L3 communications

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Multiple Launch Rocket System (MLRS) Fuzing Evolving to Meet End User Requirements

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Multiple Launch Rocket System (MLRS) Evolution

- Program History
- System Overview
- Rocket / Fuzing Development
- Conclusions

Evolutions in MLRS Rockets

1979

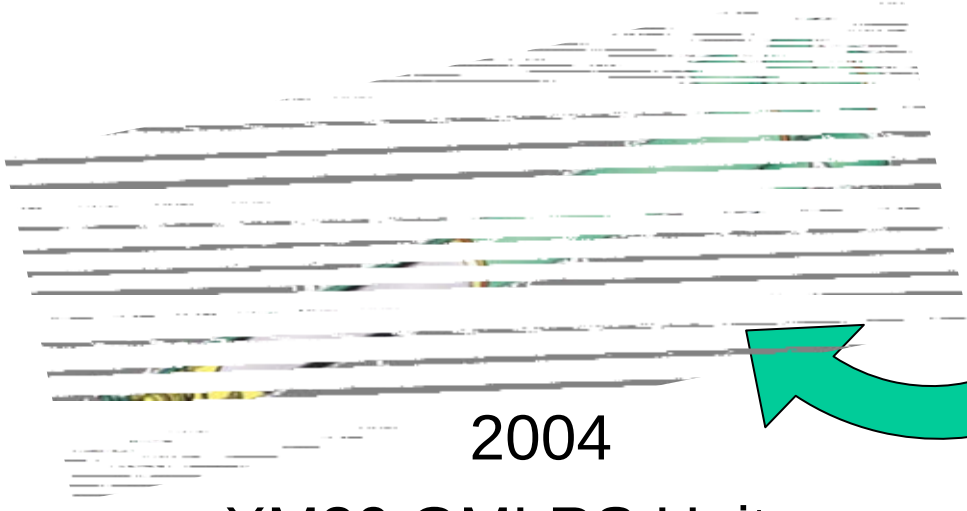
M26 MLRS

1992

M26A1 ER-MLRS

2001

M30 GMLRS DPICM

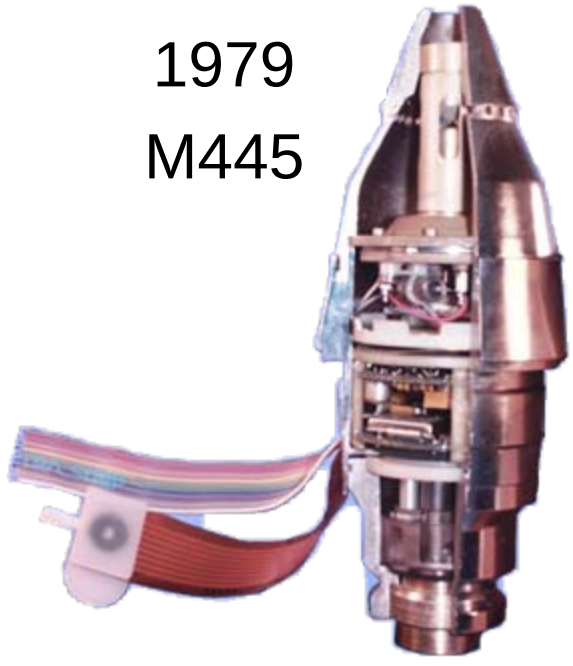


2004

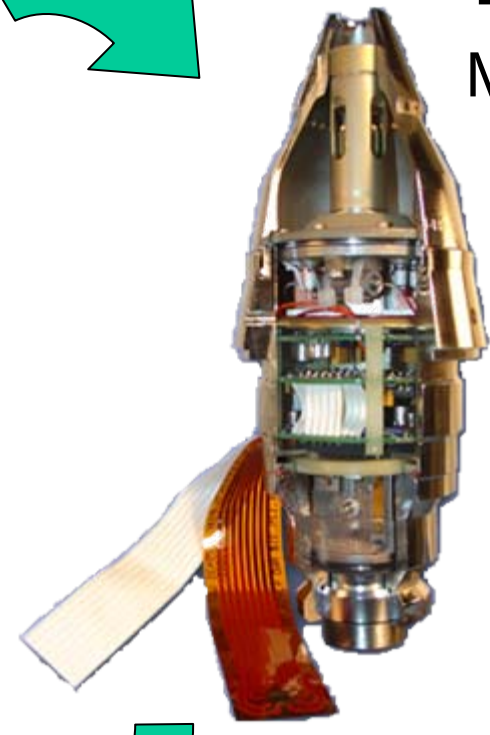
XM30 GMLRS Unitary

Evolutions in MLRS Fuzing

1979
M445



1992
M451



2004
GMLRS Unitary ESAF

2001
GMLRS DPICM ESAD

MLRS History

- Army recognized need for a weapon for counterfire, air defense suppression, and light armor and personnel targeting
- Supplement available cannon weapons for delivery of a large volume of firepower in a very short time against critical, time-sensitive targets
- Dec 1975 - MICOM released a RFP to determine the best technical approach for the General Support Rocket System (GSRS)
- Mar 1979 - Vought launched first GSRS rocket out of its "six-pack“ launch pod/container from a Self-Propelled Launcher Loader
- Nov 1979 - GSRS was redesignated MLRS
- Mar 1982 - Vought awarded concept definition contract to develop a binary chemical warhead (BCW) – XM135
- May 1982 - Vought Corporation delivered the first six M42 low-rate production rockets (one crated round)
- Feb 1983 - Production qual tests were completed at WSMR
- Nov 1984 - TGW development contract awarded
- Dec 1986 – XM29 SADARM submunitions development contract awarded

MLRS History (cont'd)

- FY 1989 - Development of German AT2 warhead program was completed
- Jul 1989 - Delivery of M270 launchers for Army TACMS missiles began
- Feb 1991 - 500th MLRS production launcher rolled out
- Feb 1991 - MLRS BCW (XM-135) program was cancelled.
- Feb 1991 - Alpha Battery, 21st FA launched first MLRS fired in combat
- Jul 1993 - Full-scale production of the MLRS basic rocket ended
- Dec 1993 - ER-MLRS development contract was signed
- FY 1994 - TGW program was terminated
- FY 1994 - SADARM program was terminated due to underfunding
- FY 1994 - Guided MLRS Advanced Technology Demonstration (ATD) initiated
- Oct 1994 - Germans fired first MLRS AT2 with live mines at WSMR
- FY 1996 - Bat-On-A-Rocket Demo Program designed to show that ATACMS/BAT submunition could be integrated into an MLRS rocket
- May 1996 - ER-MLRS program approved to enter LRIP
- May 1998 - First Guided MLRS flight conducted at WSMR

MLRS History (cont'd)

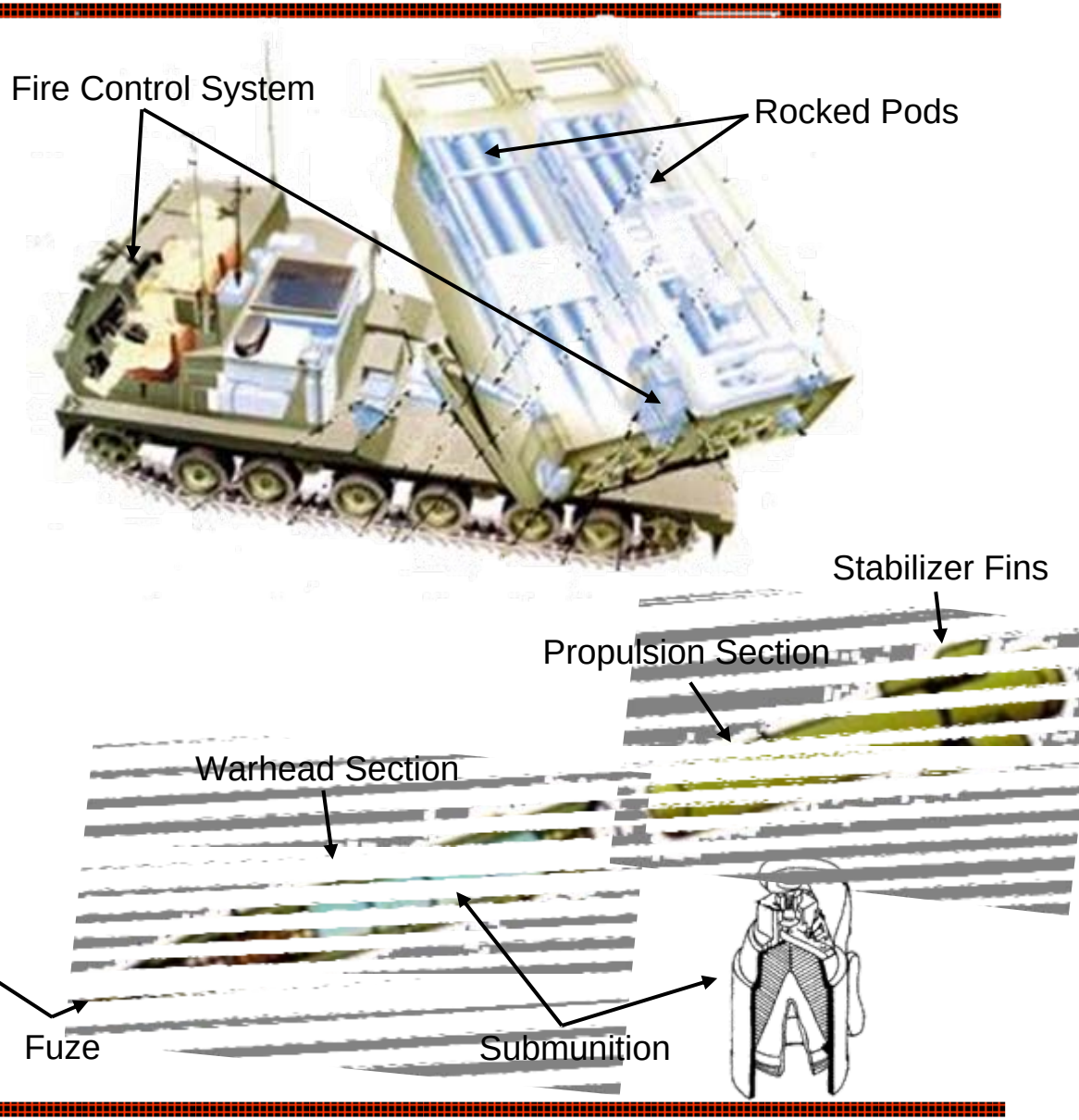
- 1999 - M30 GMLRS DPICM development started
- Jan 2003 - GMLRS SDD phase completed Production Qual Flight Testing
- Oct 2003 - Lockheed Martin was awarded an SDD contract for 86 Guided Unitary XM31 variant rockets
- 2003 - Lockheed Martin received GMLRS M30 LRIP contract
- 2004 - GMLRS M30 Operational Tests were completed
- Dec 2005 - M30 GMLRS full rate production contract awarded
- May 2005 - XM31 Guided Unitary delivered, following a US Army Urgent Need statement
- Aug 2005 - XM31 Guided Unitary variant began field testing in Iraq
- Q3/Q4 2005 - 498 XM31 rockets were delivered to the U.S. Army
- Sep 2005 - XM31 GMLRS Unitary fired for first time in combat operations by 3rd Battalion, 13th Field Artillery (3-13 FA), 214th Field Artillery Brigade

MLRS System Overview

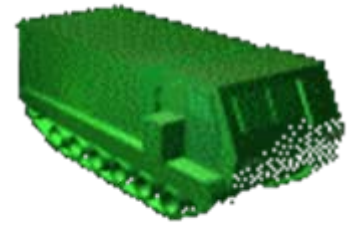
- Highly mobile, automatic system that fires surface-to-surface rockets and missiles from M270 platform
- Co-produced by United States, Germany, United Kingdom, France, and Italy and fielded in 14 countries
- MLRS Family of Munitions (MFOM) includes three rockets and four missiles with an additional variants in development
- Upgraded in early 1990s to fire Army Tactical Missile System (ATACMS)
- Missions completed with crew of three and automated Fire Control System
- Can fire up to 12 MLRS rockets or 2 ATACMS in less than one minute
- MLRS employs the "shoot and scoot" principle to limit vulnerability to counterbattery fire
- More than 10,000 rockets and 32 ATACMS fired in combat during Desert Storm and was referred to as “steel rain”

MLRS System Overview

- Launcher
  - Fire Control System
  - Rocket Pod
- Rocket
  - Stabilizer Fins
  - Propulsion Section
  - Warhead Section
    - Fuze
    - Submunition / Warhead



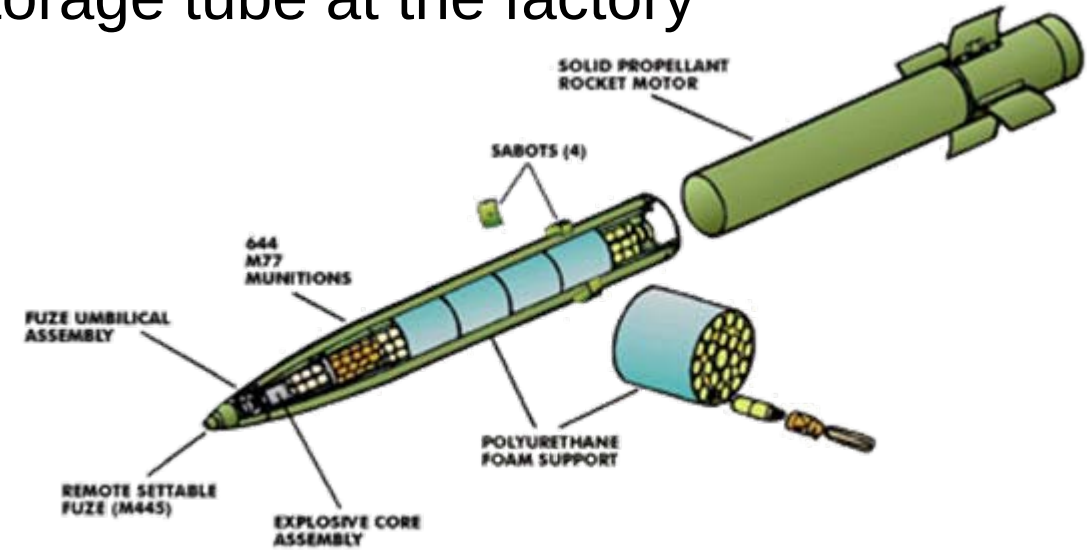
M270 / M270A1 Launcher



- Derivative of the Bradley Fighting Vehicle (BFV)
- Accommodates the MLRS Family of Munitions including the Army Tactical Missile System (ATACMS)
- 12 rockets or 2 ATACMS missiles
- Capable of firing one at a time or in rapid ripples to ranges of more than 30 kilometers
- Can attain speeds reaching 65km/hr
- Can maneuver over most terrain

MLRS Rocket

- MFOM includes three rockets and four missiles with others in development
- 13 feet long and 9 inches in diameter
- Tube-launched, spin-stabilized, free-flight projectile
- Range is a function of launcher elevation
- Assembled, checked, and packaged in a dual-purpose launch-storage tube at the factory

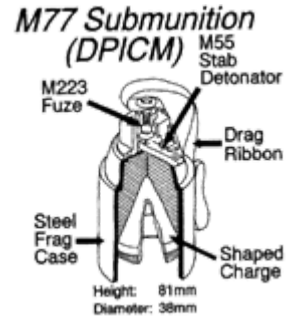


MLRS Rocket – Major Components

- Four stabilizer fins
  - Located on aft end of the rocket
  - Provide in-flight stability by maintaining a counterclockwise spin
  - Initial spin is developed by spin rails on inner wall of the launch tube
- Propulsion section
  - Solid propellant rocket motor
  - Umbilical cable links the FCS to igniter in rocket nozzle
  - Motor ignited by electrical command from FCS
- Warhead section
  - Center core burster with submunitions or unitary warhead
  - Fuze – Electro-mechanical S&A, ESAD or ESAF

Warhead / Submunitions

- M77/M85 Dual Purpose Improved Conventional submunition (DPICM)
  - High explosive grenades detonates on impact
  - Case fragments produce antipersonnel effects
  - Can penetrate up to four inches of armor
- West German-developed AT2 scatterable mine warhead
- Brilliant Anti-armor Technology (BAT)
  - Precision engagement weapon
  - Integrates stand-off delivery accuracy with a submunition that can kill moving armor columns in the deep battle zone
- Unitary Warhead
  - 200 pounds of high explosive
  - Greatly reduces collateral damage
- Potential for delivering other warheads



AT2 Mine

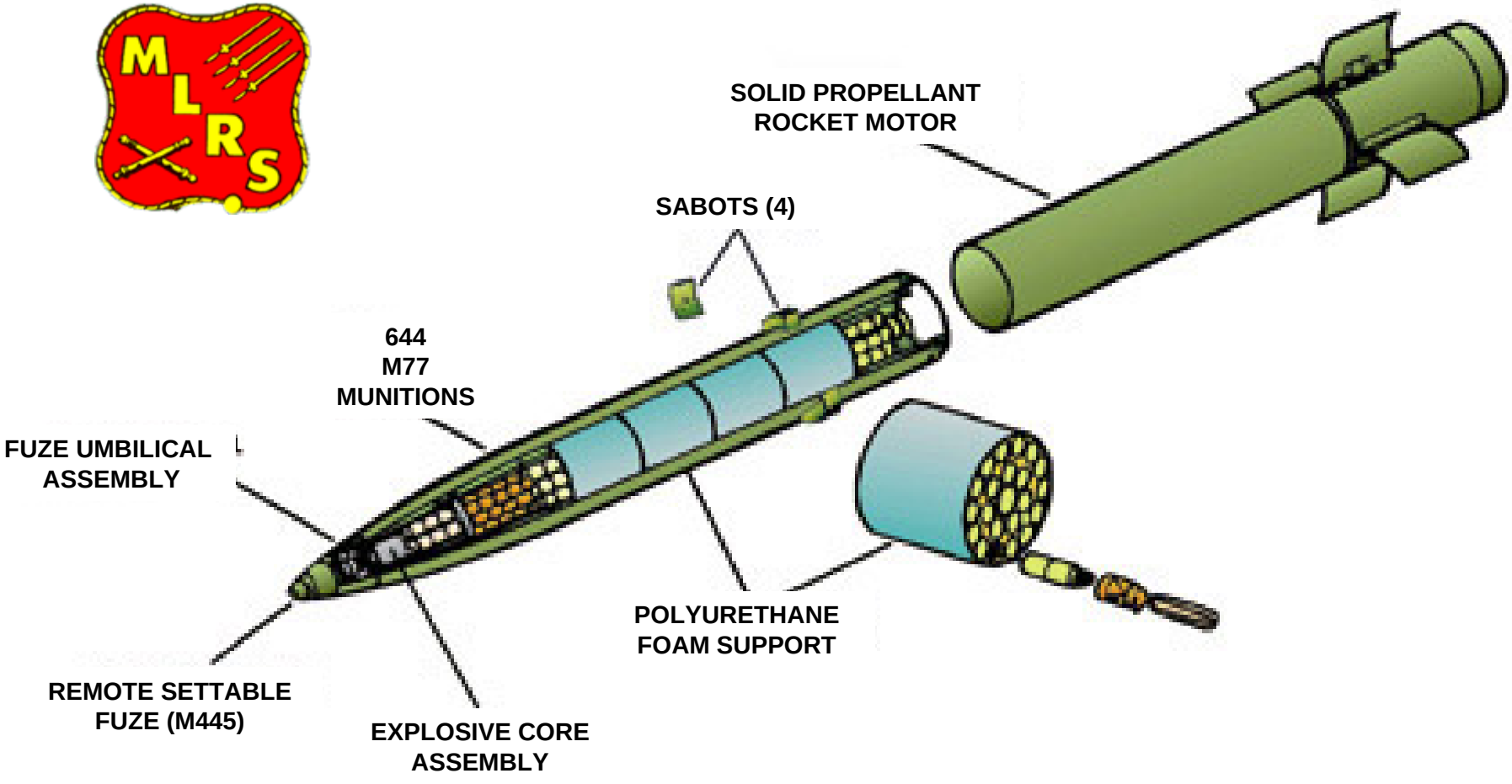
B.A.T.

Unitary Warhead

Baseline M26 Rocket

- Dec 1975 - Started development
- Feb 1983 - Production qualification test program was successfully completed at WSMR
- Used for counterfire, air defense suppression, and targeting of light armor and personnel
- Free flight ballistic rocket
- Range limited to approximately 30km
- Function time set into fuze prior to launch
- Dispensed 644 M77 munitions over target area
- Used M445 remote settable fuze

Baseline M26 Rocket

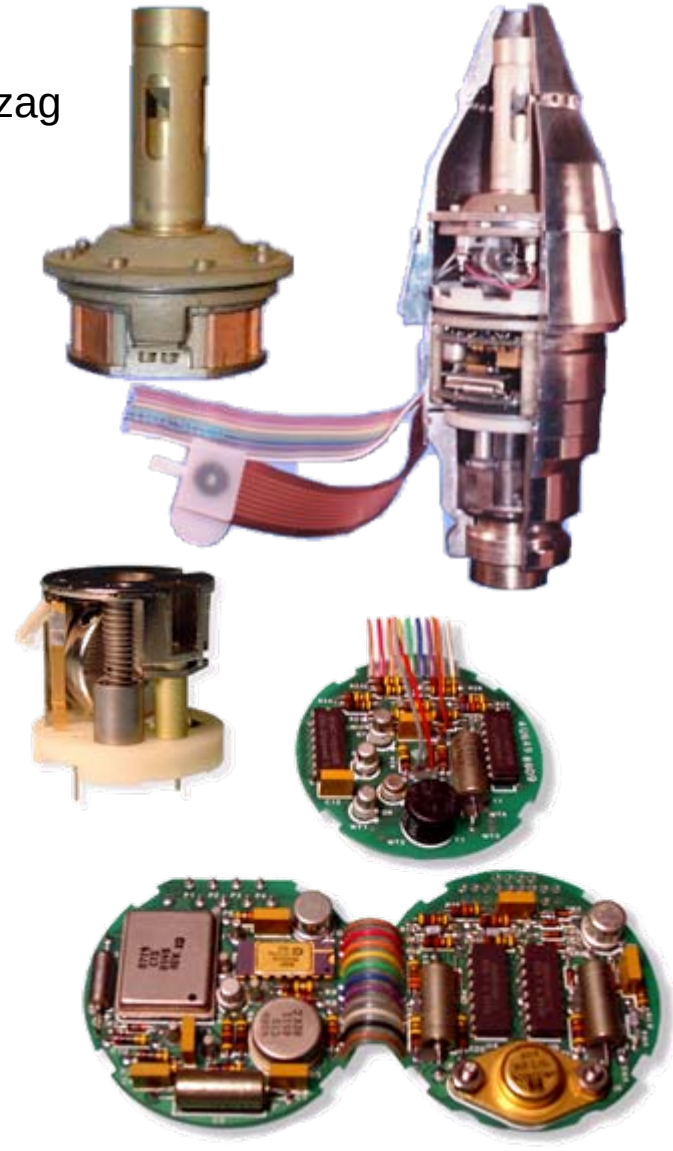


M445 Fuze

- 1978 - Army Harry Diamond Labs (HDL) developed M587 Mortar Fuze
  - Interface Hybrid - Honeywell
  - Non-volatile Memory Timer – Nitron
  - 10 KHz RC Hybrid – Timex
- 1979 - KDI contracted to design, develop, and produce M445 Fuze
- 1982 - KDI completed development, production engineering, and qualification phases of the program
- 1983 - Started LRIP
- 1985 - High rate production started
- 10 years production – produced ~700,000 fuzes

M445 Fuze

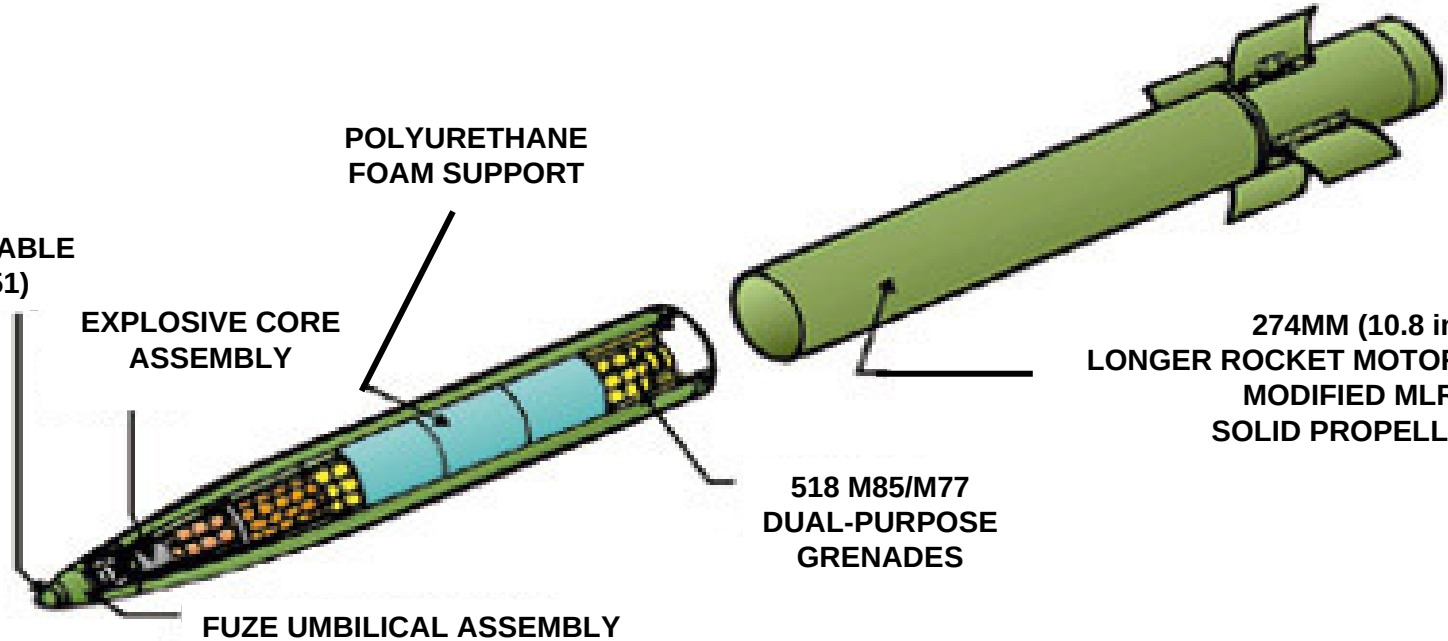
- S&A assembly for mechanical arming
  - Contains unique gearless S&A - setback weight runs in zig-zag path (24 g's) - used as first safety environment
- Fluidic generator
  - Environmentally-energized fluidic generator powered the electronics
  - Used as second safety environment
- Electronics design
  - Provided overhead safety for electrical arming
  - Remote settable function time: 4.0 – 199.99 seconds
  - Firing capacitor held shorted until 3.4 seconds before set function time
  - Used same 3 custom chips at the M587
  - Added PA fire circuit and power supply circuit
  - Piston actuator removes 2nd rotor lock after electronic delay based on fluidic generator frequency
- Explosive Output:
  - Lead: CH6, 760 mg



M26A1/A2 ER-MLRS (Extended Range)

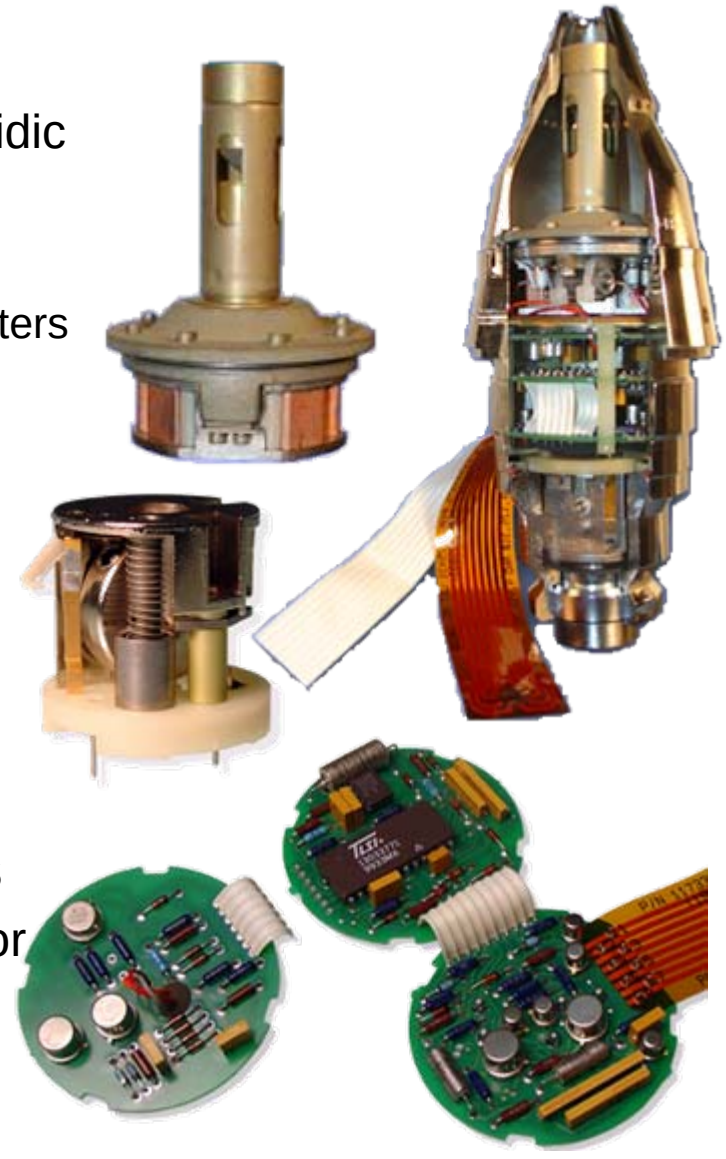
- MLRS was outranged by a majority of foreign systems
- 1993 - LVS officially began the ER-MLRS EMD program
- Rocket motor modified to increase range from 30km to 45km
- Improved accuracy
- Targets include soft and light armored personnel and equipment
- Smaller warhead section with fewer submunitions
  - M26A1 - 518 M85 DPICM submunitions
  - M26A2 - 518 M77 DPICM submunitions
- New warhead fuze - XM451 remote settable fuze
- > 14,000 produced

M26A1/A2 ER-MLRS



XM451 Fuze

- 1993 - XM451 Fuze Development awarded to KDI
- Increased range and altitude required redesign of fluidic generator and low power electronics
- XM451 Electronics
  - Based on M445 and made compatible with existing setters
  - 3 custom chips replaced with custom Timer ASIC with built in clock and reset
  - Reduced current from 20mA to 1mA
- Fluidic Generator
  - High altitude reduced the airflow to fluidic generator
  - Nozzle body and reed relay redesigned to operate in a high altitude/low pressure environment
- S&A Device
  - Uses same version as M445, XM447, XM448 and TCS
- Safety Environments – Setback and Fluidic Generator
- 1996 - ER-MLRS entered LRIP
- > 16,000 Fuzes produced prior to ending in 2002

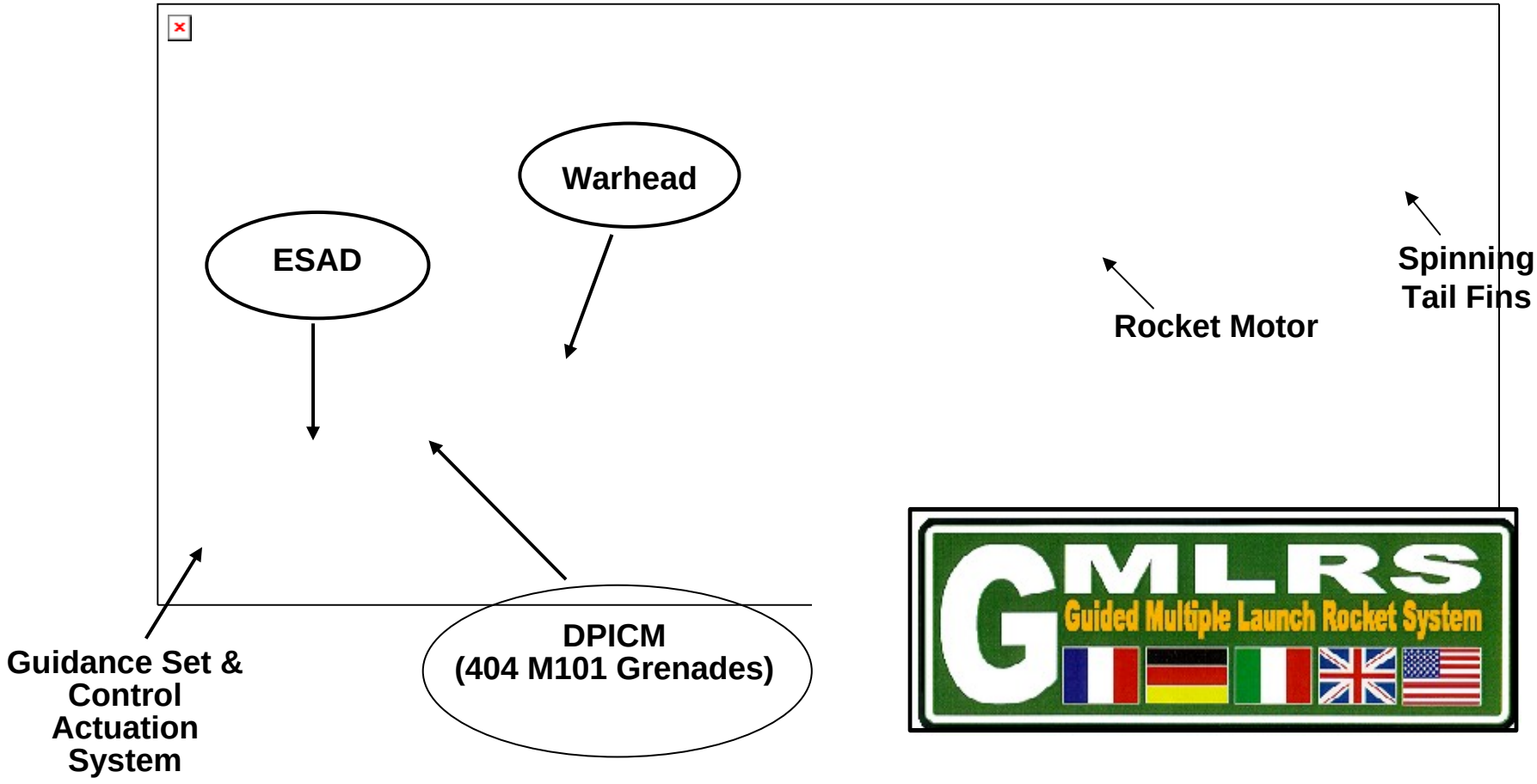


M30 Guided MLRS (DPICM)

- Began EMD in 1999
- Grew from need for increased range and accuracy
  - GPS aided inertial guidance package
  - Control actuation system
  - Spinning tail fins
  - Canards provide basic maneuverability

- Maximum range 60+ km
- Accuracy measured in meters
- Enhanced anti-jam capabilities
- Dispenses 404 M101 DPICM Submunitions
- Decreases number of rockets to defeat targets by as much as 80%
- New Fuze – GMLRS ESAD

M30 Guided MLRS (DPICM)



KDI ESAD / Technology Evolution

Jan. 1991 - Nov. 1998 1st Generation ESAD 2500 Vdc	Nov. 1998 - Jan. 2002 2nd Generation ESAD 1600 Vdc	Jan. 2002 - Today 3rd Generation ESAD 1250 Vdc
KDI EFI	LEEFI (**)	
Microcontroller	Dual FPGA	
MIL Spec thru Hole Components	SMT & COTS	
Spark Gap Switch	N-Channel MCT	
Hermetic	Hermetic	

* = Currently in SDD

** = Began incorporating IPS in 2005

Updated: June 2006

1991
1st KDI ESAD
ATACMS ESAD

1992
PATRIOT ESAD
Dual Redundant ESAD & FTSA

1993
Swiss Dragon ESAD

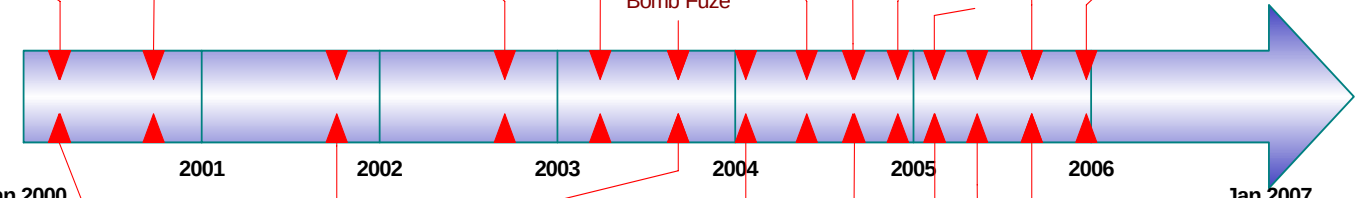
1994
Triple Tandem Outputs
Swiss TOW

1995
1st Air Force NNMSB Approved ESAD
1st Navy WSESRB Approved ESAD
JSOW ESAD

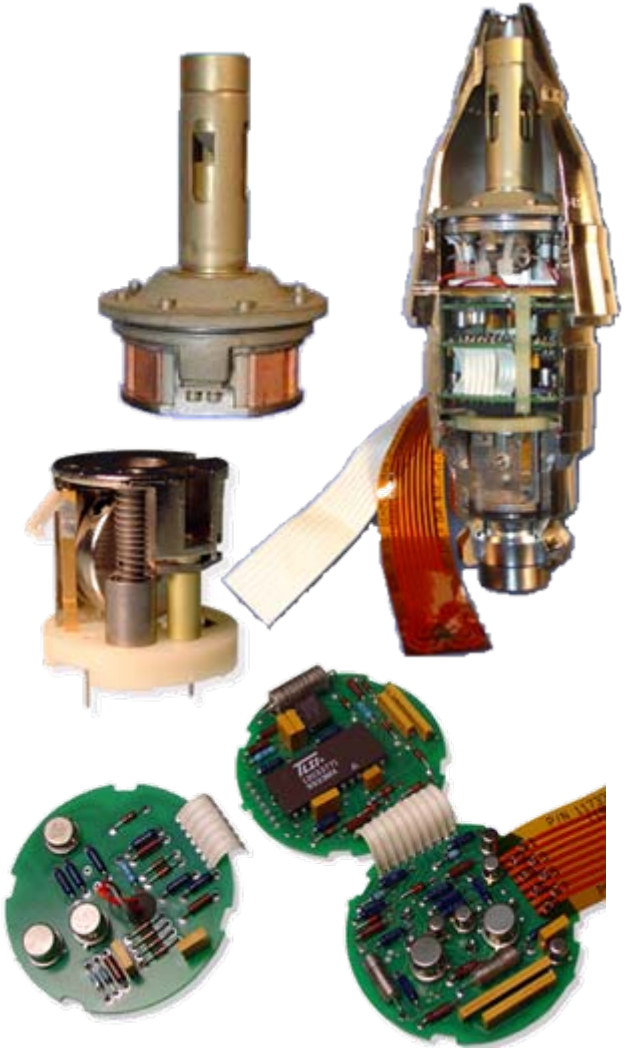
1996
TSSAM ESAD W/RFU

1997
JSOW & ATACMS FTSA's

1998
Separated Firing Module
EFOG-M ESAD



M451 to GMLRS ESAD Evolution



Out-of-Line

MIL-SPEC components

Through Hole Parts

Sensitive Explosives

In-Line

Hermetic

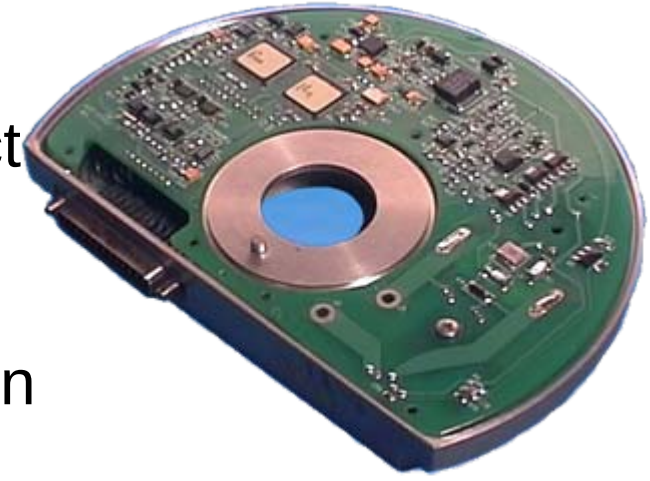
COTS Components

SMT Technology

Insensitive Explosives

Guided MLRS (DPICM) ESAD

- Replace existing electro-mechanical fuze with In-Line Electronic Safe and Arm Device (ESAD)
- Design meets MIL-STD-1316D and STANAG 4187
- High voltage generation needed to due removal of mechanical interrupters
- Uses solid state high voltage switch (NMCT)
- External Low Energy EFI (LEEFI) used
- Safety environments – changed from setback and ram air to umbilical disconnect and acceleration
- Utilizes MEMS accelerometer
- First motion and safe separation verification
- Sequencing and acceleration for time



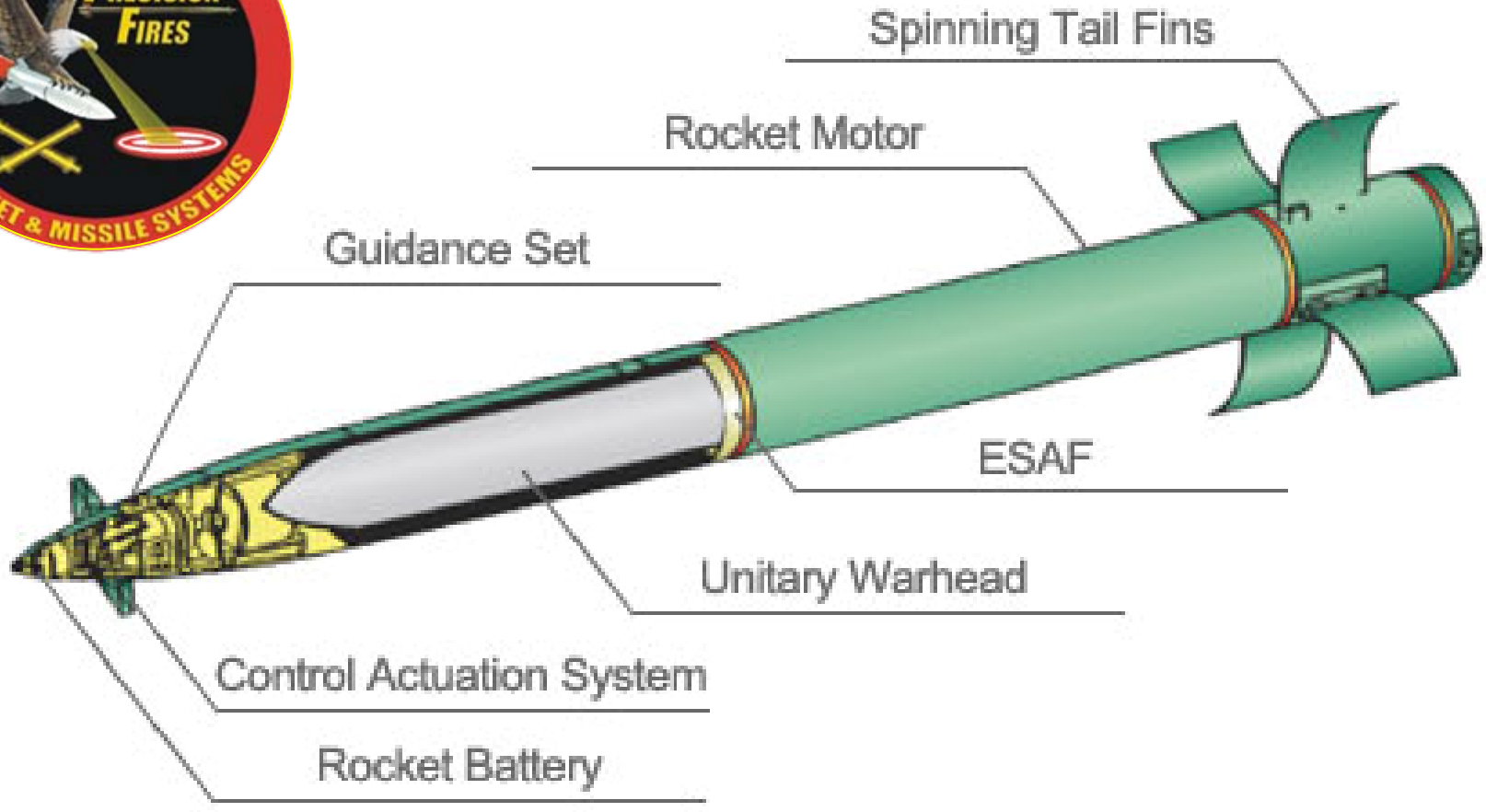
Guided MLRS (DPICM) ESAD

- Serial interface
  - Overhead safety timer can be programmed in launcher
  - Provides real time status of events
- Arm/fire command issued 200 ms prior to desired detonation point
- Dual Actel anti-fuse Field Programmable Gate Arrays (FPGAs) used to implement timing, sequencing and communications logic
- Surface mount COTS parts used
- Increased shelf life & reliability over mechanical system
  - No mechanical parts
  - Hermetically sealed housing
- Increased testability
  - NMCT switch allows unlimited number of test firings
  - Can be fully tested on bench to verify proper operation
- Qualified in 2002
- > 2200 Delivered to date

XM31 Guided MLRS Unitary

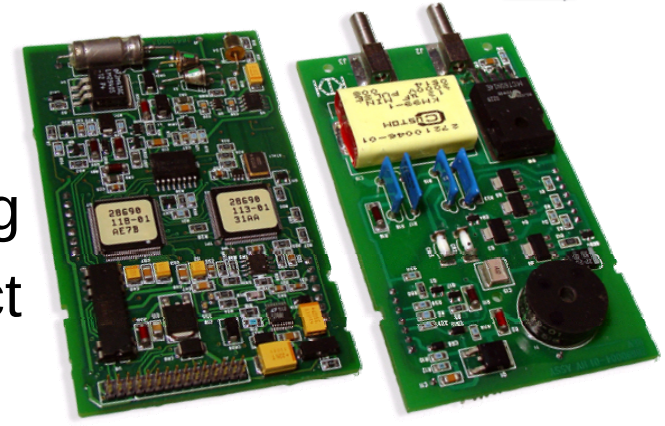
- October 2003 - Lockheed Martin awarded an SDD contract for 86 unitary variant rockets, to last until 2007
- Integrates a 200 pound unitary warhead
- Reduces collateral damage by providing a “one round, one kill capability”
- New Tri-mode fuze allows airburst, point impact and delay modes for penetrator capability
- May 2005 - First units delivered - accelerated following a US Army Urgent Need statement
- H2 2005 - First 498 rockets were delivered to the U.S. Army
- Aug 2005 - Unitary variant began field testing in Iraq
- Sep 2005 - First GMLRS unitary rockets fired in combat operations by 3rd Battalion, 13th Field Artillery (3-13 FA), 214th Field Artillery Brigade
- > 2100 Produced to date
- Today, GMLRS unitary is the Army’s only surface-fired, precision, longer range indirect fire munition available to troops in contact in an urban environment
- Affectionately referred to as the “70km sniper round”

GMLRS Unitary Rocket



GMLRS Unitary ESAF

- Tri mode fuze functionality – proximity, impact, and impact with delay
- Design compatibility with MIL-STD-1316E and STANAG 4187
- GMLRS (DPICM) ESAD was baseline design
- Added internal impact switches
- Added external impact switch fire input
- Added proximity sensor interface
- Impact survivability
  - Survives high g longitudinal loads
  - Settable detonation delay time
  - Potting material & mechanical packaging
- Safety Environments – Umbilical disconnect and acceleration



GMLRS Unitary ESAF

- Proximity sensor interface
  - Provides +8V at 400mA for proximity sensor logic circuitry
  - Provides +5V at 500mA for proximity sensor transmitter circuitry
  - Interface circuitry for proximity fire input

- Fits 3” fuze well
- Serial Communications to set overhead safety time, detonation delay time, function mode, receive command arm/fire and provide status during test and flight
- Meets insensitive munitions (IM) requirements
- Qualified 2006

GMLRS Unitary

- Proximity Sensor Firing Mode
- Selectable 3M & 10M HOB
- Approach velocities near Mach 2.5

- Impact Survivability – ESAF tested against hardened concrete target

GMLRS Unitary

Conclusions

- MLRS program has evolved over the last 30 years
  - MLRS improvements have focused on upgrading launcher responsiveness and enhancing the range and precision of its munitions over the last 10+ years
  - Increased range – from 30km to 70km+
  - Improved lethality and reduced collateral damage by changing submunitions / warhead – DPICM, Unitary
  - Systems have adapted to evolving technology – GPS/INS, control systems, Fire Control, Fuzing improvements
- Program team always focused on delivering weapon to meet war fighters needs - “one round, one kill capability”