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# FOREWORD

Over the last 25 years, MSIAC has developed a suite of tools to support member nation's efforts to design, develop, procure, and use safer munitions. During this time the numbers of tools and their format have changed considerably, but the goal remains essentially the same: to add value to shared knowledge and understanding for the purposes of promoting and improving munitions safety.

The tools are available to individuals in MSIAC member nations, upon approval, so I would encourage you to make full use of the tools and to inform colleagues who may also benefit. Please consider whether you can contribute to the continuous process of improvement and update of tools by providing information or by offering feedback.

Project Manager, MSIAC

# **INTRODUCTION TO MSIAC TOOLS**

MSIAC has developed a secure suite of applications to aid its members in their day-to-day business. Access to these tools is fast, secure and developed to be intuitive. The tools can be beneficial to any MSIAC member working in the fields of Munition Safety and/or Insensitive Munitions.

Secure access to the tools is via the MSIAC website under the 'Secure Website' tab. The tools are located in either the **Portal** or **Weblink**. This guide will provide you with the location for each tool.

Permission is granted to users by their National Focal Point Officer (NFPO) after completion of the on-line access form: www.msiac.nato.int/access

Please browse each tool for further details on their functions, features and location. Then go online and take advantage of these free tools.



# **APPLICATION OF MSIAC TOOLS**

The MSIAC tools can be used at different stages in the life cycle of munitions, as shown in the image below.



# **AIMS - ADVANCED INSENSITIVE MUNITIONS SEARCH**

Advanced IM Search is a quick, easy and fully searchable database of IM test results. It is intended to support munitions designers, test centres, IM boards, program managers and munitions suppliers.

Format:	Online
Responsible TSO:	Warhead Technology and Propulsion Technology
Documents:	O-156 AIMS Advanced Insensitive Munitions Search
Accessible via:	Portal
Link:	https://aims.msiac.nato.int
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

AIMS provides access to IM test results for munitions and generic test units for each threat defined by the NATO IM policy: fast heating, slow heating, bullet impact, fragment impact, sympathetic reaction and shaped charge jet.

Every test result is fully referenced, searchable and in certain cases access is granted directly to the source material. The information is displayed in a table that provides the munitions name, its main characteristics (energetic material, caliber, case material, packaging), mitigation, test set-up and test results. For each test result, a detailed view provides additional information on the munitions and the test itself, and when available, a picture of the test is included.

The platform also enables users to search through all the databases at once by using a unique and simple interface. The results are displayed per IM threat in separate tabs that reproduces the interfaces of each database. Tests performed with the standardized IM threats can also be sorted in a synthesized table that easily allows comparison of the munitions IM signatures.

Users can also access the related NATO test standards, the list of references used to populate the database as well as a description of commonly used generic test units and shaped charges.



# **AIMS - ADVANCED INSENSITIVE MUNITIONS SEARCH**



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# **ARM - ANALYTICAL RESPONSE MODELS**

ARM is being developed to provide a web based software suite of empirical and analytical models dedicated to ammunition safety. The ARM software provides computational tools for the use of modeling in assessing munitions safety. The initial modeling capability provided in ARM is for the prediction of detonation by impact threats.

Format:	Online
Responsible TSO:	Warhead Technology
Documents:	L-254 Analytical Response Models (ARM) Application Specification
Accessible via:	Portal
Link:	https://arm.msiac.nato.int
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

ARM is a "toolbox" of empirical and analytical models dedicated to ammunition safety. The objective of the ARM computer program application is to provide a powerful software package that utilizes a library of empirical or semi-empirical models dedicated to insensitive munitions (IM) assessment. It is being developed with the intention of allowing full flexibility to add custom models or to enhance existing ones. ARM provides an intuitive and relatively simple graphical user interface (GUI) for data input and for results display.

ARM is being developed to replace the MSIAC TEMPER application. TEMPER was written in Microsoft Visual Basic 6.0 (VB6). Unfortunately, the final release of VB6 was in 1998. On April 8, 2008 Microsoft stopped supporting VB6. As a result, ARM is being developed to replace TEMPER. ARM is being developed using JavaScript in order to provide both a single application that is web based, but can be run in a stand-alone mode.

Currently, ARM contains the Jacobs-Roslund impact initiation model. It has a small library of Jacobs-Roslund model parameters. The MSIAC modified Jacobs-Roslund model is being introduced into ARM



# **ARM - ANALYTICAL RESPONSE MODELS**

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# **EMC - ENERGETIC MATERIALS COMPENDIUM**

The Energetic Materials Compendium (EMC) is a quick, easy and fully searchable database to access explosive property data on energetic materials. It is intended to support formulation scientists, energetic chemists and warhead designers.

Format:	Online
Responsible TSO:	Energetic Materials
Documents:	O-157 The Development and Future of EMC
Accessible via:	Portal
Link:	https://emc.msiac.nato.int
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

EMC provides one location to access test data for high explosives, gun propellants, rocket propellants and pyrotechnic formulations. The database is a collation of openly published energetic material technical data and has been organised by two connected databases: formulations and components.

The powerful search feature within the formulation database allows users to find data from multiple fields such as performance (detonation velocity), sensitivity (impact), physical properties (thermal conductivity), composition details (component percentage), manufacturer and application.

Within the components database users are able to search both energetic and non-energetic ingredients via name, Chemical Abstract Service (CAS) number, and chemical formula. Data will also be fully searchable across chemical (enthalpy of formation), physical (density), explosive (detonation velocity) and hazard (LD50, STEL, REACH) properties.

A side-by-side comparison tool for both the formulations and components databases allows users to compare up to four materials.

Every formulation and component is fully referenced, searchable and in certain cases access is granted directly to the source material.



#### **EMC - ENERGETIC MATERIALS COMPENDIUM**

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# MADx - MSIAC ACCIDENT DATABASE EXCHANGE

MADx allows easy searching in over 14,000 accident reports associated with munitions. Information is provided by Australia, Canada, France, Germany, the Netherlands, the United Kingdom and the United States.

Format:	Online
Responsible TSO:	Munitions Transport and Storage Safety
Documents:	None
Accessible via:	Portal
Link:	https://madx.msiac.nato.int
Accessible to:	Selected governmental MSIAC members AUS, CAN, DEU, FRA, GBR, NLD, USA

#### Main Functions/Features of the Tool:

MADx provides access to multinational accident information in a common format allowing fast and easy searching across countries. The database contains information about the accident date, location, weapon and munition type, cause, life cycle phase, damage category, and both the number of fatalities and injured.

A powerful search engine allows information to be retrieved using the aforementioned criteria. Search results are displayed in a summary table including a brief description of the accident, date and location. Results are also displayed as histograms that show the number of accidents per year, probable cause, category and country. The application also offers the possibility to select a list of accidents and then print or export to an Excel format for further analysis.

MADx can be used in safety assessments of particular weapon types and to support ammunition accident investigations.

We invite other nations to contribute to MADx and in turn gain access to the database.

#### **MADx - MSIAC ACCIDENT DATABASE EXCHANGE**

#### Terminology

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#### Category (Severity of the accident)

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# **MQD - MSIAC QUANTITY DISTANCE**

The MQD tool performs an experimentally validated consequence analysis of ammunition storage accidents. It supports risk analysis as well as further development of QDs.

Format:	Online
Responsible TSO:	Munitions Transport and Storage Safety
Documents:	L-229 Experimental and Theoretical Basis of NATO standards for safe Storage of Ammunition and Explosives – Final Report
Accessible via:	Portal
Link:	https://mqd.msiac.nato.int
Accessible to:	All approved members

#### Main Functions/Features of the Tool:

The MQD tool performs an experimentally validated consequence analysis of the accidental initiation of various types and quantities of munitions in various types of magazines, and with possible mitigation measures in place. This includes blast damage to buildings, direct blast injury, thermal effects, as well as hazards from debris and fragments. The results of the MQD tool can be compared with current QD standards for all Hazard Divisions (HD) over the full range of NEQ. This provides insight into which consequences are to be expected at the QDs and informs risk analysis. Also it supports further development of QDs, making use of up to date experimental results. The MQD tool does not deal with mixed storage; it performs calculations for one HD at a time.

It should be noted that the MQD tool has a different objective than a number of existing QD tools (Explosive storage capacity calculator, (N)ASAP-X, ESS) which are aimed to reproduce QDs provided in guidelines.

#### Future updates to MQD beyond the current version are planned with:

- Addition of links to references and pictures with to be expected damage
- Addition of engineering models for some of the physical effects
- Addition of QD from AASTP-1 and other documents to compare results



# **MQD - MSIAC QUANTITY DISTANCE**

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# **MTM - MITIGATION TECHNIQUES FOR MUNITIONS**

Mitigation techniques for munitions is a searchable database containing the state of the art on mitigation technologies with regards to less sensitive storage configurations and insensitive munitions design methods. It is intended to support munitions designers, IM boards, program managers and the military by offering a source of potential options or solutions to satisfy today's munitions IM Requirements.

Format:	Online
Responsible TSO:	Propulsion Technology
Documents:	O-165 MTM – Technical Specifications O-173 MTM – Easy Access Online
Accessible via:	Portal
Link:	https://mtm.msiac.nato.int
Accessible to:	All approved members

#### Main Functions/Features of the Tool:

MTM provides access to technologies to mitigate the reaction of munitions against IM threats as defined by the NATO IM policy: fast heating, slow heating, bullet impact, fragment impact, sympathetic reaction and shaped charge jet. Munitions manufacturers may use it to design less sensitive munitions and containers (e.g. venting, thermal protection). The military will find storage solutions specifically to avoid sympathetic reaction (e.g. barrier, storage arrangement).

A powerful search engine and table provides a short description of the technologies and its related attributes. The numerous criteria allow searching by text, threat, component, category of munitions, mitigation family, configuration, design change and reference. In the detailed view, each technology is fully described and illustrated with picture(s) when available. The user can easily navigate from one technology to another by using the arrows on a keyboard or by swiping on a touch screen.

The application offers the possibility to select a list of mitigations and then print or create a PDF document.

The active behaviour of the application makes it convenient for use with smartphone and tablets.

Every technology is fully referenced, searchable and in certain cases access is granted directly to the source material.



#### **MTM - MITIGATION TECHNIQUES FOR MUNITIONS**





# SASO - SAFETY ASSESSMENT SOFTWARE

SASO is an online tool that enables identification and selection of the appropriate policy, design requirements, environmental and other testing requirements from international and national Standards considered appropriate to support the S3 process.

Format:	Online
Responsible TSO:	Munition Systems
Documents:	None
Accessible via:	Portal
Link:	https://saso.msiac.nato.int
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

SASO provides a step-by-step tool to provide fast access to relevant standards and is an enabler for anyone involved or interested in munitions safety. This tool supports anyone working in any capacity, from designers through to final risk and safety assessment.

From the user input the tool selects requirements based on the munition type, features incorporated (e.g. EEDs), applicable international and national standards, environmental lifecycle profile and identified threats.

Standards are selected by providing details of the Lifecycle Environmental Profile (LCEP). These are down-selected by identifying and adjusting phases (storage, carriage) during the life and the potential threat source(s) during each phase.

The output includes relevant tests, standards, policy and design requirements specific to the munition and its lifecycle. All documentation is directly accessible from an up-to-date repository.



### SASO - SAFETY ASSESSMENT SOFTWARE



#### SASCI Heat Assessments Documents this







### **CBAM - COST BENEFIT ANALYSIS MODEL**

Cost Benefit Analysis Model (CBAM) is available to help member Nations calculate the benefits of introducing Insensitive Munitions (IM) into their munitions inventory. It is intended to assist the decision making process by informing on the costs and benefits of introducing Insensitive Munitions over the munition lifecycle.

Format:	.exe
Responsible TSO:	Munition Systems
Documents:	O-80 Cost Benefit Analysis Studies of the Introduction of IM L-104 The NIMIC CBAM: User Guide and Input Data Compilation
Accessible via:	WebLink
Link:	https://www.msiac.nato.int/cbam
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

CBAM is used to compare costs associated with introducing IM versus non-IM versions of the same munition. The tool analyses direct costs, such as development and procurement related costs, as well as potential ones, those associated with accidents or unplanned events. The model employs a Monte Carlo simulation to help assess data uncertainty and results are displayed as graphical representations of the most likely outcome.

#### Other potential uses for CBAM include:

- Determining life cycle costs of weapon systems (and the life cycle cost comparison between different technologies)
- Risk analysis
- Threat hazard assessment (using the life cycle tree capabilities)

# **CBAM - COST BENEFIT ANALYSIS MODEL**





# **IMSOA - INSENSITIVE MUNITIONS STATE OF THE ART**

IM State of the Art provides a snap shot of system improvements and IM technology trends that provide benefit to the warfighter.

Format:	.pdf
Responsible TSO:	Warhead Technology
Documents:	None
Accessible via:	WebLink
Link:	https://www.msiac.nato.int/imsoa
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

IMSOA contains information on over 50 systems that are at high level of maturity.

The topics are divided between Land, Sea and Air Launched Systems. The information normally provided includes the performance relative to a non-IM variant for comparison, customers, indication of which nations have the round in service, indication of program status, IM technology, details of energetic fill, mitigation devices, design options, packaging, IM Benefits, Cost comparison IM vs. non-IM, IM Signature, and the IM signature of round compared to non-IM when available.



# **IMSOA - INSENSITIVE MUNITIONS STATE OF THE ART**







# **MHCDX - MSIAC HAZARD CLASSIFICATION DATABASE EXCHANGE**

MHCDx contains Hazard Classification data on items and munitions systems from selected member nations that can be accessed by governmental users from those nations.

Format:	.mbd, .pdf, .xls
Responsible TSO:	Munitions Transport and Storage Safety
Documents:	None
Accessible via:	WebLink
Link:	https://www.msiac.nato.int/mhcdx
Accessible to:	Selected governmental MSIAC members AUS, BEL, CAN, DEU, FIN, FRA, GBR, NLD, NOR, POL, US Selected governmental non-MSIAC members CZE, LTV, SVK, SVN, UKR

#### Main Functions/Features of the Tool:

MHCDx typically contains, as a minimum, information on the Hazard (sub) Division, National Stock Number (NSN), and the Net Explosive Quantity (NEQ). Most nations provide regular updates to their national HC data. MHCDx can be used to exchange HC information, which is helpful during the national HC process and in preparation of multinational missions and exercises.

MHCDx is currently available in the original file formats provided by the nations, but there are plans to develop a common database application.

We invite other nations to contribute to MADx and in turn gain access to the database.



# **MSAS - MUNITIONS STANDARDS AND SAFETY DATABASE**

MSAS is a library of unclassified munitions and safety related International and national standards considered relevant for the munition safety community.

Format:	Online
Responsible TSO:	Munitions Systems
Documents:	None
Accessible via:	WebLink
Link:	https://www.msiac.nato.int/msas
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

MSAS is a library of munitions and safety related international and national standards considered relevant for the munition safety community and which are not classified. The contents are based on accumulated knowledge and understanding of documents that may be appropriate for as wide an audience as possible within MSIAC nations.

NATO standards are more readily accessible than from the NATO repository and national documents are updated regularly.

MSAS can be used by nations as a readily accessible repository for their own Standards and documents.



NEWGATES is a database of common gap test set ups and test results. It has been designed to provide scientists and engineers with a comparison tool.

Format:	.xls
Responsible TSO:	Warhead Technology
Documents:	O-89 The NIMIC Excel Worksheets on Gap Tests (NEWGATES) L-148 Ed3 NEWGATES Version 1.10 User Guide
Accessible via:	WebLink
Link:	https://www.msiac.nato.int/newgates
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

NEWGATES has been designed to provide:

- Scientists and engineers with a tool, which is easy to use and up to date. It can be used to compare gap tests results and/or calculate critical initiation pressure and critical initiation time
- Modellers with a flexible research tool containing referenced data required to validate models

#### It also provides the IM community with 6 databases:

- Information about 10 gap tests (description and diagrams, complete with dimensions, scope, principles)
- Pressure calibration curves
- Time calibration curves
- Shock curvature calibration curves
- 1568 gap test results
- 250+ Hugoniots

A module has also been added to calculate analytically the Hugoniot parameters of an energetic mixture from its ingredients. This module can be used to estimate the initiation pressure threshold for the energetic composition itself.



#### **NEWGATES - NIMIC EXCEL WORKSHEETS ON GAP TESTS**





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# TEMPER - TOOLBOX OF ENGINEERING MODELS FOR THE PREDICTION OF EXPLOSIVE REACTIONS

TEMPER is a tool for the prediction of explosive reactions to insensitive munitions (IM) threats. It utilizes a library of empirical or semi-empirical models dedicated to insensitive munitions (IM) assessment.

Format:	.exe
Responsible TSO:	Warhead Technology
Documents:	O-176 Temper status and recommendations
	L-139 TEMPER v2.0 – User's Manual
Accessible via:	WebLink
Link:	https://www.msiac.nato.int/temper
Accessible to:	All approved MSIAC members

#### Main Functions/Features of the Tool:

TEMPER provides a:

- Library of threats, models and parameters to run the models
- Direct selection of threat / mitigation / structure / model from the Graphic User Interface with automatic compatibility management
- Ability to perform parametric or stochastic simulations by varying one or two parameters of the problem
- Ability to draw curves and save results using an embedded Excel workbook

It also includes models for fragment impact, shaped charge, sympathetic reaction and thermal threats such as:

- an MSIAC modified Jacobs-Roslund model that is based on an analysis of many experimental test results and that requires only one parameter
- the implementation of conical fragment that enables simulation of the NATO fragment defined in STANAG 4496 for IM testing
- the modelling of a residual fragment after perforation of a mitigation for conical-ended and parallelepiped fragment. This model will be very useful to simulate the impact of a NATO fragment on bare or packed munitions
- a sympathetic reaction model, SANDI, that is based on a different approach than that of the One on One Warhead model



#### TEMPER - TOOLBOX OF ENGINEERING MODELS FOR THE PREDICTION OF EXPLOSIVE REACTIONS







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MSIAC - NATO HQ 1110 Brussels - Belgium www.msiac.nato.int info@msiac.nato.int

1615-19 NATO GRAPHIC & PRINTING