Insensitive Munitions
Analytical Compliance System
(I-MACS) Concept
Insensitive Munitions
(OSD & NATO)

“…munitions which reliably fulfill their performance, readiness and operation requirements on demand, but which minimize the probability of inadvertent initiation and severity of subsequent collateral damage to weapon platforms, logistic systems, and personnel, when subjected to unplanned stimuli.”

**BENEFITS**

• Enhanced survivability of logistical and tactical systems
• Reduced risk of injury to personnel
• Applicability across services/platforms
• More efficient to transport, store and handle
• More cost effective
# Historic Incidences

(Four Aircraft Carrier Accidents in 1966, 1967, 1969 & 1981)\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>ACTUAL STATISTICS</th>
<th>IM MUNITION EST'D % ↓</th>
<th>EST'D SAVINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lives Lost</td>
<td>220</td>
<td>72</td>
<td>$148M</td>
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<tr>
<td>Injuries</td>
<td>709</td>
<td>132</td>
<td>577M</td>
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<tr>
<td>Aircraft Lost</td>
<td>42</td>
<td>10</td>
<td>32M</td>
</tr>
<tr>
<td>Aircraft Damaged</td>
<td>72</td>
<td>12</td>
<td>60M</td>
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<tr>
<td>Potential Total $ Savings</td>
<td></td>
<td></td>
<td>$1.4B</td>
</tr>
</tbody>
</table>

\(^a\) From 1991 CNA Study
Munitions Life Cycle Unplanned Stimuli

- Leakage
- Vibration
- Temperature (FCO, SCO)
- Penetration (FI, BI)
- Aging
- Humidity
- Pressure
- Sympathetic Detonation
- Incompatibility
- Dropping

MUNITION LIFE CYCLE

- Storage
- Shipping
- Research & Development
- Manufacturing
- Demilitarization
- Usage

Chemical Compliance Systems, Inc.
Sources of Weapon System Vulnerabilities

- External Stimuli
- Internal Constituent Sensitivities
- Incompatible Constituent Proximity
Sensitive Constituents Database Endpoints

- Enthalpy
- Heat of Formation
- Conductance
- Entropy
- Static Charge Accumulation
- Particle Size/Form
- Heat Capacity
- Vapor Pressure
- Density
- Specific Gravity
- Physical State
- Amмо & Explosives Compatibility Groups
- Corrosivity Grade
- Chemical Incompatibilities
- Corrosion Susceptibility
- Hazard Classification
- Energetic Family
- CHEETAH Calculated Temperature/Pressure
- CHEMICAL CAS #
- SYNONYM
- DICTIONARY
Incompatible Chemical Proximity Database

- Locations Enhanced MIDAS
- INCOMPATIBLE MUNITION CONSTITUENTS
- Aging Impact
- Improved Design Barriers/ Buffers

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Hurdles for Developing Insensitive Munitions

“HURDLE”

1. The problem is extremely complex
2. IM is only one of the problems
3. Some test protocols are not standardized
4. Some IM test results are not standardized, nor shared
5. IM Test Data must be secure
6. Incident “Root Cause” Analyses are not in a database

“SOLUTION”

1. Utilize “outside the box” thinking
2. Start — Integrate — Enhance
3. Begin with a standardized data repository
4. Develop a Centralized Database—require submissions
5. Obtain DoD & NSA clearance for I-MACS Security
6. Develop a chemical-based “Root Cause” for each incident
Insensitive Munitions Analytical Compliance System (I-MACS)

The CCS Relational Chemical & Product Database (R–CPD)

CCS CENTRALIZED DATABASE

1 Chemicals
2 Alternative Chemicals
3 Commercial Products
4 Green Criteria
5 Security Factors
6 Biobased Ratings
7 Munitions – Midas
8 Chemical Agents
9 Agent Simulants
10 Bioterrorism Agents
11 Radioisotopes
12 Regulations

1 Cross-Reference Dictionary
   Chemical Compound Dictionary
   Chemical Alternatives
   Toxicology Data
   Holistic Hazard Ratings
   Personal Protective Equipment
   SAF-T-LABEL®
   Safe Storage Codes
   Safe Disposal Codes
   Alloy Constituents
   Emergency Response
   Elemental Composition
   Incompatibilities
   Physical/Chemical Parameters

2 39 Generic Categories, e.g.,
   Solvents Reducing Agents
   Acids Surfactants
   Bases Binders
   Oxidizers Alloys
   Antioxidants Metal Compounds
   80 Subcategories

3 Product Descriptions
   Product Components
   MSDS Images
   MSDS Index
   Generic Categories
   Manufacturers
   User Directory
   Processes
   Green Ratings
   Corrosive Ratings
   Biobased Ratings

4 43 Endpoint Criteria
   Ecological—Air, Water, Soil
   Health—Acute, Chronic
   Safety—Fire, Reactivity, Special
   Chemical-based
   Objective & Quantitative

5 Chemical Security Risk List
   Precursor Chemical Security Risk List
   Theft & Population Risks
   Accessibility Factors

6 13 Endpoint Criteria
   Biomass Score
   Regulatory Score
   Economic Score

7 Munitions Characterization—MIDAS
   Demil Processes
   Constituent Chemicals
   Chemicals Released
   Green Criteria
   Insensitive Criteria
   Corrosive Criteria
   Packaging Criteria
   Transportation/Storage Factors
   Reliability Factors
   Hazardous Waste Forms
   Regulations

8/9 Properties
   Toxicology Data
   Hazard Issues
   Incompatibilities
   Storage Recommendations
   TICs/TIMs

10 20+ Agents
   Disease Descriptors
   Pathogenesis
   Prophylaxis
   Emergency Response
   Decontamination
   Treatment

11 Generic Families
   Properties
   Effects & Actions
   Storage & Security
   Diagnosis & Treatment
   Decontamination
   Emergency Response

12 650 Total Regulations
   Local
   State
   Federal
   International
   Non-government
   Corporate or Trade Association

CCS Chemical Compliance Systems, Inc.
Munitions Analytical Compliance Suite (MACS)

MACS Centralized Databases
- Munitions Characterization – MIDAS
- Demil Processes
- Constituent Chemicals
- Chemicals Released
- Concern Criteria
- Green Criteria
- Insensitive Criteria
- Corrosive Criteria
- Packaging Criteria
- Transportation/Storage Factors
- Reliability Factors
- Hazardous Waste Forms
- Regulations

MACS–1
- Demil (Web)

MACS–2
- RATS
  - Range Assembly (Concept)

MACS–3
- Theoretical Compliance Analyses
  - (Web)

MACS–4
- Sources & Shortages
  - (Proposal)

MACS–5
- Manufacturing
  - (Proposal)

MACS–6
- Storage & Packaging
  - (Concept)

MACS–COC
- Chemicals of Concern

MACS–PODS
- (Client–Server)

MACS–1
- Demil (Web)

U–MACS
- UXO Remediation
  - (Concept)

TRACS
- Hazardous Waste
  - (Web)

G–MACS
- Green Munitions
  - (Web)

I–MACS
- Insensitive Munitions
  - (Proposal)

C–MACS
- Corrosives
  - (Proposal)

ARAS
- Ammo Reliability
  - (Concept)

RATS
- Range Assembly
  - (Concept)

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Significance of each sub-score can be individually weighted

**ECOLOGICAL SCORE**
(0-100%)  ____% A.W.

**HEALTH SCORE**
(0-100%)  ____% A.W.

**SAFETY SCORE**
(0-100%)  ____% A.W.

**FINAL GREEN GRADE**
(0 - 100%)

"Endpoint" Criteria

**TOXICITY - AIR**
(V.P. + LC50) + BCF

**LONG-TERM EFFECTS - AIR**
Global Warming Potential
Ozone-Depleting Potential
Smog
Acidification

**TOXICITY - WATER**
Fish LC50
Daphne LC50
Green Algae EC50
(Solubility + W-LC50) + BCF

**LONG-TERM EFFECTS - WATER**
Eutrophication
Theoretical Oxygen Demand

**TOXICITY - SOIL**
(Koc + O-LD50) + BCF
14-day Worm LC50

**LONG-TERM EFFECTS - SOIL**
Groundwater Mobility Factor
CERCLA RQ

**FLAMMABILITY**
Flash Point
Boiling Point

**G–MACS “Green” Score Scheme**

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Insensitive Munitions Analytical Compliance System (I-MACS)

I-MACS System Components

- Munition Sensitivity Risk Assessment
- Munition Test Plan Status
- IM Test Result Analyses
- IM Document Tracking
Insensitive Munitions Analytical Compliance System (I-MACS)

Main Menu Screen

MACS-1
Analytical
Input Results

Munition
Sensitivity
Risk
Assessment

IM
Test Plan
Status

IM
Test Result
Analyses

IM
Document
Tracking

I-MACS
Analytical
Results Output
(to G-MACS)
Munition Sensitivity Risk Assessment Algorithms

- Correlation Analysis
- Historic Incidents Database
- "At Risk" Sensitive Constituents Database
- Risk Sources Database
- Risk Source Test Results
- Risk Sources Compensation Strategies Database
- Risk Source Compensation Strategy Test Results
- Correlation Analyses

Key Risk Sources:
- ENERGETICS
- CORROSIVES
- CORROSION SENSITIVE
- HEAT SENSITIVE
- INCOMPATIBLES

Chemical Compliance Systems, Inc.
Insensitive Munitions Analytical Compliance System (I-MACS)

Test Plan Status & Document Tracking

IM Life Cycle Environmental Profile
IM Threat Hazard Assessment
IM Test Plan & Results
IM Test Plan Safety Goals
IM Test Report
IM Hazard Assessment Test Results

Program Manager

Review & Approval
Review & Approval
Review & Approval
Review & Approval
Review & Approval
Review & Approval

Service Review Organization

Review & Approval
Review & Approval
Review & Approval
Review & Approval
Review & Approval
Review & Approval

IM FINAL RECOMMEND.

CCS

Chemical Compliance Systems, Inc.
### Test Plan & Results

<table>
<thead>
<tr>
<th>Test Plan</th>
<th>Results</th>
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<tbody>
<tr>
<td>28-Day Temperature &amp; Humidity Test</td>
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</tr>
<tr>
<td>Vibration Test</td>
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<tr>
<td>4-Day Temperature &amp; Humidity Test</td>
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<tr>
<td>12-Meter Drop Test</td>
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<tr>
<td>Fast Cook-Off Test</td>
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<tr>
<td>Slow Cook-Off Test</td>
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<tr>
<td>Bullet Impact Test</td>
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<tr>
<td>Fragment Impact Test</td>
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<tr>
<td>Sympathetic Detonation Test</td>
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<tr>
<td>Shaped Charge Jet Impact Test</td>
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<td>Spall Impact Test</td>
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<td>Specialty Test</td>
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5.2.1 I-MACS Fast Cook-Off Test Results

**ITEM NO.**

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<tr>
<th>Description</th>
<th>Normal</th>
<th>Abnormal (describe)</th>
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<tr>
<td>Radiographic Inspection</td>
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<tr>
<td>Position</td>
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<tr>
<td>Distance from Fuel Basket</td>
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<tr>
<td>Restraint Method</td>
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<td>Suspension Method</td>
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**AVERAGE FLAME TEMPERATURE:** °C ($< 850°C = 1560°F$)

**PHOTOGRAPHY:**
- [ ] 043
- [ ] Video tape/record

**TEST RESULT SUMMARY**

1. Type 1 (Distention Reaction)
2. Type 2 (Exhaustion Reaction)
3. Type 3 (Explosion Reaction)
4. Type 4 (Deflagration Reaction)
5. Type 5 (Burning Reaction)

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**Thermal Couple Readings:**

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<tr>
<th>(°F)</th>
<th>TC1</th>
<th>TC2</th>
<th>TC3</th>
<th>TC4</th>
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<td>30a</td>
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</tbody>
</table>
Significance of each sub-score can be individually weighted

- **CONSTITUENT SENSITIVITY SCORE**
  - (0-100%)
  - _____% A.W.

- **INCOMPATIBLE CONSTITUENT PROXIMITY SCORE**
  - (0-100%)
  - _____% A.W.

- **EXTERNAL STIMULI SCORE**
  - (0-100%)
  - _____% A.W.

- **“At Risk” Constituents Score**

- **Risk Sources (RS) Score**

- **RS Component Strategies Score**

- **External Score**

- **Internal Score**

- **Mil-STD 2105B Score**

- **“Endpoint” Criteria**
  - Energetics
  - Corrosives
  - Corrosion Vulnerability
  - Heat Sensitivity
  - Incompatibles
  - Corrosion
  - Temperature
  - Humidity
  - Static Charge Accumulation
  - Shock
  - Vibration
  - Age
  - Design Barriers
  - H/T Control
  - Grounding
  - Protective Packaging
  - Reliability Tests
  - Ambient T/H
  - Salt Air
  - Package Design
  - Within Munition
    - Within Component
    - Within Part
    - Design Barriers
  - Fast Cook-Off
  - Slow Cook-Off
  - Bullet/Fragment/Spall Impact
  - Vibration Test
  - Drop Test

- **CCS Chemical Compliance Systems, Inc.**
Insensitive Munitions Analytical Compliance System (I-MACS)

For more information on I-MACS, or a remote demonstration of other MACS modules, please contact . . .

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