AUTOMATED AMMUNITION IDENTIFICATION

What was that anyway?

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Automated Ammo ID

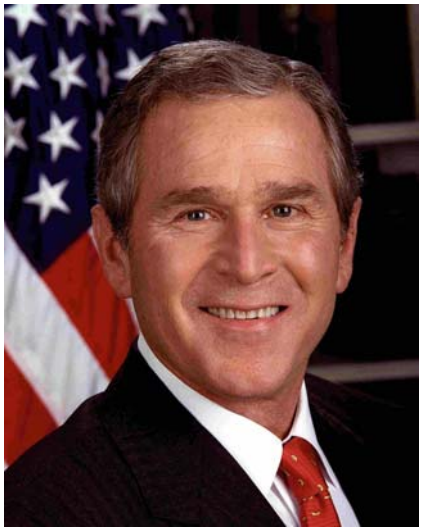
United Defense

- Problem Definition
- Requirements
- Technology
- 2D Data Matrix Coding
- Marking Ammunition
- Lessons Learned
- Questions
  - Photo Test

1

2

3



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What is the problem?

United Defense

- New ammunition utilizes high energy propelling charges to achieve extended range.
- The latest upgrades to the 5-Inch Naval gun (MK45 Mod 4) allow it to handle increased energy.
  - Chamber Pressures
  - Recoil Stroke
  - Muzzle Energy increased from 10MJ to 18MJ
- Existing MK45 Mod 1 & 2 guns can not handle this increased energy.
- Existing projectiles are not qualified for these launch forces.

Problem Statement

United Defense

- If an extended range propelling charge is accidentally loaded into / fired from a Mod 1 or 2 gun the resulting overpressure could be catastrophic.
- If an existing projectile is loaded with an extended range propelling charge and fired from a Mod 4 gun, the 'set back' forces will exceed the limits of the projectile.
  - 'In-bore' explosion
  - Unknown flight characteristics

Stated Requirements

United Defense

Provide an automated Ammunition Identification (Ammo ID) capability to:

- Preclude the inadvertent loading of high energy propelling charges behind incompatible projectiles in Mod 4 guns
- Preclude the loading of high energy propelling charges in existing Mod 1 and Mod 2 guns

Derived Requirements

United Defense

- **The Ammo ID capability must be compatible with existing ammunition already in the fleet**
  - **Must be able to distinguish between existing ammunition and new extended range rounds**
- **The Ammo ID capability must have adequate growth potential to support expanded weapon system functionality**
  - **Improved Gun Fire Control ballistic predictions**

5” Gun Ammunition

United Defense

Typical Propelling Charge ~ 40lbs

Typical Projectile ~ 70lbs

Typical Projectile Stowage

Typical Prop Charge Stowage

Ammunition Loading

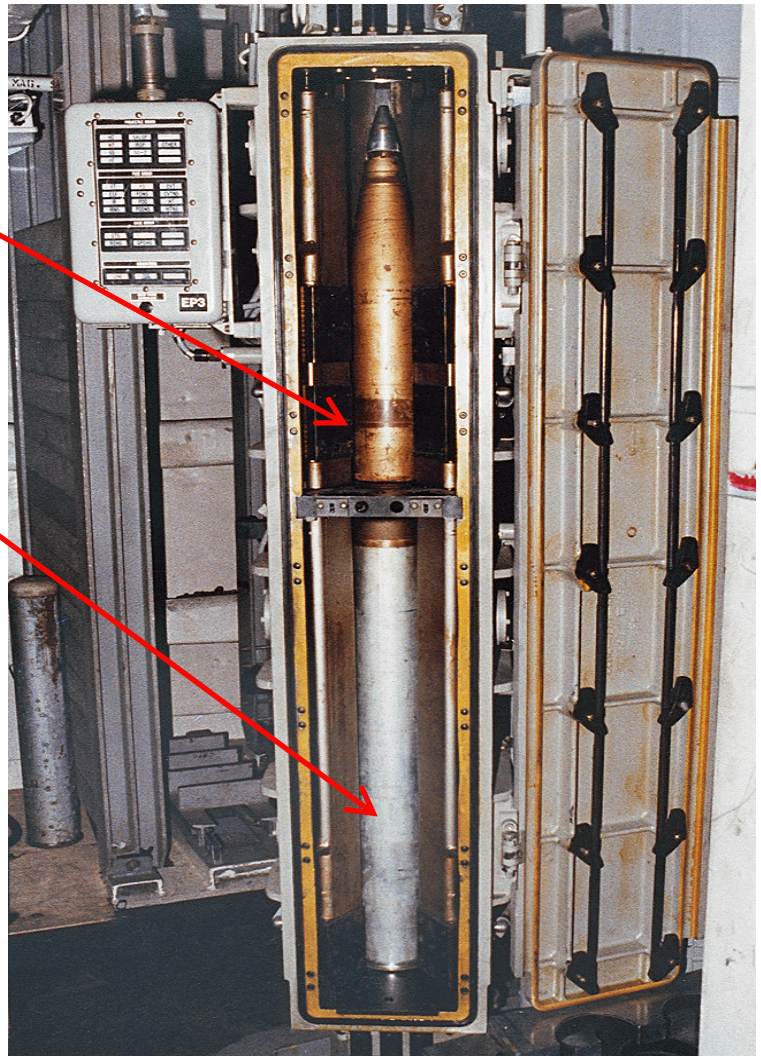
United Defense

Projectile Loading Station in Magazine

Propelling Charge Loading Station in Magazine

Maximum Rate of Fire for the Gun System is 20 Rounds per Minute

- Magazine crew can match maximum rate for ~ 10 minutes
- Sustained reload rate drops to about 8-10 rounds per minute



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Ammo ID Technologies

United Defense

- Human / Procedures
- Automatic Color Detection
- RF Tags
- Standard 1D Bar Codes
- 2D Data Matrix

Ammo ID Technologies

United Defense

- **Human / Procedural**
  - **Logistic Control**
    - **Do not issue high energy propelling charges to Mod 1 or 2 ships**
  - **Use color coded closure plugs**
    - **Red = ERGM**
    - **Green = Extended Range Cargo or Hi-Frag**
    - **White = Standard Propelling Charge**
  - **Expected human error of 1/1000**

Ammo ID Technologies

United Defense

- **Automatic Color Detection Sensors**
  - **Detects propelling charge plug color or applied color band on projectile or charge**
  - **May have issue with existing projectiles**
    - **Several colors already used**
    - **System needs to identify existing versus new rounds**
  - **Very limited – no growth potential**

Ammo ID Technologies

United Defense

- **RF Identification Tags**
  - **Operational problems in shipboard EMI environment**
  - **Difficult to incorporate into projectile design**
  - **No ability to distinguish between existing ammunition (no tag) and defective tags**

Ammo ID Technologies

United Defense

- **Standard 1D Bar Code**
  - **Unreliable / Poor read rate**
    - **Retail store experience**
  - **Numeric encoding requires data base cross reference**
    - **Adds to cost of ownership**

Ammo ID Technologies

United Defense

- **2D Data Matrix**
  - **Full ASCII encoding**
  - **Redundant Data / Error Correction**
  - **Provides Future Growth Potential**
  - **Selected by gun community**
    - **Mature technology / readily available**
    - **Straight forward integration into ammunition components**

2D Data Matrix Code

United Defense

- **ECC 200 Code Format**
  - **Incorporates Reed-Solomon Error Correction**
- **Consistent with ANSI AIM BC11 Data Matrix Symbology Specification**
- **22 X 22 Matrix Density Selected**
  - **0.55 inch square**
  - **43 encoded characters**

Encoded Data

United Defense

Characters		Data	Comment
1		Projectile / Charge Identifier	P/C/H
2-5	4	DoDIC Identification Code	Alpha/Num
6-8	3	Assembly Mark Number	Numeric
9-10	2	Assembly Mod Number	Numeric
11-19	9	National Item ID Number	Numeric
20-33	14	Ammunition Lot Number	ASCII
34-38	5	Weight (implied decimal .01)	Numeric
39-43	5	Spares	

Data Matrix Considerations

United Defense

- Symbol must be durable & high quality
- Must work regardless of ammunition component orientation in load station
  - Sailor does not have time to look for the data matrix
  - Band of identical code squares uniformly placed around each ammunition component
  - Multiple squares in Field-of-View of sensor
- Application rate must be compatible with projectile & propelling charge production lines
  - Four per minute

Data Matrix Marking Sample

United Defense

26 evenly spaced data matrix squares with English text printed below

PD3490420100480338 9CRA75D001-024B07000

DoDIC

Weight = 70.00 lbs

Assy Mark Number

14 Character Lot Number

Assy Mod Number

Projectile/Charge Indicator

9 Character National Item ID Number

Symbol Quality

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Initial Marking Quality

- Grade "A"
- Symbol Contrast ≥ 70%
- Print Growth ≤ ± 0.50
- Axial Nonuniformity ≤ 0.06
- Unused Error Corr. ≥ 62%

Sensor Capability

- Grade "C"
- Symbol Contrast ≥ 40%
- Print Growth ≤ ± 0.85
- Axial Nonuniformity ≤ 0.12
- Unused Error Corr. ≥ 0%

High quality initial markings provide for robust read capability taking into account degradation over time

Data Matrix Application Techniques

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- Stick-on Labels
- LASER Etching
- LASER Color Bond
- Ink Jet Printing
- Mechanical Stamping
- Silk Screen Ink

Application Techniques

United Defense

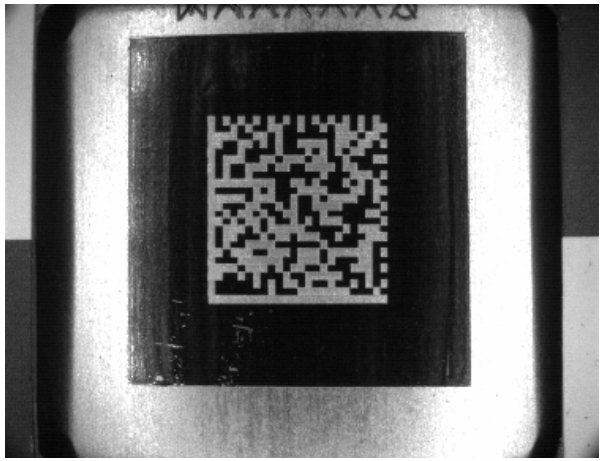
- **Stick-on Labels**
  - **Cheap, easy application**
  - **Tear off during handling**

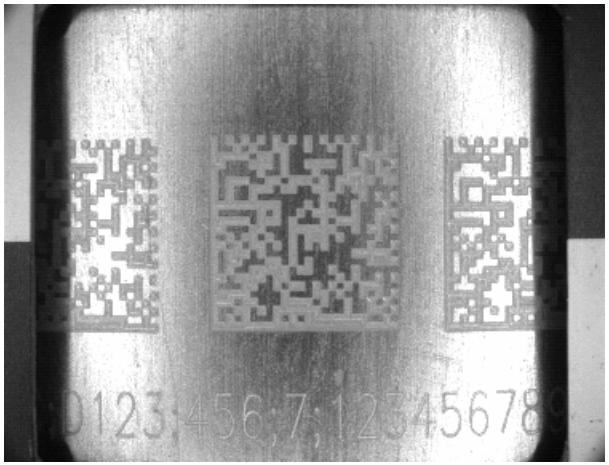
*** Labels were selected for use during development testing**

Application Techniques

United Defense

- **LASER Etching**
  - **Expensive Equipment**
  - **Very Slow Process**
    - **Estimated to take more than 5 seconds per data matrix square**





Application Techniques

United Defense

- **LASER Color Bond**
  - **Expensive Equipment**
  - **Very Slow Process**
    - **Estimated to take up to 60 seconds per data matrix square**

Application Techniques

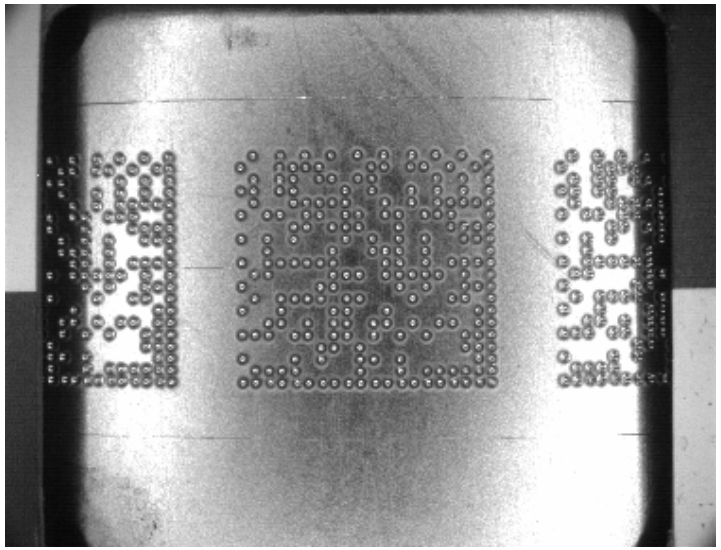
United Defense

- **Ink Jet Printing**
  - **Moderate Equipment Cost**
  - **Slow Process**
    - **Estimated to take 3 seconds per data matrix square**

Application Techniques

United Defense

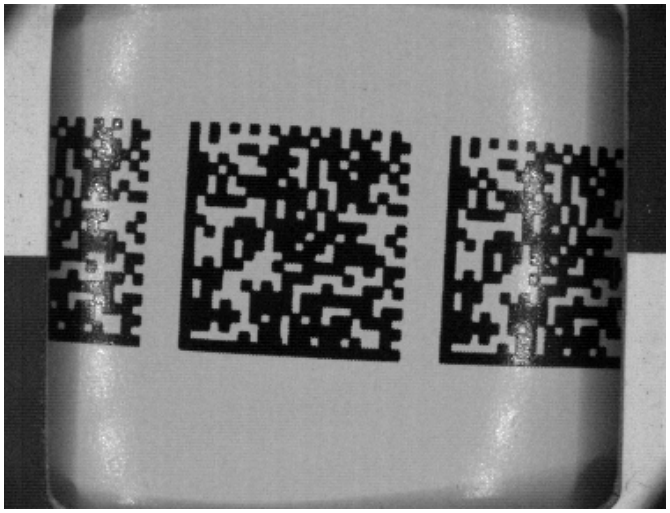
- **Mechanical Stamping**
  - **Low Contrast**
  - **Negative Impact on Environmental Resistance**
  - **Slow Process**
    - **Estimated to take about 25 seconds per data matrix square**



Application Techniques

United Defense

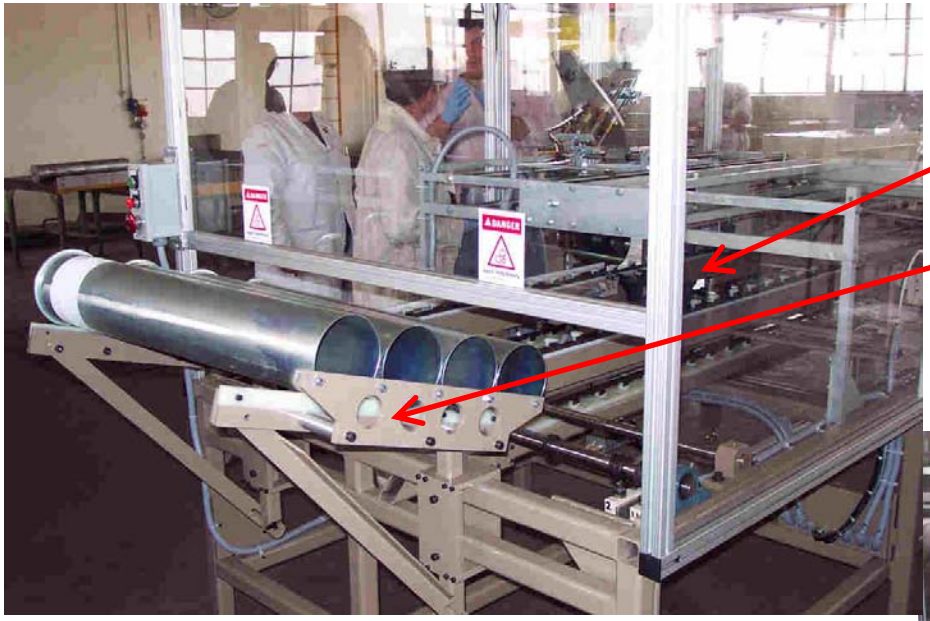
- **Silk Screened Ink**
  - **Moderate Equipment Cost**
  - **Very Fast Process**
    - **Estimated to take less than 0.1 second per data matrix square**



*** Silk screened ink was selected for production use**

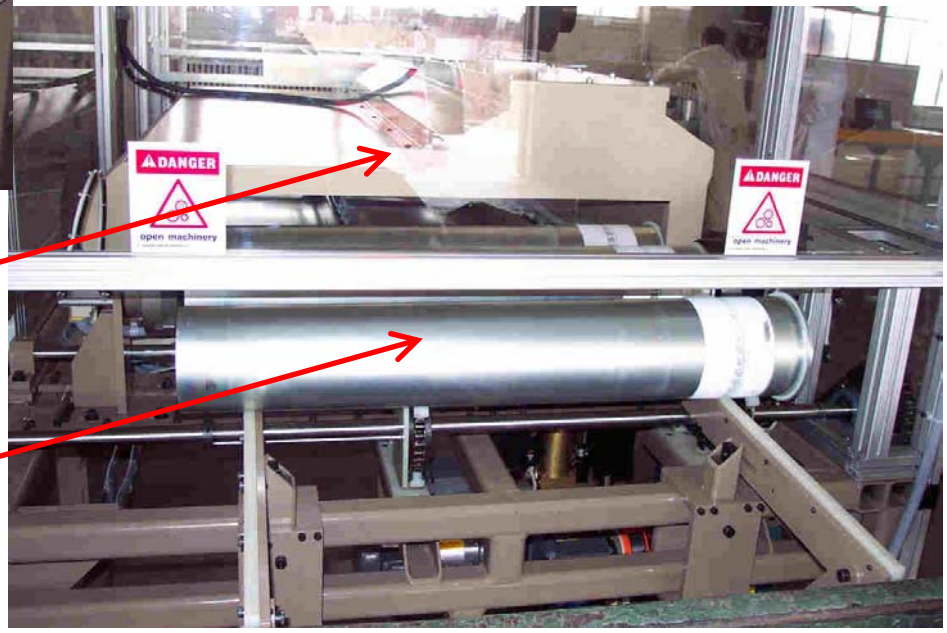
Prototype Marking Equipment

United Defense



Silk Screen Area

Propelling Charge Feed Area



Dryer Section

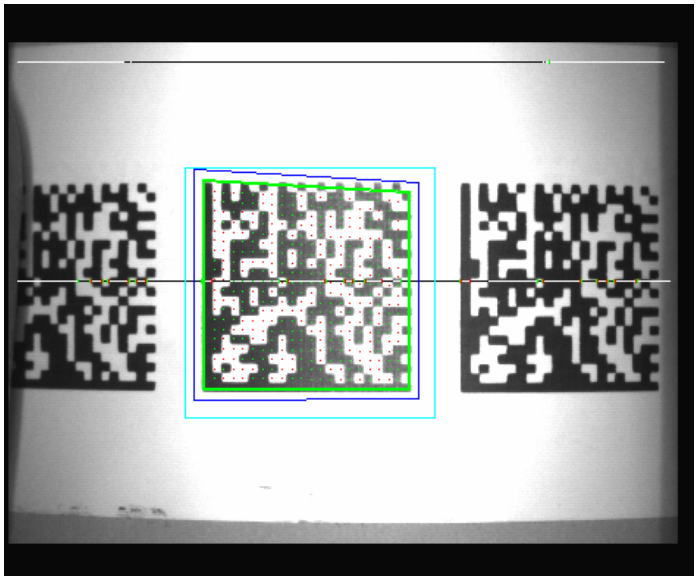
Propelling Charge Exit

Auto ID Sensors

United Defense

- **DVT Corporation Sensors**
  - **Five sensors used in gun mount, one sensor at each ammunition loading station**
    - **LED illumination**
    - **Robust 2D data matrix 'reader tool'**
    - **Less than 2 second inspection time**
    - **'Feature tools' able to discriminate damaged, unreadable tag from existing ammo with stenciled writing in field of view**
    - **Serial interface with gun mount control system**

DVT Model 630
"Custom COTS Sensor"



Auto ID Lessons Learned

United Defense

- Must be mature technology
  - Readily available / moderate cost
- Application method must be able to meet ammunition production rates
- System design must support anticipated future growth
- Auto ID system must be robust
  - High and reliable read rate
  - Able to distinguish ‘bad tag’ from ‘no tag’
  - Able to support maximum gun mount loading rate without delay

Automated Ammo ID

United Defense

QUESTIONS ??

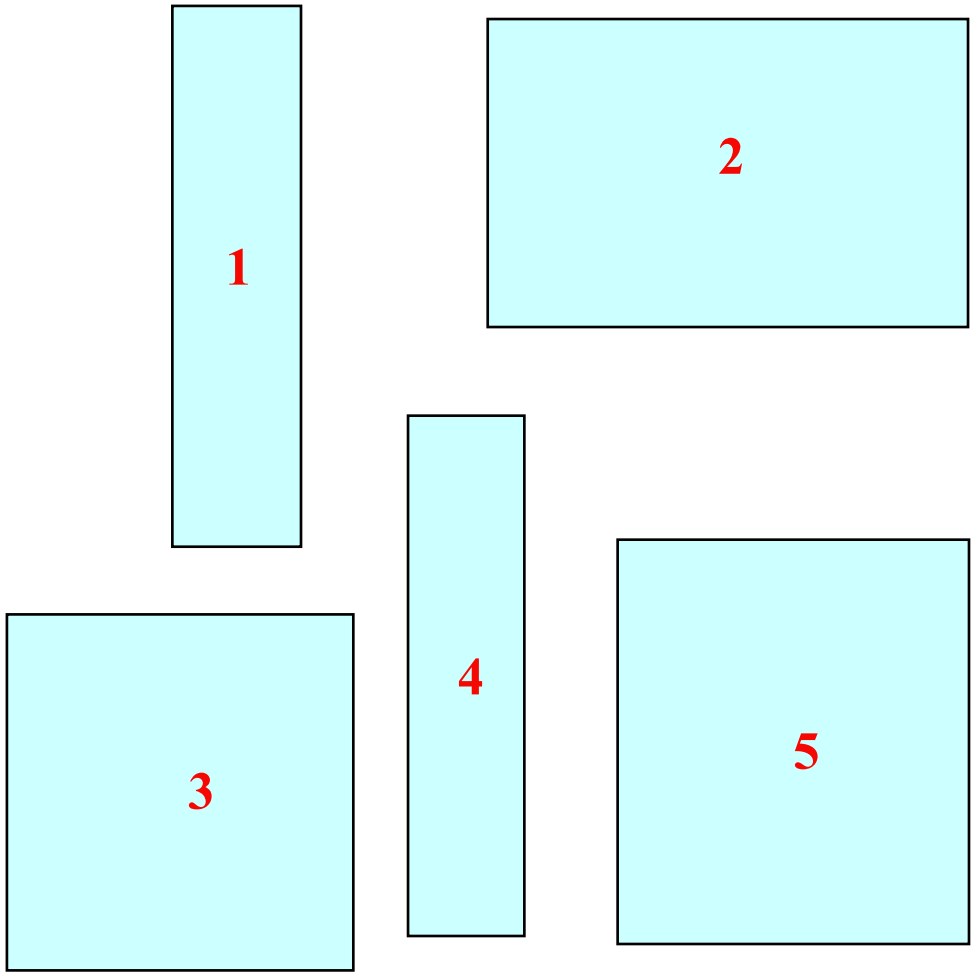
President George W. Bush

Standard Propelling Charge

Pamela Anderson

1965 Mustang

High Energy Propelling Charge



Now its time for the Coors Lite!