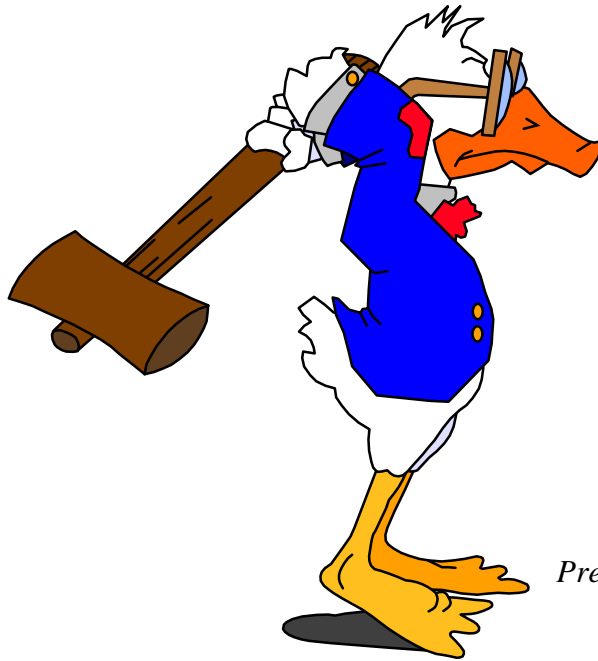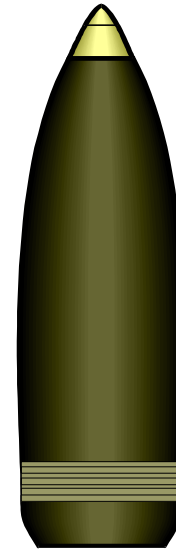# Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Presented by

George R. Thompson, Ph.D.
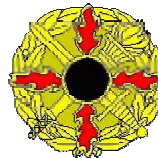PRESIDENT & CEO

Tyrone D. Nordquist
LOGISTICS MANAGEMENT SPECIALIST
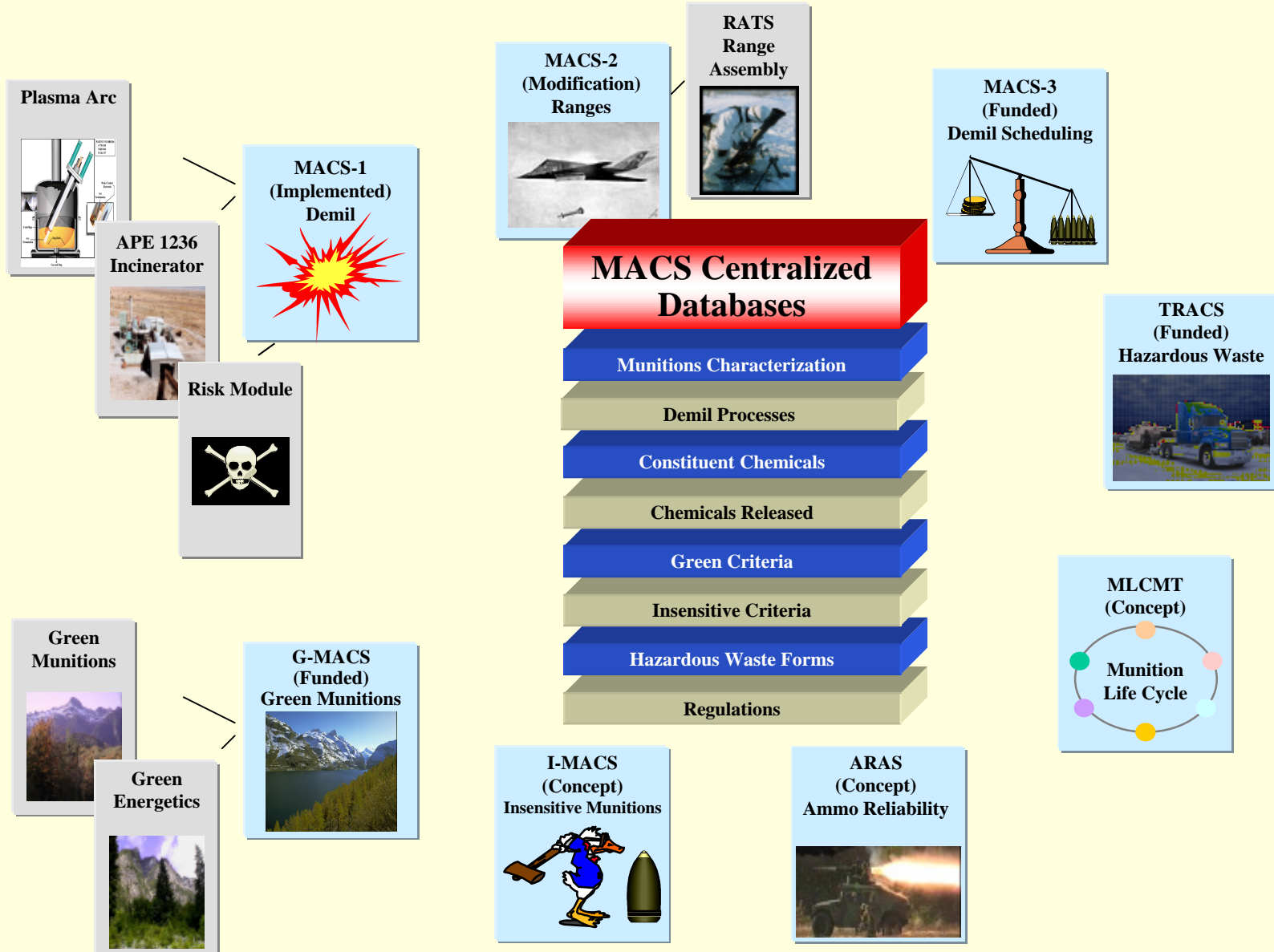
Chemical Compliance Systems
706 Route 15 South, Suite 207 • Lake Hopatcong, NJ 07849 • 973-663-2148 • (fax) 973-663-2378
ciiccs@bellatlantic.net • www.chemply.com

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1CTree Road, Bldg. 35 • McAlester. OK 74501 • 918-420-8144 • (fax) 918-420-8717
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Munitions Analytical Compliance Systems (MACS)

Plasma Arc

MACS-2 (Modification) Ranges

RATS Range Assembly

MACS-3 (Funded) Demil Scheduling

MACS-1 (Implemented) Demil

APE 1236 Incinerator

Risk Module

MACS Centralized Databases

Munitions Characterization

Demil Processes

Constituent Chemicals

Chemicals Released

Green Criteria

Insensitive Criteria

Hazardous Waste Forms

Regulations

TRACS (Funded) Hazardous Waste

MLCMT (Concept)

Munition Life Cycle

Green Munitions

G-MACS (Funded) Green Munitions

Green Energetics

I-MACS (Concept) Insensitive Munitions

ARAS (Concept) Ammo Reliability

Munitions Analytical Compliance Systems (MACS)

Plasma Arc

MACS-2
(Modification)
Ranges

RATS
Range
Assembly

MACS-3
(Funded)
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APE 1236
Incinerator

MACS Centralized Databases

Munitions Characterization

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Constituent Chemicals

Chemicals Released

Green Criteria

sensitive Criteria

dous Waste Forms

Regulations

Risk Module

I-MACS
(Concept)
Insensitive Munitions

TRACS
(Funded)
Hazardous Waste

MLCMT
(Concept)

Munition
Life Cycle

Green
Munitions

G-
(F
Green

Green
Energetics

ARAS
(Concept)
Ammo Reliability

Hazardous Munition Components, Parts and Constituents

Heavy Metals

Lead

Hazardous Chemicals

Energetics

M A N U F A C T U R E

HANDLING

STORAGE

D E M I L I T A R I Z A T I O N

Heavy Metals

Lead

Hazardous Chemicals

Energetics
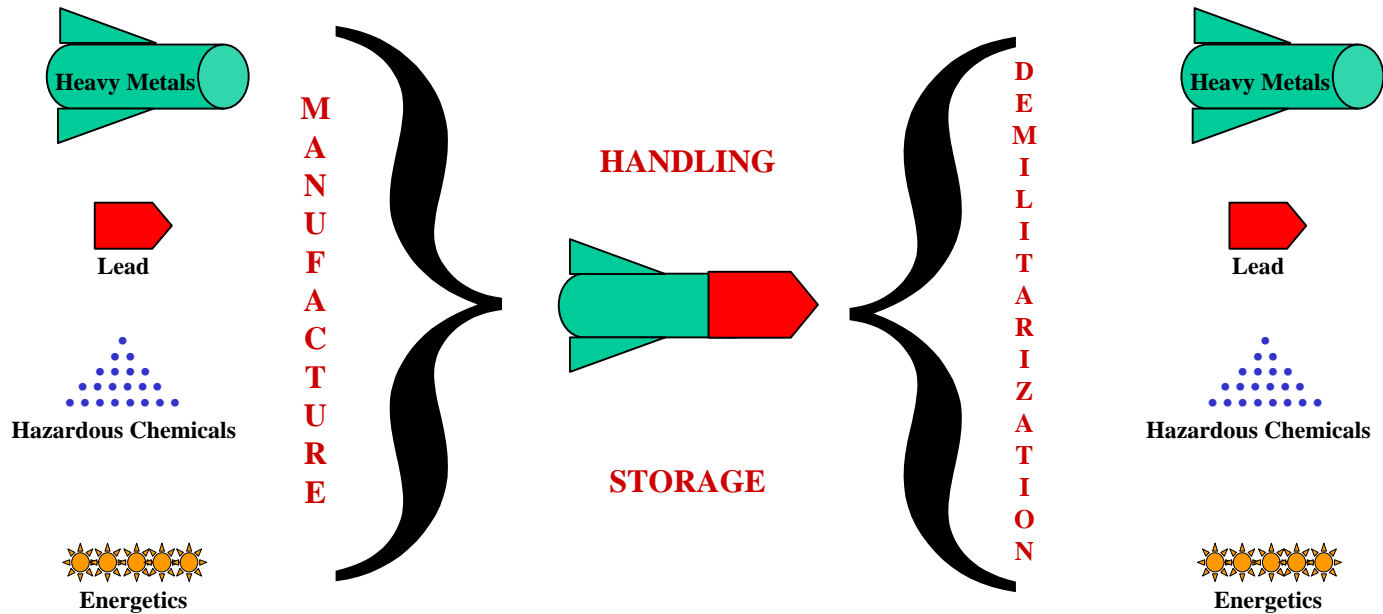
Munitions Life Cycle Unplanned Stimuli
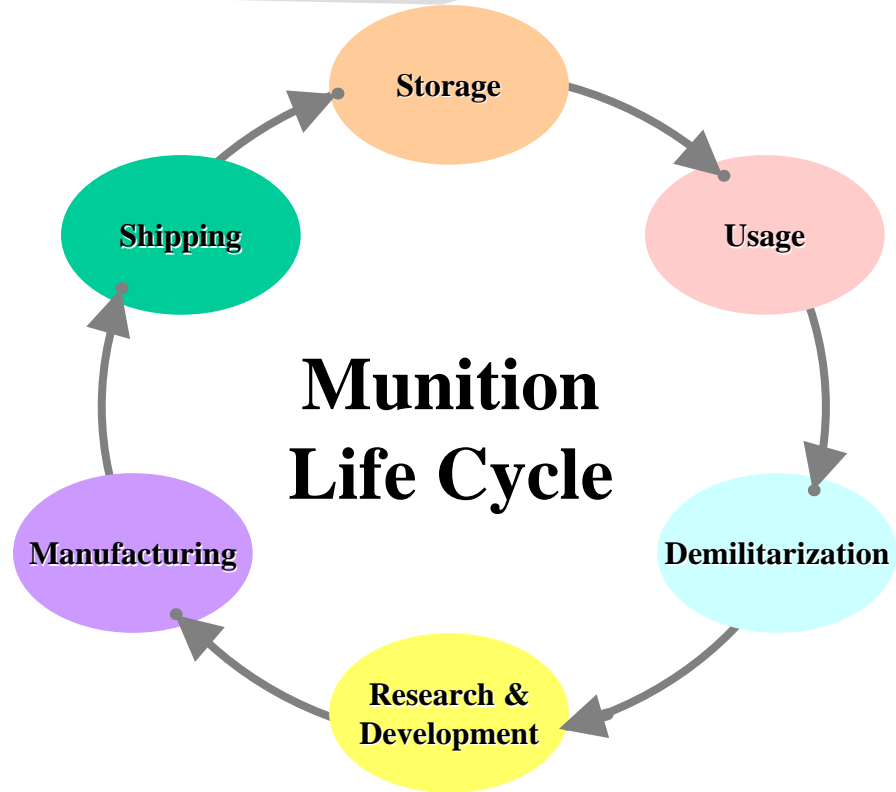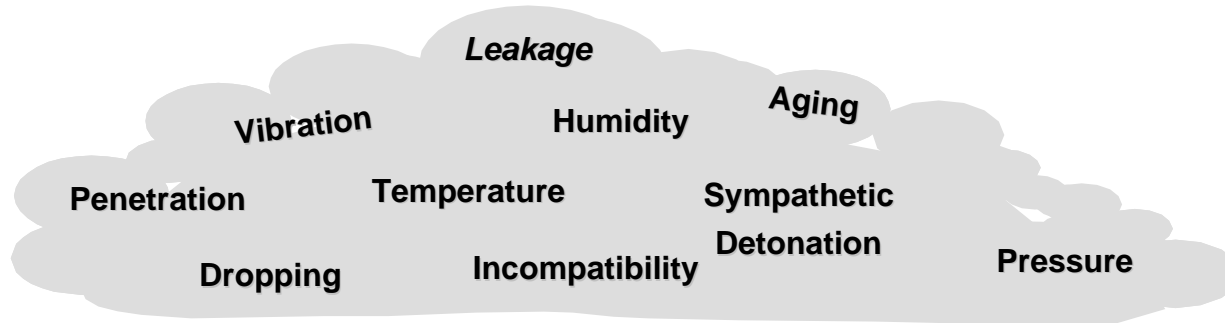
Leakage

Vibration   Humidity   Aging

Penetration   Temperature   Sympathetic Detonation

Dropping   Incompatibility   Pressure

RIP
- Lost Lives
- Personal Injuries
- Damaged Facilities

Storage

Shipping

Usage

Munition Life Cycle

Manufacturing

Demilitarization

Research & Development

Current "Hurdles" for Developing Insensitive Munitions

1. ATTITUDE: *"The IM Problem is Too Complicated to Solve"*

- The science is poorly understood
- How do you define "insensitive?"
- Can insensitivity be quantified?

SOLUTION

Force "Outside the Box" Thinking
(Make waivers increasingly difficult to justify.)

Current "Hurdles" for Developing Insensitive Munitions

1. ATTITUDE: *"The IM Problem is Too Complicated to Solve"*

2. IM Is Only One of the Problems

- Performance
- Manufacturing
- Environmental / "Green"
- Cost

SOLUTION

Start — Integrate — Enhance

Current "Hurdles" for Developing Insensitive Munitions

1. ATTITUDE: *"The IM Problem is Too Complicated to Solve"*
2. IM Is Only One of the Problems

3. Test Protocols Are Not Standardized Between the Services

- Testing Rationale
- Testing Requirements
- Testing Details
- Minimizes Data Pool, Greatly Slows Learning, Precludes Munition Comparisons

SOLUTION

Establish a Standardized Data Repository
(Only accepts specified parameters derived under certified conditions.)

Current "Hurdles" for Developing Insensitive Munitions

1. ATTITUDE: *"The IM Problem is Too Complicated to Solve"*
2. IM Is Only One of the Problems
3. Test Protocols Are Not Standardized Between the Services

4. IM Test Results Are Not Centralized—Nor Shared
(therefore, CANNOT maximize rate of learning)

- Confined Within an IPT
- Restricted Between IPTs
- ARDEC vs. Indian Head vs. China Lake
- U.S. vs. NATO

SOLUTION

Develop a Centralized Database—Require Submissions
(JROC only accepts output reports from this database.)

Current "Hurdles" for Developing Insensitive Munitions

1. ATTITUDE: *"The IM Problem is Too Complicated to Solve"*
2. IM Is Only One of the Problems
3. Test Protocols Are Not Standardized Between the Services
4. IM Test Results Are Not Centralized—Nor Shared

5. IM Test Data Must Be Secure

- Hide Munition Vulnerabilities
- Protect Contractor Proprietary Rights
- Access Through Multi-Level Security Protection

SOLUTION

Obtain DoD Accreditation and NSA Certification for I-MACS Security Capabilities

Current "Hurdles" for Developing Insensitive Munitions

1. ATTITUDE: *"The IM Problem is Too Complicated to Solve"*
2. IM Is Only One of the Problems
3. Test Protocols Are Not Standardized Between the Services
4. IM Test Results Are Not Centralized—Nor Shared
5. IM Test Data Must Be Secure

6. Incident "Root Cause" Analyses Are Not Incorporated Into a Database

- IM Development Process = (1) Energetic Material, (2) Munition Design, (3) Packaging
- Incidence Evaluations = (1) Political, (2) Public Relations, (3) Scientific (?)
- Every Incident Derives from Chemical Changes (Physical/Chemical/Thermodynamic)
- Greatest Learning Opportunity

RESOLUTION

Develop a Chemical-Based "Root Cause" for Each Incident
(Push the Envelope — Maximize Lessons Learned)

Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Insensitive Munitions System Requirements

Standardize IM Criteria

Facilitate IM Development

I-MACS

Enhance IM Evaluations
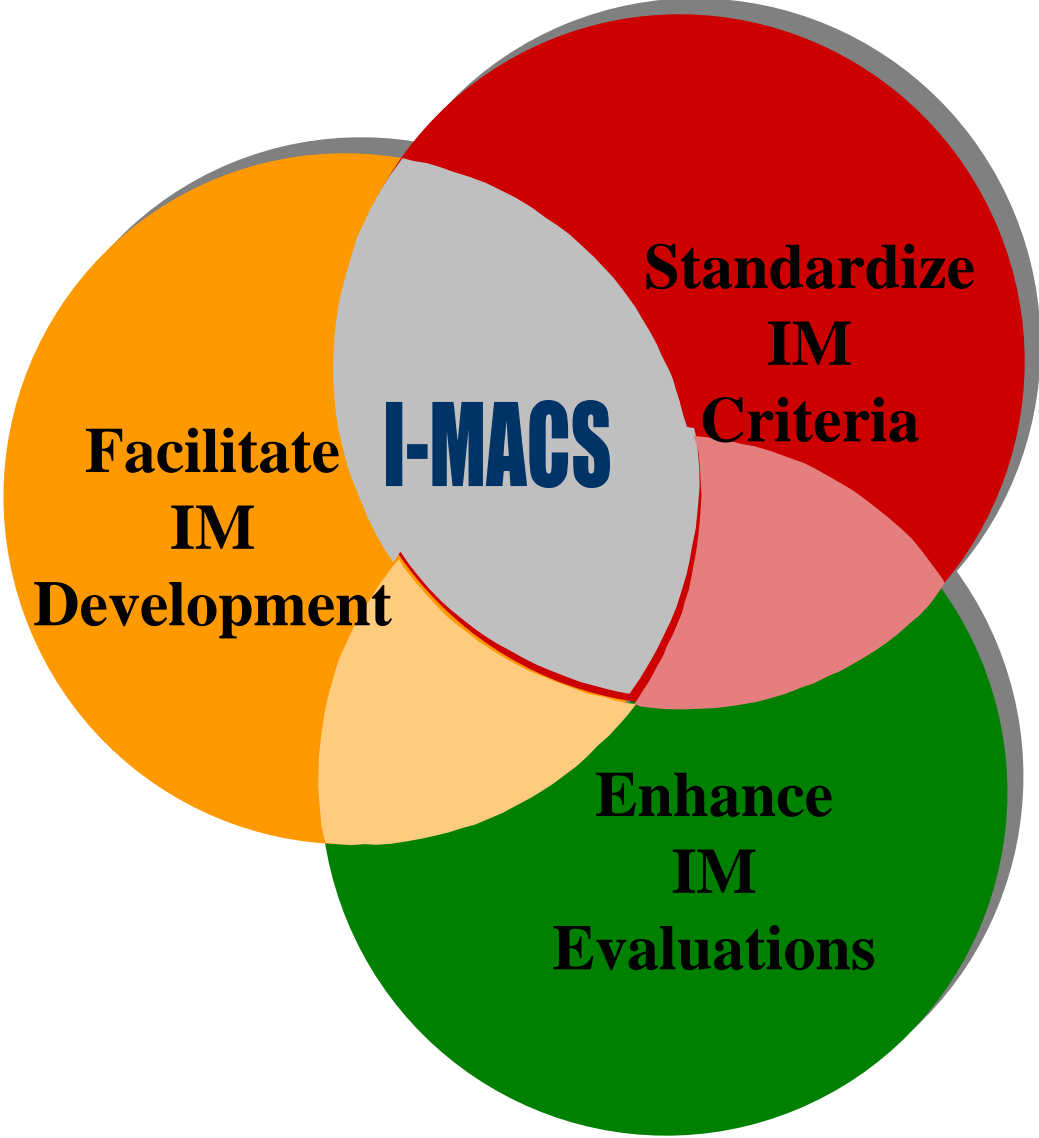
Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Incompatible Chemical Database

Chemical Class	Chemical	Incompatible Chemical	I.C. Class	Interaction Hazard
Corrosives	Acetic Acid	Hydrogen Peroxide	Oxidizer	Explosion
	Nitric Acid	Acetylene	Flammable	Explosion
	Chlorine	Aluminum Powder	Metal	Spontaneous Fire
Flammables	Acetone	Chloroform	Carcinogen	Explosion
	Benzene	Chlorine	Corrosive	Explosion
	Carbon Disulfide	Potassium	Flammable	Violent Explosion
Reactives	Nitrotoluene	Sulfuric Acid	Corrosive	Explosion
	Nitroethane	Hydrocarbons	Combustible	Explosion
	Acrylonitrile	Bromine	Corrosive	Explosion
Products	Toilet Bowl Cleaner	Metal Powders	Metals	Explosion
	Bleach	Ammonia	Product	Poisonous Gas
	Paint Solvent	Chloroform	Carcinogen	Explosion

Constituent Analogous Criteria Database

Analogous Database	Chemical	+	Incompatible Chemical	→	Interaction Hazard

Munitions Database	Munition (Components, Parts, Chemicals)	+	Unplanned Stimuli	→	Sensitivity Hazard
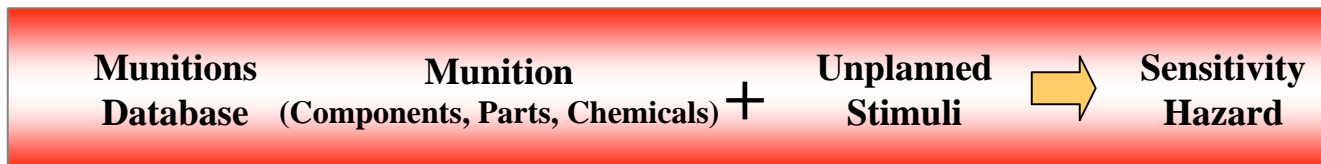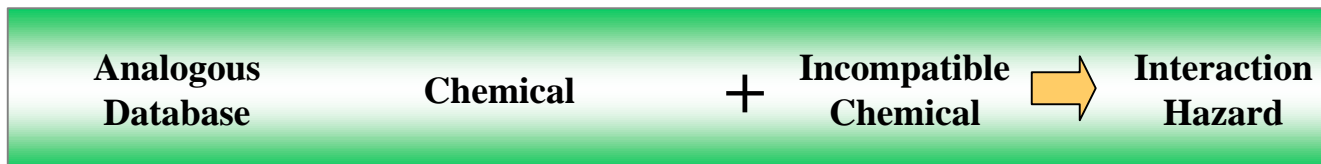
Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Main Menu Screen

MACS-1
Analytical
Input Results

IM
Test Plan
Status

IM
Test Plan
and
Results

Hazard
Classification
Test Results

System
Specific
Vulnerability
Test Results

I-MACS
Analytical
Results Output
(to G-MACS)
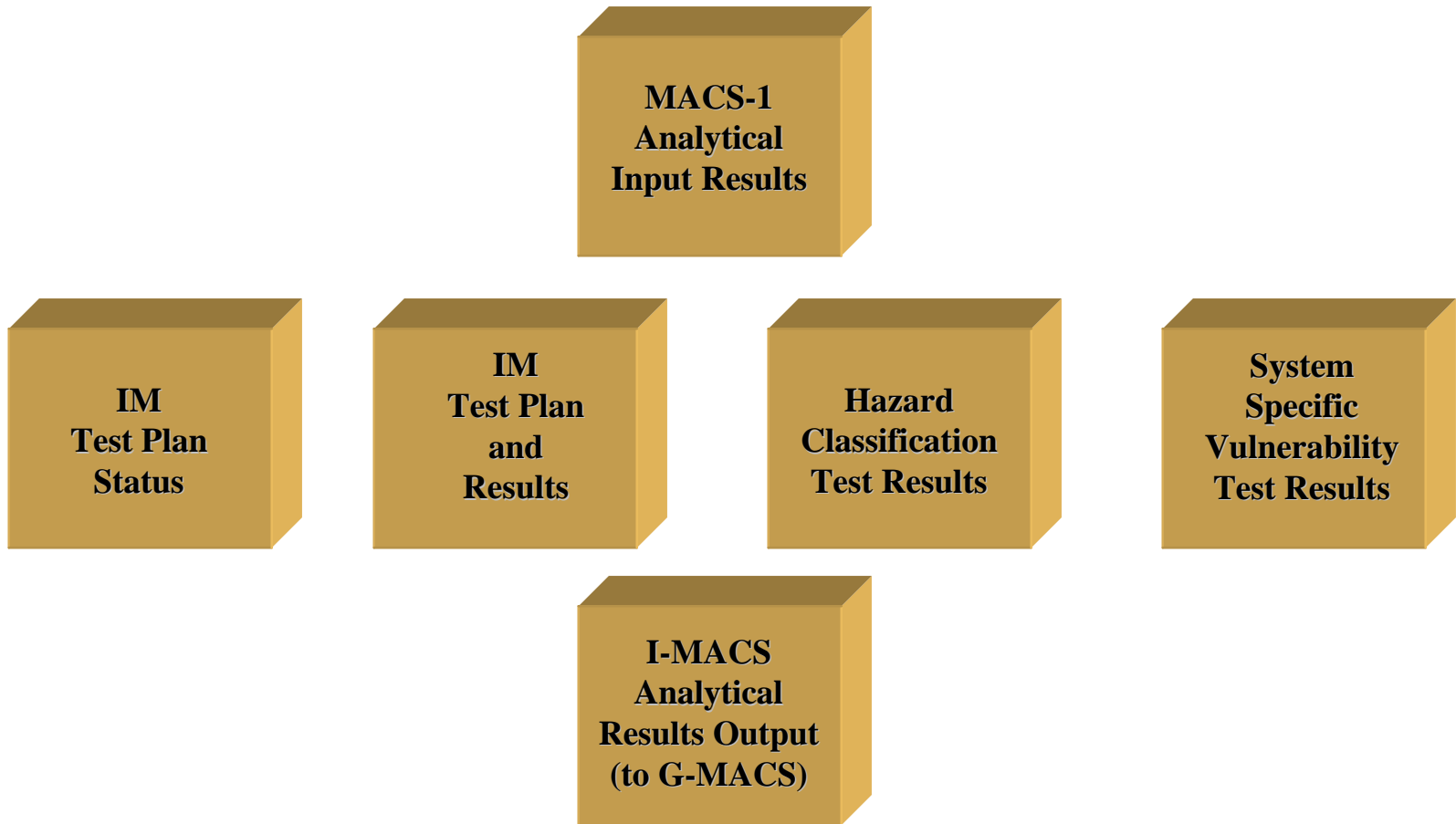
Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Test Plan Status

PROGRAM MANAGER

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

SERVICE REVIEW ORGANIZATION

Review and Approval	Review and Approval	Review and Approval	Review and Approval	Review and Approval	Review and Approval	IM FINAL RECOMMEND.
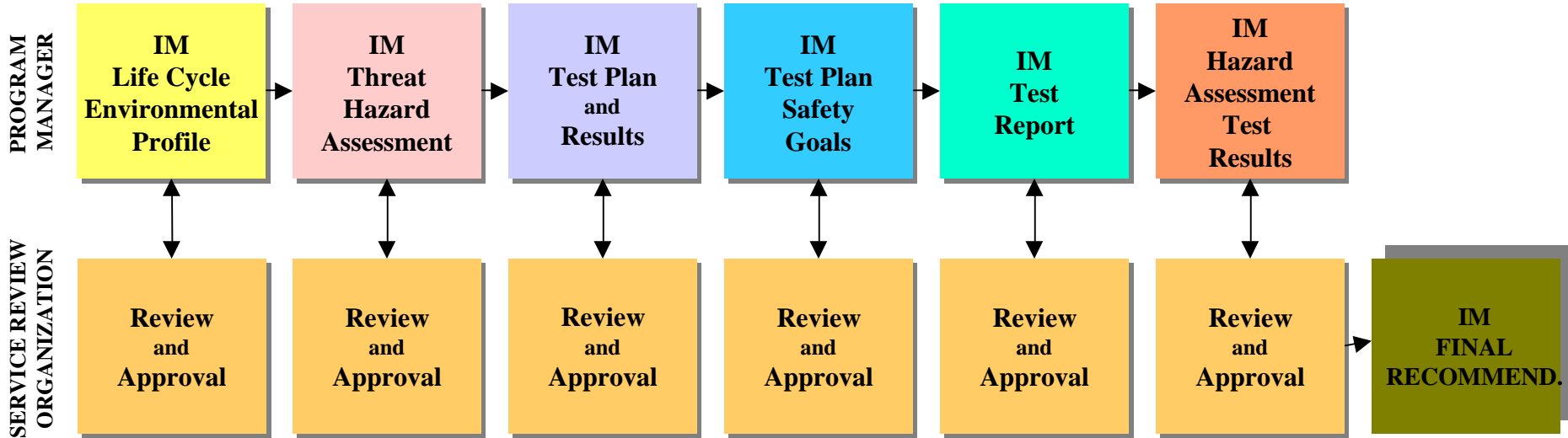
Test Plan and Results

28-Day Temperature and Humidity Test	Vibration Test	4-Day Temperature and Humidity Test	12-Meter Drop Test
Fast Cook-Off Test	Slow Cook-Off Test	Bullet Impact Test	Fragment Impact Test
Sympathetic Detonation Test	Shaped Charge Jet Impact Test	Spall Impact Test	_____ _____ Specialty Test
_____ _____ Specialty Test	_____ _____ Specialty Test	_____ _____ Specialty Test	_____ _____ Specialty Test

5.1.1 I-MACS 28-Day Temperature and Humidity (T&H) Test Results

ITEM NO.

Expose at least three test items to alternating periods of high and low temperatures derived from the Life Cycle Environmental Profile for at least 20 temperature changes (hot/cold) or 10 full cycles (hot/cold/hot).

Day	Time		Temperature			Humidity			Visual		Radiographic		Transfer Interval >30 Min. (a)	Dimensions (a)		
	Start	End	Max	Min	Planned	Max	Min	Planned	Normal	Abnormal	Normal`	Abnormal		Length	Width	Height
0																
1																
2																
3																
4																
5																
6																
7																
8																
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25																
26																
27																
28																

PHOTOGRAPHY: [1] Still   Pretest_____ Post-Test _____

(a) COMMENTS:

TEST RESULT SUMMARY

1. No Explosive Reaction   _____

2. No Explosive Exudate   _____

3. No Hazardous Cracking or Separation   _____

4. All Safety Devices Remain Safe   _____

5. No Structural Loosening, Distortion or Corrosion_____

5.2.1   I-MACS Fast Cook-Off Test Results

ITEM NO.	Engulf at least two test items in the flame envelope (complete engulfment).
Visual Inspection	Normal _____ Abnormal (describe) _____
Radiographic Inspection	Normal _____ Abnormal (describe) _____
Position	Major Axis Horizontal _____ Most Probable Attitude (describe) _____
Distance from Fuel Basin	(Item Centerline to Fuel Surface) _____mm
Restraining Method	
Suspension Method	
Fuel Type	
Flame Temperature Rise Time (time to reach 540°C=1000°F)	

AVERAGE FLAME TEMPERATURE: _____°C (≥870°C = 1600°F)

PHOTOGRAPHY: [1] Still   Pretest_____ Post-Test _____
                        [2] Videotape w/sound   _____

TEST RESULT SUMMARY
1. Type 1 (Detonation Reaction)
2. Type 2 (Partial Detonation Reaction)
3. Type 3 (Explosion Reaction)
4. Type 4 (Deflagration Reaction)
5. Type 5 (Burning Reaction)

Thermal Couple Readings @:	2 * I TCI	TC2	TC3	TC4	Bore Pressure
2s					
4s					
6s					
8s					
10s					
12s					
14s					
16s					
18s					
20s					
22s					
24s					
26s					
28s					
30s					

5.2.3   I-MACS Bullet Impact Test Results

At least two test items are impacted by 1-3 caliber .50 type M2 armor-piercing (AP) projectiles at a velocity of 850 ± 60 m/s (2,800 ± 200 ft/s) and a firing interval of 80 ± 40 milliseconds (ms) with impacting bullets penetration in the first test item, the most sensitive material(s) that is not separated from the main explosive charge by barriers or other safety devices and the second test item impacted at the most shock-sensitive location (typically the ignition/initiation system).

ITEM NO. 1

Visual Inspection	Normal _____ Abnormal (*describe*) _____
Radiographic Inspection	Normal _____ Abnormal (*describe*) _____
Airblast Overpressure (*optional*)	[1] Gauge Calibrated (Y/N) _____ [2] Gauge Frequency Response: _____ kHz [3] Pressure: 1 ms _____ 6 ms _____ 2 ms _____ 7 ms _____ 3 ms _____ 8 ms _____ 4 ms _____ 9 ms _____ 5 ms _____ 10 ms _____

Bullet Velocity: _____ m/s   Method: _____

PHOTOGRAPHY: Test Item Reaction Method: _____
               [1] Film/Video Type: _____
               [2] Exposure Rate: _____
               [3] Frame Rate: _____
               Still [1] Pretest: _____ Post-Test _____

WITNESS PLATE IMPACT: Photographs _____   Description _____

TEST RESULT SUMMARY–TEST NO. 1

1. Type 1 (Detonation Reaction)

2. Type 2 (Partial Detonation Reaction)

3. Type 3 (Explosion Reaction)

4. Type 4 (Deflagration Reaction)

5. Type 5 (Burning Reaction)

ITEM NO. 2

Visual Inspection	Normal _____ Abnormal (*describe*) _____
Radiographic Inspection	Normal _____ Abnormal (*describe*) _____
Airblast Overpressure (*optional*)	[1] Gauge Calibrated (Y/N) _____ [2] Gauge Frequency Response: _____ kHz [3] Pressure: 1 ms _____ 6 ms _____ 2 ms _____ 7 ms _____ 3 ms _____ 8 ms _____ 4 ms _____ 9 ms _____ 5 ms _____ 10 ms _____

Bullet Velocity: _____ m/s   Method: _____

PHOTOGRAPHY: Test Item Reaction Method: _____
               [1] Film/Video Type: _____
               [2] Exposure Rate: _____
               [3] Frame Rate: _____
               Still [1] Pretest: _____ Post-Test _____

WITNESS PLATE IMPACT: Photographs _____   Description _____

TEST RESULT SUMMARY–TEST NO. 2

1. Type 1 (Detonation Reaction)

2. Type 2 (Partial Detonation Reaction)

3. Type 3 (Explosion Reaction)

4. Type 4 (Deflagration Reaction)

5. Type 5 (Burning Reaction)

I-MACS Potential Reports

- **Executive Summary**

- **Munition Threat Hazard Assessment (THA) Data**

- **Munition Composition & Packaging Data**

- **Munition Accident History Data**

- **Munition Test Results Data**

- **Munition Risk Assessment Data (Summary)**

- **Review/Approval Data Summary(s)**
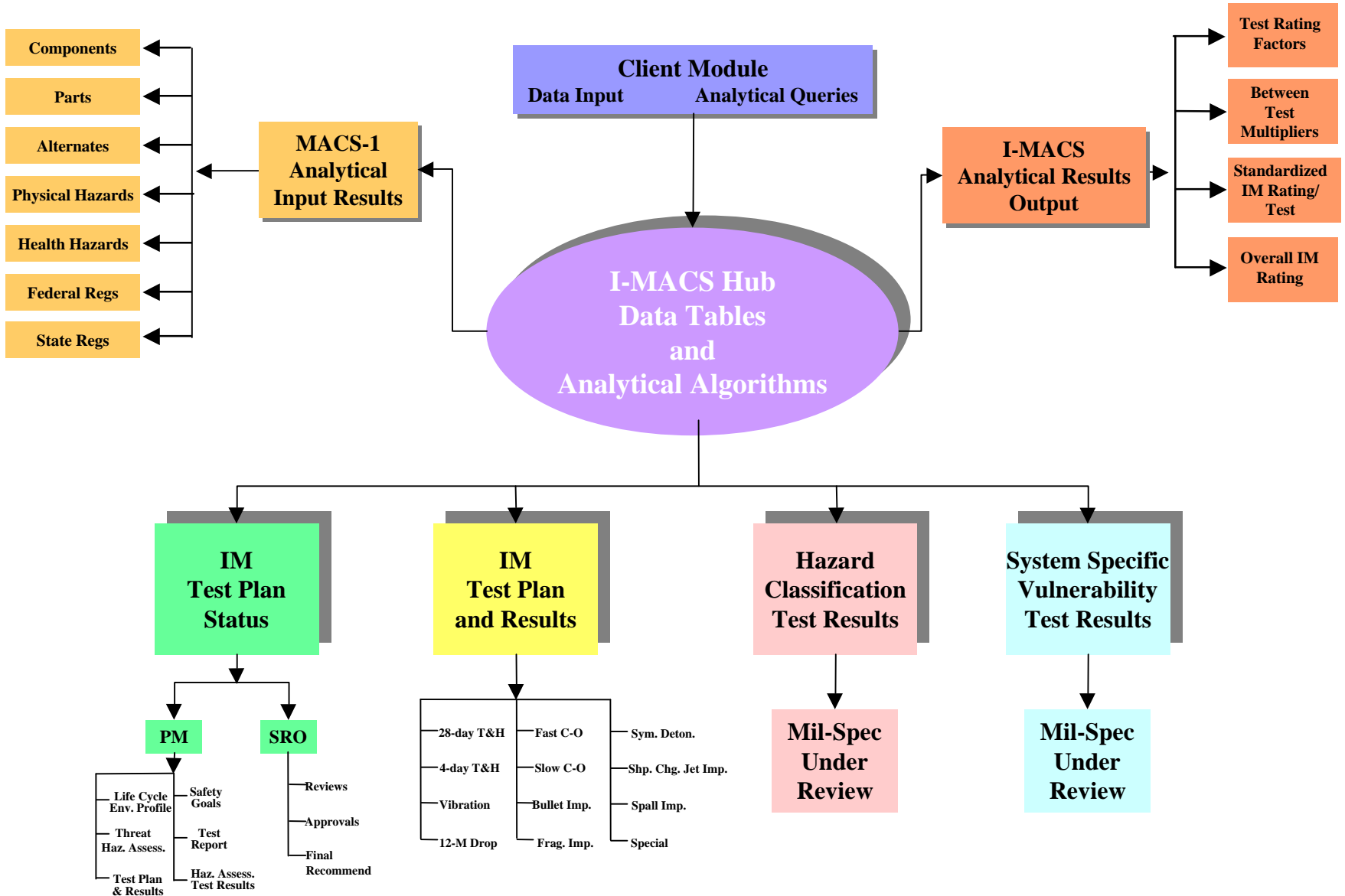
- **Cost/Benefit Analysis Data**

Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Analytical Results Output to G-MACS

I-MACS Test	Test Result Summary	Between Test Multiplier (1-10)	Standardized IM Rating
1. 28 Day Temperature and Humidity (T&H) Within Test			
2. Vibration Test Results Within Test			
3. 4-Day Temperature and Humidity (T&H) Within Test			
4. 12 Meter (40') Drop Within Test			
5. Fast Cook-Off Within Test			
6. Slow Cook-Off Within Test			
7. Bullet Impact Within Test			
8. Fragment Impact Within Test			
9. Sympathetic Detonation Within Test			
10. Shaped Charge Jet Impact Within Test			
11. Spall Impact Within Test			
12. _____ Specialty Within Test			
13. _____ Specialty Within Test			
14. _____ Specialty Within Test			
15. _____ Specialty Within Test			
16. _____ Specialty Within Test			

OVERALL IM RATING FACTOR (Average or Total) =

Data Acquisition and Analytical Report Capabilities

Components

Parts

Alternates

Physical Hazards

Health Hazards

Federal Regs

State Regs

MACS-1 Analytical Input Results

Client Module
Data Input   Analytical Queries

I-MACS Hub Data Tables and Analytical Algorithms

I-MACS Analytical Results Output

Test Rating Factors

Between Test Multipliers

Standardized IM Rating/ Test

Overall IM Rating

IM Test Plan Status

PM
- Life Cycle Env. Profile
- Threat Haz. Assess.
- Test Plan & Results
- Safety Goals
- Test Report
- Haz. Assess. Test Results

SRO
- Reviews
- Approvals
- Final Recommend

IM Test Plan and Results

28-day T&H	Fast C-O	Sym. Deton.
4-day T&H	Slow C-O	Shp. Chg. Jet Imp.
Vibration	Bullet Imp.	Spall Imp.
12-M Drop	Frag. Imp.	Special

Hazard Classification Test Results

Mil-Spec Under Review

System Specific Vulnerability Test Results

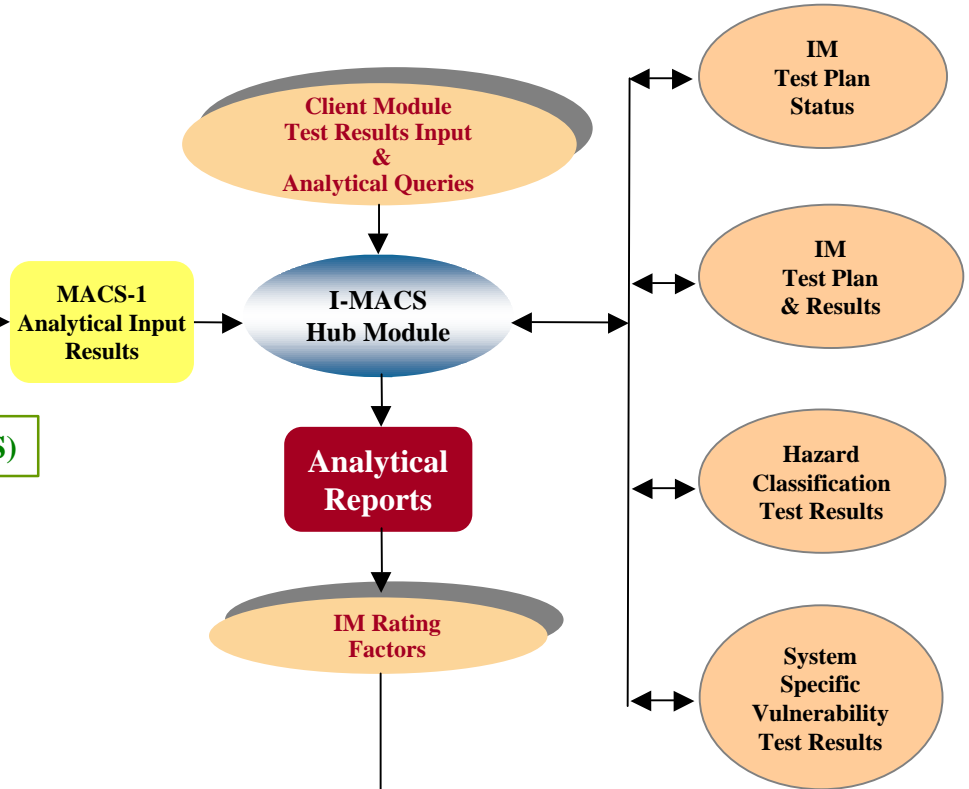**Mil-Spec Under Review**

Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Integration With Other Munitions Analytical Systems

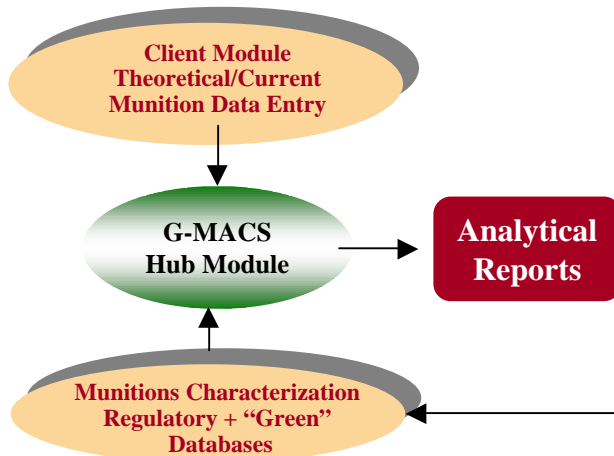## Munitions Analytical Compliance System (MACS-1)

Client Module
Demil Input
&
Analytical Queries

MACS-1
Hub Module

Analytical Reports

Munitions Characterization
&
Regulatory Databases

Insensitive Munitions Analytical Compliance System (I-MACS)

Client Module
Test Results Input
&
Analytical Queries

MACS-1
Analytical Input
Results

I-MACS
Hub Module

IM
Test Plan
Status

IM
Test Plan
& Results

Analytical Reports

Hazard
Classification
Test Results

IM Rating
Factors
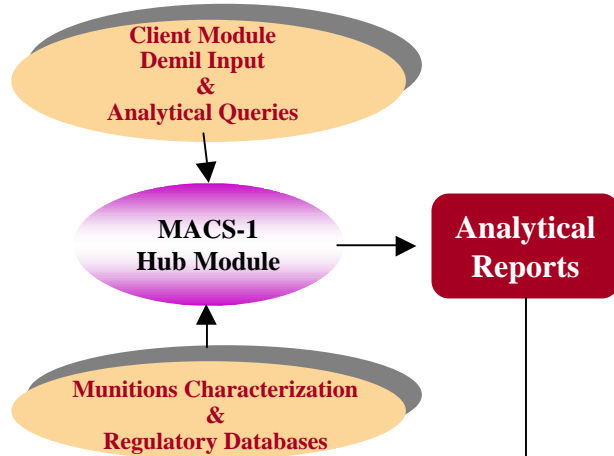
System
Specific
Vulnerability
Test Results

"Green" Munitions Analytical Compliance System (G-MACS)

Client Module
Theoretical/Current
Munition Data Entry

G-MACS
Hub Module

Analytical Reports

Munitions Characterization
Regulatory + "Green"
Databases

Integration With the Munitions Life Cycle Management Tool (MLCMT)

G-MACS

Munitions Manufacturing Data Input & Analytical Client Module

I-MACS

Munitions Handling/Storage/Usage Data Input & Analytical Client Module

MACS-2

I-MACS

MACS-1

Munitions Research & Development Data Input & Analytical Client Module

MLCMT Hub

Munitions Demil Data Input & Analytical Client Module

G-MACS

PM Analytical Client Module

M I D A S	**Munitions Data**
	Component Data
	Parts Data
	Chemical Data
	Regulatory Data

Client-Specific Data

Other (?) Munitions Data Input & Analytical Client Modules

Insensitive Munitions Analytical Compliance System (I-MACS) Concept

Applications

Hierarchical Management Tool
(IPT ⟶ JROC)

Centralized/Standardized Data Repository

Sophisticated Analytical Capabilities

Equivalent Munition Comparisons

Integrates with MACS-1 G-MACS MLCMT

Benefits

Requires
"Out of the Box"
Thinking

Defines / Quantitates
the IM Problem

Standardizes Protocols
Facilitates IM Comparisons

Centralizes Secured Data
Maximizes Learning

Initiates "Root Cause" Analyses
Pushes the Envelope

AVAILABLE
WITHIN
SIX MONTHS

I-MACS Conclusions

• **I-MACS will centralize/standardize IM criteria**

Munition Specific

• **I-MACS will facilitate IM development—improve "IMness"**

• **I-MACS will accelerate scientific understanding of IMs**

• **I-MACS will enhance and integrate IM analytical capabilities**

• **I-MACS will improve with use**

• **I-MACS should not be rejected simply because it is not mature**