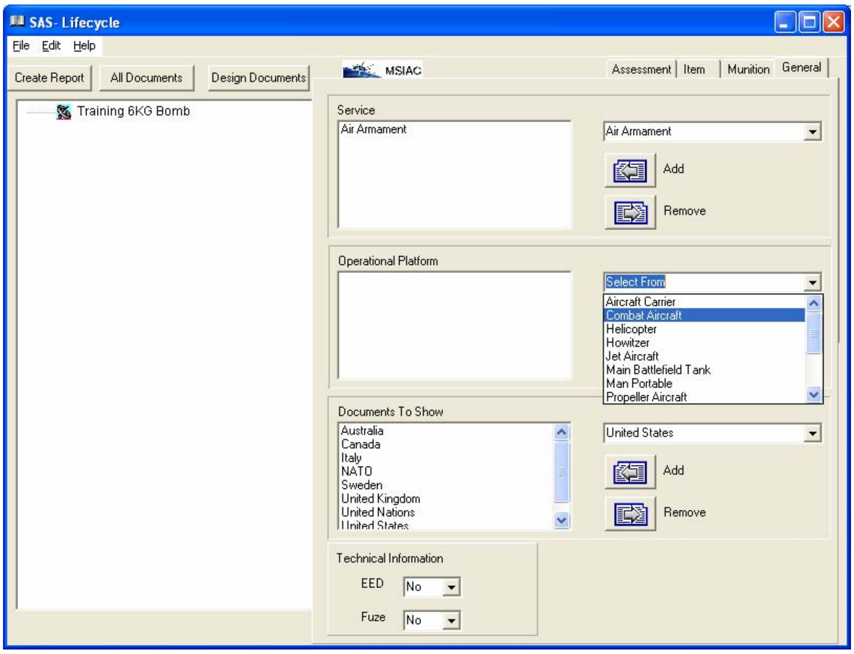

Figure 1 – SAS LIFECYCLE GENERAL OPTIONS

5.1 LIFE CYCLE DEVELOPMENT

The main activity when assessing the testing requirements to provide the evidence for a Safety and Suitability for Service Assessment (S^3) is to create an accurate life cycle for the munition. The life cycle should be constructed from "Cradle to Grave" in order to take into account initial delivery through to demilitarisation. The safety requirements of the manufacturing process are outside the scope of SAS and all testing is carried out on the as delivered item or in some cases representative parts of the munitions are substituted for the real sub section to either, reduce cost, reduce risk or prevent one element of the system masking another elements results. The life cycle will need to contain details of duration (time spent in storage, on board ship etc.) and various configurations i.e. palletised or bare or loaded. It is important to create a life cycle that considers the worst case scenario and if required include limitations in the clearance for use until adequate evidence has been generated.

To aid the process SAS allows the user to create a life cycle by constructing a life cycle tree, an example is given in Figure 3. The tree shown is constructed by creating various Phases and Situations. For example, Transport, Storage and Operations are contained in the life cycle tree example. The life cycle tree creator allows considerable flexibility and can be as complex or as simple as the user requires.

For each item added to the life cycle tree, information on the time spent by the munition in that particular phase or situation should be added to complete the audit trail, and to give the environmental specialist the total requirement for storage times at various conditions and transport times by various means i.e. Road, Rail, Air, Sea, etc.

The life cycle tree that is generated by the user is a graphical representation which would help the future users of the safety case and indeed a safety audit team to visualise what testing was required to meet each phase of the munition life cycle.

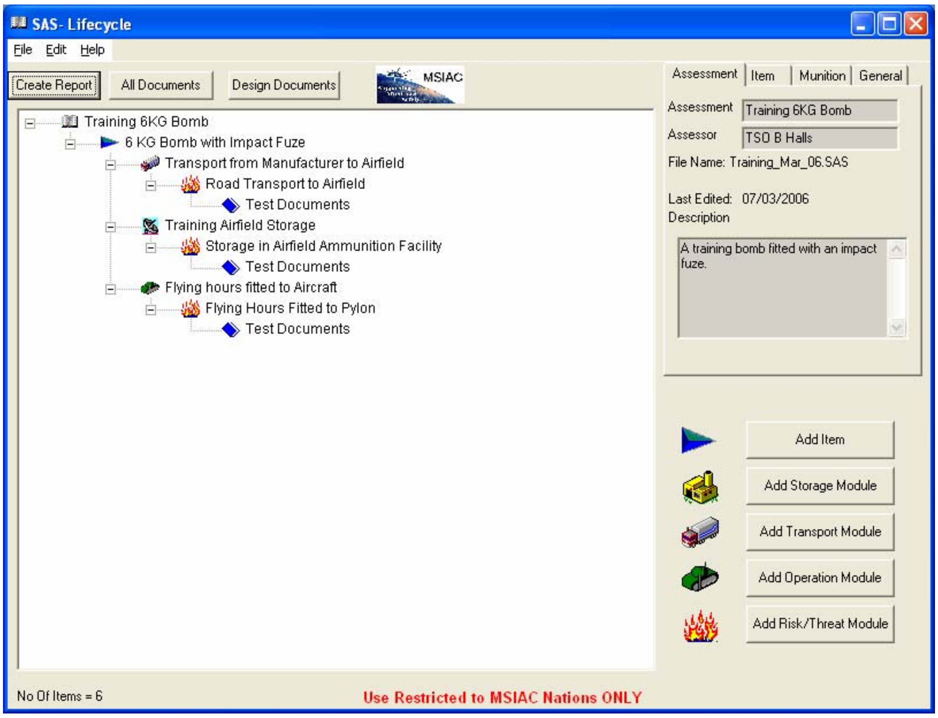

Figure 2 – SAS Beta 1.1 - Life Cycle for a Simple Training Bomb

6. RISK/THREAT MODULE

SAS risk modules should be defined by the Threat Hazard Analysis (THA) and be identified in the life cycle of the munition. Each risk module corresponds to a threat identified in the specific Cradle-to-Grave Sequence (CGS). The most typical CGSs have been identified in the following paragraphs.

The total duration of the life cycle for a shell is generally between 20 and 25 years, but may be as short as a few years for more volatile munitions. Three sub-phases should be defined for the life cycle:

- Peacetime. Generally associated with good storage conditions and limited temperature ranges
- Crisis/Tension/Peace Keeping or Peace Enforcement Operations. Storage conditions may be degraded from the peacetime environment with greater exposure to temperature ranges, the elements, vibration as well as a greater threat of external stimuli.
- Conflict. Tends to be of much shorter duration but may be exposed to extreme conditions or have protection from packaging removed.

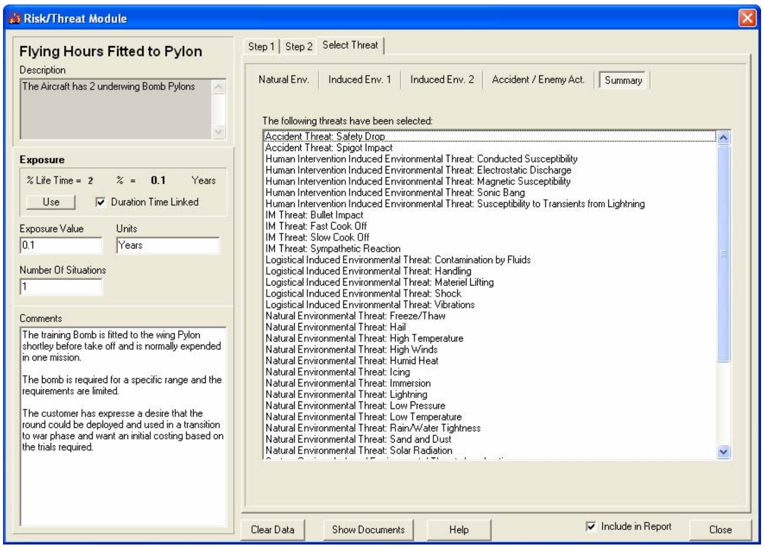

Figure 3 – SAS Beta 1.1 – Risk Threat Module for 6 kg Training Bomb showing some of the summary of the threats during the Flying Hours Fitted to Pylon phase.

6.1 STORAGE

The appropriate tests for the threats and the environment are selected by SAS based upon the input from the user. If, for instance, A1 climatic conditions are selected then the appropriate testing will be selected. The exact determination of the duration of testing is outside the scope of SAS. Duration of testing is dependant upon munition specific issues, such as materials used in the design (and associated activation energy for degradation). The test specification will need to use these factors to calculate duration for a test. For example, 28 days diurnal cycling might suggest a safe storage life of 5 years in good conditions but only 6 months in open field storage conditions. This determination is outside the scope of SAS.

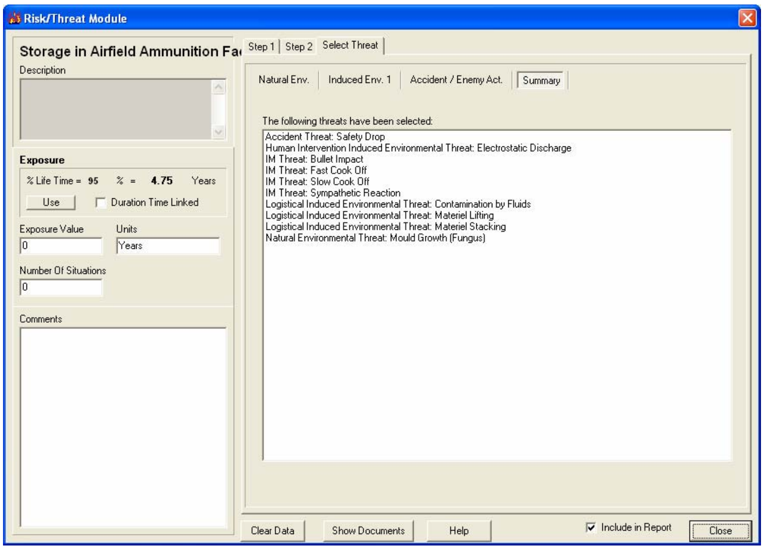

Figure 4 - Risk/Threat Module Summary 6 kg Training Bomb
Showing the Threats during the Storage in Airfield Facility phase

This means that the storage selected in SAS is informative rather than definitive. The SAS user selects appropriate conditions for the location described ie the SAS user may select solar radiation for a store that is left out in the field, and conversely the SAS user will not select such harsh conditions for munitions that are stored in good storage condition such as an igloo.

- Exposure. Definition of the time spent in each storage environment (CGS). This data should be available in the munition requirement document (logistic life cycle profile). Storage durations (generally in years or in percentage of the life time) are required.

- Threat. The threat in each scenario needs to be considered although where it is known that a threat is already being addressed in another part of the life cycle then it is of no significance to the total testing package given in the final report. However from a safety case point of view it may be useful for audit purposes to show that this threat has also been considered in the situation being recorded.

- SAS does not provide any information on Consequences. The consequences in storage could be assessed using existing models (SAFER (US), AMMORISK (NO), RISKWING (UK), RISK-NL (NL), etc.), rules (or regulations) defined nationally or internationally and historical data.

6.2 TRANSPORTATION AND HANDLING

Several transport items will be created for the assessment depending on the specific phases of the life cycle. The preliminary activities related to these phases are:

- Exposure. Definition of the time spent in each transport environment. This data should be available in the munition requirement document (logistic life cycle profile). An exposure unit may vary depending on the type of transport (day (sea transport), km (land transport), and hour (air transport)).

- Threat. The identified threat, will be decided by:
  - The phase of the life cycle (peacetime, crisis, conflict);
  - The type of transport;
  - The transport vehicle (armoured vehicle, wheeled vehicle, etc.).

The threat will need to be carefully considered and if not included should be justified, for example if you have a heavyweight torpedo that is always stowed in a submarine pressure hull then the possibility of bullet attack may be considered incredible. However, during transport to and from the depot and during loading there may be a threat and additional protection may be employed to prevent a bullet reaching the torpedo.

6.3 SURVEILLANCE, TRAINING, EOD AND DEMILITARISATION

The testing which is called for is always based upon a normally configured munition. If the munition has been damaged in any way then careful consideration should be given as to the possibility that reaction to a stimulus may well be different to that expected from the normal munition, and deciding on the best course of action should be carried out in accordance with national emergency processes, but will normally involve a team of suitably qualified and experienced people assisting in deciding the best course of action.

6.4 DEMILITARISATION PHASE

Unless disposal adds any new environments then no additional testing will be required subject to the munition being within the previously tested life cycle.

6.5 CONFLICT

SAS does not include any requirement to investigate the probability of an event. If it is considered possible that a threat, be it environmental or direct attack, can occur and this is recorded in any of the life cycle stages then that test will be called up. The safety and suitability information gained, as a result of the testing, will allow the Safety Panel to assess the risks and decide if further action is required to make the munition suitable for service. Due consideration of the changing circumstances needs to be taken by the Safety Panel. For example a bare fuzed 105mm HE shell will be laid out on the ground behind a gun shortly before and during firing. At other times it will be packaged and may not be fuzed. On one hand the bare rounds, if laid close together, may be more susceptible to Sympathetic Reaction but if sufficiently separated or have good IM properties they may not. These risks need to be considered assessed and if required trialed.

6.6 LIFE/DURATION

The duration of these phases are often specified in the weapon system programme and the values defined in programme documentation should be used in the Safety Assessment study. It is important to be aware of the reduced life associated with the change of environment therefore an increase in life of a munition by 20% may only relate to an increase in the peacetime storage life and not the field conditions as there is an exponential element associated with munition degradation with the increase in temperature.

It is an important point that the threats if identified are tested for. The probability of the initiating event is not considered however if the threat is considered to be very low probability (incredible) then, subject to agreement by the National Approving Authority, testing may not be required.

- The exposure to the threat (unit can be time, distance, etc.); or
- The number of situations. To clarify this point there may be a munition such as a flare that needs to withstand the vibration of flying 10,000 km. However, as the vibration is worse for take-off and landing, but may be of less consequence during strait and level flight, then specifying 50 take-off and landings may also be required.

By adding modules through the life cycle the user is effectively completing a Munition Threat Assessment (MTA). This is an assessment of the threats a munition is likely to see during its lifetime.

7. GAP ANALYSIS FROM AN EXISTING ASSESSMENT WITH A NEW COUNTRIES REQUIREMENTS

It is a very easy task to change the country specific documents to include or discard another country or source such as NATO or United Nations. For instance a munition that has been brought into service in the USA may have been tested against USA and NATO documents. It is possible to carryout a gap analysis i.e. to check if more documents are called up if the munition is being considered for another country. It does not have a hierarchy in that where there is a UK requirement and a French requirement it will not generate a preference order, this could be a future development.

Documents have been used from Australia, Canada, France, Italy, Sweden, the United Kingdom, the United States, the United Nations and NATO. Only documents that have been release to MSIAC or are in open literature have been included. The different document and trial outputs can be compared and any new or different requirements identified.

8. LIBRARY OF ASSOCIATED TEST SPECIFICATIONS

The library of documents available on the CD is directly linked to the assessment. When an assessment is made the linked documents are copied and stored in a unique sub-directory that stays with that assessment. Therefore, a complete record of the source documents will remain available for the future so that if an assessment is revisited the original requirement documents will be available even if the current reference documents have been updated. Any updated reference documents will also be available on the latest version of SAS.

9. TRAINING

The SAS installation disk includes a tutorial help file, which is linked to the main programme. Figure 5 shows the content of the tutorial. SAS is relatively easy to use and has incorporated the standard File Save and Save As options as most files in the Windows environment. It is possible to save many versions of an assessment as it is developed, although each version will have a sub-directory with all the called up references included, therefore the space required will grow considerably if many versions are recorded.

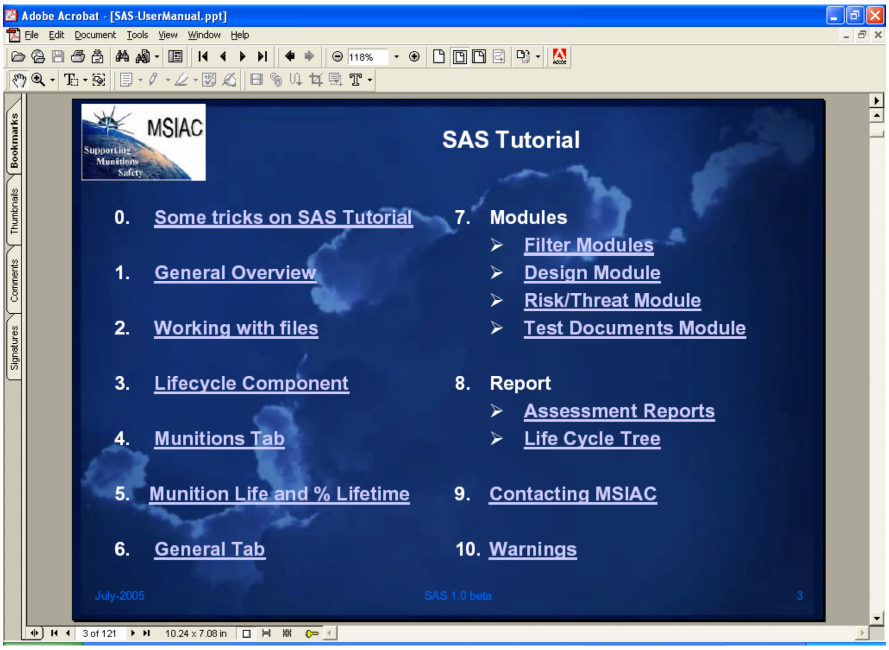

Figure 5 – Screen Shot of SAS Tutorial Chapter Headings

10. REPORTS

10.1 DESIGN DOCUMENTS

There are a number of options when creating reports. The main options are the Design documents.

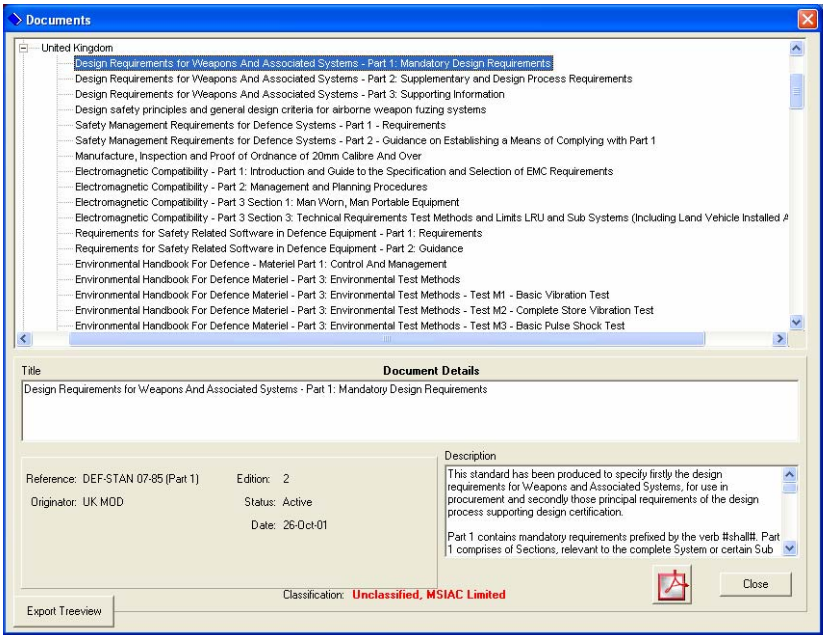

Figure 6 – Print-out of Design Safety Documents for 6kg bomb – only UK selected

As can be seen by highlighting a document the details are shown and the link to the acrobat source document is available.

10.2 TEST DOCUMENTS

The reports can be printed or exported as an MS-Word document. It is also possible to export a tree view of a document as a text file or directly into an MS Excel Worksheet

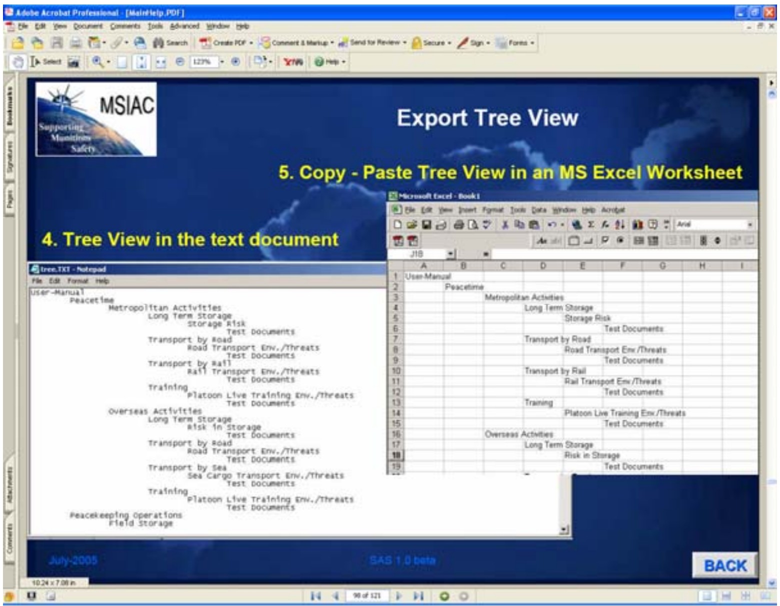

Figure 7 – Example of the Exportable Tree View

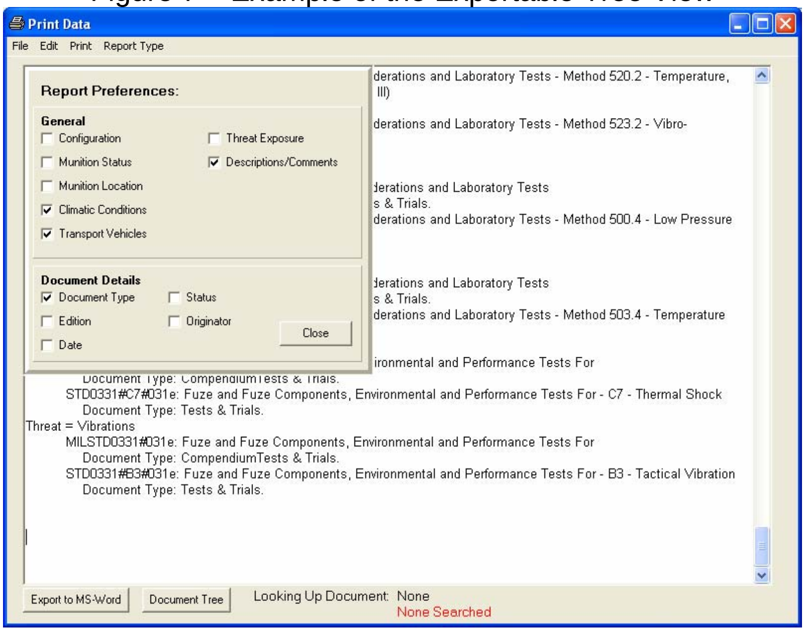

Figure 8 - The report screen has various options as to what details are included in the report.

11. DEVELOPMENTS

The SAS tool can be developed to meet customers' needs although, as discussed in the next section, there will be tasks that are beyond the scope of a program like this. Future ideas include:

- A new front end
- A faster program
- More counties specifications (if released to MSIAC)
- A record of threats to be exported to the larger safety case

- Automatically tallying durations such as road miles
- Library of assessments (either real or generic).

12. DISCUSSION

What SAS does not do is generate the duration of testing. This is why a safety advisor/analyst still needs to seek advice on the duration of testing. Fall back requirements such as "2 hours per axis" may be sufficient in some cases where this represents an overtest, and that test is unlikely to cause any damage or loss in reliability. However, tailored testing may well be required.

12.1 TAILORED TESTING

In the specific case of AS90 the British self-propelled Howitzer, it was probably not sufficient to just do the testing in STANAG 4242 (generic tracked vehicle vibration). Following testing in the various stowage positions it was possible to derive a test, which took into account the vehicle variations as well as the range of speeds and over a range of surfaces. This is where an element of risk comes into the testing. The risk is two-fold; there is a risk that by taking the worst vehicle tested and adding a safety margin at the worst speed in the worst shell position for the longest envisaged duration that you will derive a test that cannot be passed by anything more fragile that a block of wood. However, there is a risk that if you do not consider the one in a million situation then when that event occurs such as the Concorde disaster, you will not have a robust safety case to fall back upon.

The aim of the above discussion was to explain why the generation of testing durations becomes at best difficult and possibly can only be derived by a knowledgeable panel taking into account all the circumstances.

13. CONCLUSION

SAS allows the user to quickly input a life cycle which is presented graphically. The threats and hazards which may be appropriate are then available from menus for the user to select. The documentation appropriate to the selected countries source documents for design and for testing are then selected by the program and are available as an output either within the SAS environment or are exportable to Microsoft Excel or Word documents.

The reports generated and a folder containing all the source documentation is created which allows the report to be revisited at a later date with the appropriate references used at the time of its creation.

SAS's delivers the Safety testing requirements for bringing Munitions into service. It is evident that there are some additional potential usages of SAS version Beta 1.1 which shall include:

- Life Cycle Representation;
- Threat Hazard Representation;
- Test Requirement Gap analysis between different nations;
- It is an up to date Library of associated test specifications;
- A common approach to testing requirements which may enable industry to do its own testing requirement development and therefore arrive at a position where costing analysis can take place.

The international munitions community may be interested in some of these potential uses. Indeed, it may be the Defense Community as a whole that has use for such a tool, which allows the manufacturer to assess and therefore cost the potential testing requirements.

For Commercial Off the Shelf (COTS) munitions that have been tested for use in one nation it is possible with SAS to run the munition through the tool and come up with a new list of documents required for other nations. This list can be compared and a gap analysis conducted. In the future it may be possible to generate this gap analysis automatically but currently this would need to be done manually.

REFERENCES

1. AOP15 – Ed 2 Nov 1998, Guidance on the Assessment of the Safety and Suitability for Service of Non-Nuclear Munitions for NATO Armed Forces.