PAC-3® MSE Overview
Outline

• PAC-3 Evolution
• Hit-to-Kill Technology
• Patriot and PAC-3 Missile Segment Enhancement (MSE)
• M903 Launcher Upgrades
• Summary and Reference Data
PAC-3 Evolution
PAC-3 missiles defend against incoming threats – including tactical ballistic missiles, cruise missiles and aircraft - through direct body-to-body contact delivering exponentially more kinetic energy on the target than can be achieved with blast-fragmentation kill mechanisms.

Building on the combat-proven PAC-3 Cost Reduction Initiative (CRI), the PAC-3 MSE expands the lethal battlespace with a two-pulse solid rocket motor, providing increased performance in altitude and range.
PAC-3 MSE Historical Timeline

- **2014**: Production decision reached
- **2015**: First Unit Equipped (FUE) declared
- **2016**: Initial Operational Capability (IOC) declared
  - First FMS customer contract signed
- **2017**: PAC-3 MSE intercept opens door to full-rate production
- **2018**: Full-rate production (FRP) achieved
- **2019**: Contract signed to increase annual production capacity to 500 missiles
- **2020**: 600th Launcher Modification Kit (LMK) delivered
  - 400th PAC-3 MSE conversion kit delivered
- **2021**: First Field Surveillance Program (FSP) flight tests
  - First successful engagement with U.S. Army’s Integrated Air and Missile Defense Battle Command System (IBCS)
- **2022**: Contract signed to increase annual production capacity to 550 missiles
- **2023**: Expanded international user community
PAC-3 International User Community

CRI & MSE
- Germany
- Japan
- Kuwait
- Netherlands
- Republic of Korea
- United Arab Emirates
- Taiwan

MSE
- Bahrain
- Poland
- Qatar
- Romania
- Sweden
- Switzerland

CRI
- Kingdom of Saudi Arabia

Security Assistance
- Ukraine

14 INTERNATIONAL PAC-3 USERS ON CONTRACT
PAC-3 International User Community

Europe
- Sweden
- Poland
- Netherlands
- Germany
- Romania
- Switzerland
- Ukraine

Middle East
- Kuwait
- Bahrain
- United Arab Emirates
- Kingdom of Saudi Arabia

Asia Pacific
- Japan
- Korea
- Taiwan

Legend:
- Yellow: PAC-3 CRI Customer
- Green: PAC-3 MSE Customer
- Blue: Security Assistance to Ukraine

Summary
- PAC-3 Evolution
- Hit-to-Kill Technology
- Patriot and PAC-3 MSE
- M903 Launcher
Hit-to-Kill Technology
PAC-3 Hit-to-Kill Fundamentals

Sensing the Threat
- Highly accurate seeker
- High data processing rates
- Scanning and search capability

Guidance
- Optimum engagement geometry
- Aimpoint selection
- High-speed computing of guidance algorithms
- World-class simulation and testing

Hitting the Threat
- Extremely responsive control system with forward-mounted side thrusters
- High agility airframe

Lethality
- High-energy impact defends against current and emerging threats
- Momentum transfer
Energy Required for Intercept

Effectiveness vs. Submunitions

Hit-to-Kill Intercept
- Typically the aeroshell is destroyed
- Most submunitions are destroyed
- Remaining submunitions typically sustain moderate to significant deformation
- Debris propagates downwards

Blast Frag Intercept
- Typically the aeroshell is destroyed
- Few submunitions are punctured
- Outer layer of submunitions provides effective shielding of inner layer and far-side submunitions
- Ballistic trajectory of debris is generally unchanged

Preventing lethal effects on the ground requires Hit-to-Kill
Hydrocode Analysis of the Intercept

**Blast Frag Intercept**
Delivers a few mega joules of energy on the target

**Hit-to-Kill Intercept**
Delivers hundreds of mega joules of energy on the target

Hydrocode provides a means to analyze the intercept dynamics of missile defense intercept mechanisms
Debris on the Ground

**Hit-to-Kill Intercept**
- Most submunitions are destroyed
- Remaining submunitions sustain significant deformation
- Debris propagates downwards

**Blast-Fragment Intercept**
- Few submunitions are punctured
- Ballistic trajectory of debris is generally unchanged
- Threat / Engagement Dependent

**Effective Defended Area**

**Defended Asset**

Protect Defended Asset and Minimize Collateral Damage
PAC-3 Missile Segment
How PAC-3 MSE Works
*Patriot Configuration

**ACQUISITION**
Onboard seeker acquires target

**INERTIAL FLYOUT**
Flies to nominal intercept point with control fins

**Uplink / Downlink**

**HOMING**
Thrusters provide rapid response
Missile seeker provides guidance accuracy

**ENDGAME**
Final homing maneuver
Achieves Hit-to-Kill guidance accuracy

**LAUNCH CONTROL**
Target trajectory and intercept point supplied by Fire Control System
Provides updated target trajectory if required

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*Patriot Configuration

How PAC-3 MSE Works
PAC-3 Missile Segment Components

M903 Launcher Components

1. PAC-3 MSE One-Packs
2. Junction-Box / Launching Station Diagnostic Unit (J-Box/LSDU)
   - Power/signal distribution for missile umbilicals
   - Performs cable diagnostic test
3. Launcher Cables
   - ELES/J-Box/LSDU interconnect
   - Dedicated umbilicals for PAC-3
4. Enhanced Launcher Electronics System (ELES)
   - Provides power and signals to missiles

Canister

PAC-3 MSE One-Pack facilitates launcher reconstitution

Fire Solution Computer Redesign (FSCR)

Calculates PAC-3 missile engagement solutions

PAC-3 Hit-to-Kill Missiles

PAC-3 Evolution
Hit-to-Kill Technology
Patriot and PAC-3 MSE
M903 Launcher
Summary

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PAC-3 MSE Interceptor

- Small (diameter, length, weight)
- Rapid acceleration from solid rocket motor (SRM) boost phase
- Sustain phase maintains high velocity for Hit-to-Kill engagement with second pulse for long-range or high-altitude intercepts
- Dual-control autopilot provides fast divert response
  - Aerodynamic Maneuvering System (control fins)
  - Attitude Control Section - Attitude Control Motors (ACM)

- High-power, highly accurate, all-weather active Ka band radar seeker
  - Range, range rate, angle data to homing guidance
- Guidance Processor Unit (GPU) - Main computer
- Inertial Measurement Unit (IMU) - Navigation system
- Multi-band Radio Frequency Data Link (MRFDL) – Uplink/downlink communication
PAC-3 MSE Capability Enhancements

- Provides performance growth against existing and advanced threats
- Improves lethality and maneuverability over entire battlespace
- Increases footprint significantly against threats
- Provides improved Insensitive Munitions (IM) capability
- One-Pack approach improves operational flexibility
- Achieves larger battlespace with longer range and higher altitude

Significant battlespace growth

PAC-3 MSE

PAC-3 CRI

Updated Seeker Software
Updated SGCP Software
11.4" Dual Pulse Solid Rocket Motor
New LE & ISD
Updated FSCR software

Jointly defined ECS changes with Raytheon

New / Modified Actuators, Batteries and Electronics

• "Kitted" Single Canister
• Armor
• TIVS

Updated ELES software

PAC-3 MSE defends against new and evolving threats while increasing capability against existing threats
PAC-3 MSE Canister Design Overview
One-Pack, External Components

Skid Attach Structure
Forward Cover
Composite Launch Tube
Detachable Shock Absorbing Skid Assembly with steps for scaling the launcher loadout
Armor Panels
Aft Stackframe
Forklift Frames

Aft End View
Improved Aft Cover
Transition Box
Two One-Packs combine to form a Two-Pack

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## MSE Single Canister Summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reconstitution / Reload</strong></td>
<td>One-Packs are field replaceable. Single use canister, missiles are not reconstitutable.</td>
</tr>
<tr>
<td><strong>Explosive Ordnance Disposal (EOD) of Single Missile</strong></td>
<td>Single One-Pack may be removed and disposed.</td>
</tr>
<tr>
<td><strong>Shipping Configurations</strong></td>
<td>Can ship as double Two-Pack, Two-Pack, or One-Pack.</td>
</tr>
<tr>
<td><strong>OCONUS Road March</strong></td>
<td>12 missile max load meets OCONUS height requirements without need for off-loading.</td>
</tr>
<tr>
<td><strong>Insensitive Munitions Compliance</strong></td>
<td>System is IM compliant.</td>
</tr>
<tr>
<td><strong>Modularity</strong></td>
<td>Mechanical interfaces maintained for multiple launcher platforms.</td>
</tr>
</tbody>
</table>
Launcher Upgrades
PATRIOT Load Out Options

- PAC-3 provides up to four times the firepower and less reloads versus PAC-2 family of missiles.
- PAC-3 CRI and PAC-3 MSE provide high load out configurations and enable defense against mass raids.

- M903 allows for a mix of PAC-3 CRI and PAC-3 MSE missiles.
- All new US launchers are M903 configuration.

M903 can launch entire family of Patriot missiles

4 PAC-2 (GEM) 16 PAC-3 CRI or 4 PAC-2 (GEM)
12 PAC-3 MSE, or 16 PAC-3 CRI or 4 PAC-2 (GEM)
6 PAC-3 MSE and 8 CRI or 4 PAC-2 (GEM)
Summary
Summary

• The PAC-3 family of missiles are **combat proven** Hit-to-Kill interceptors that defend against incoming threats, including tactical ballistic missiles, cruise missiles, advanced threats, and aircraft.

• PAC-3 missiles defend against incoming threats through direct body-to-body contact **delivering exponentially more kinetic energy on the target** than can be achieved with blast-fragmentation kill mechanisms.

• Building on the combat-proven PAC-3 CRI, the PAC-3 MSE **expands the lethal battlespace** with a two-pulse solid rocket motor, providing increased performance in altitude and range.

• **Fifteen** nations have chosen PAC-3 to provide missile defense capabilities.
**Acronyms**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABT</td>
<td>Air Breathing Threat</td>
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<tr>
<td>ACM</td>
<td>Attitude Control Motors</td>
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<td>ACS</td>
<td>Attitude Control System</td>
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<tr>
<td>AMS</td>
<td>Aerodynamic Maneuvering System</td>
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<tr>
<td>ARM</td>
<td>Anti-Radiation Missile</td>
</tr>
<tr>
<td>CDI</td>
<td>Classification, Discrimination, Identification</td>
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<tr>
<td>CONUS</td>
<td>Continental United States</td>
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<tr>
<td>COTS</td>
<td>Commercial off-the-shelf</td>
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<td>CRI</td>
<td>Cost Reduction Initiative</td>
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<td>D-Cables</td>
<td>Distribution Cables</td>
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<td>D-Box</td>
<td>Distribution Box</td>
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<tr>
<td>DT</td>
<td>Development Test</td>
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<td>ECS</td>
<td>Engagement Control Station</td>
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<td>ELES</td>
<td>Enhanced Launcher Electronics System</td>
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<td>EOD</td>
<td>Explosive Ordnance Disposal</td>
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<tr>
<td>ERINT</td>
<td>Extended Range Interceptor</td>
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<tr>
<td>EWCC</td>
<td>Expanded Weapons Control Computer</td>
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<tr>
<td>FLAGE</td>
<td>Flexible Lightweight Agile Guided Experiment</td>
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<td>FMS</td>
<td>Foreign Military Sales</td>
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<td>FOTP</td>
<td>Follow-on Test Program</td>
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<td>FSC</td>
<td>Fire Solution Computer</td>
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<tr>
<td>FSCR</td>
<td>Fire Solution Computer Redesign</td>
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<td>FUE</td>
<td>First Unit Equipped</td>
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<td>FWD</td>
<td>Forward</td>
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<tr>
<td>GEM</td>
<td>Guidance Enhancement Missile</td>
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<td>GMT</td>
<td>Guided Missile Transporter</td>
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<td>GPU</td>
<td>Guidance Processor Unit</td>
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<td>GSE</td>
<td>Ground Support Equipment</td>
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<td>GTF</td>
<td>Guided Test Flight</td>
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<td>HTK</td>
<td>Hit-to-Kill</td>
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<tr>
<td>HW</td>
<td>Hardware</td>
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<td>IM</td>
<td>Inertial Measurement Unit</td>
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<td>IOC</td>
<td>Initial Operational Capability</td>
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<td>ISD</td>
<td>Ignition Safety Device</td>
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<td>J-Box</td>
<td>Junction Box</td>
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<tr>
<td>Km</td>
<td>Kilometer</td>
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<tr>
<td>LE</td>
<td>Lethality Enhancer</td>
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<tr>
<td>LEM</td>
<td>Launcher Electronics Module</td>
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<tr>
<td>LMRD</td>
<td>Launcher Missile Round Distributor</td>
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<td>LS</td>
<td>Launching Station</td>
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<tr>
<td>LMK</td>
<td>Launcher Modification Kit</td>
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<tr>
<td>LSDU</td>
<td>Launcher Station Diagnostic Unit</td>
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<tr>
<td>MAP</td>
<td>Modular Adjunct Processor</td>
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<td>MEADS</td>
<td>Medium Extended Air Defense System</td>
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<tr>
<td>MFG</td>
<td>Master Frequency Generator</td>
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<tr>
<td>MRFDL</td>
<td>Multi-band Radio Frequency Downlink</td>
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<tr>
<td>MSE</td>
<td>Missile Segment Enhancement</td>
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<td>MSL</td>
<td>Missile</td>
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<tr>
<td>NFS</td>
<td>North Finding System</td>
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<tr>
<td>OCONUS</td>
<td>Outside the Continental United States</td>
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<tr>
<td>OT</td>
<td>Operational Test</td>
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<tr>
<td>PAC-3®</td>
<td>Patriot Advanced Capability-3</td>
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<tr>
<td>PDB</td>
<td>Post Deployment Build</td>
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<td>PALS</td>
<td>PATRIOT Automated Logistics System</td>
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<tr>
<td>POP</td>
<td>Proof of Principle</td>
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<tr>
<td>REP</td>
<td>Radar Enhancement Phase</td>
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<tr>
<td>RDP</td>
<td>Radar Digital Processor</td>
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<tr>
<td>RF</td>
<td>Radio Frequency</td>
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<tr>
<td>RLCEU</td>
<td>Remote Launch Communications Enhancement Upgrade</td>
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<tr>
<td>RPV</td>
<td>Remotely Palletized Vehicle</td>
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<tr>
<td>SBC</td>
<td>Single Board Computer</td>
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<tr>
<td>SGCP</td>
<td>System Guidance Computer Program</td>
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<tr>
<td>SIG</td>
<td>Signal</td>
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<tr>
<td>SP</td>
<td>Shorting Plug</td>
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<tr>
<td>SRHIT</td>
<td>Small Radar Homing Interceptor Technology</td>
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<tr>
<td>SRM</td>
<td>Solid Rocket Motor</td>
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<tr>
<td>SW</td>
<td>Software</td>
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<tr>
<td>TBM</td>
<td>Tactical Ballistic Missile</td>
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<tr>
<td>T-Box</td>
<td>Transition Box</td>
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<tr>
<td>THAAD</td>
<td>Terminal High Altitude Area Defense</td>
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<tr>
<td>TIVS</td>
<td>Thermally Initiated Venting System</td>
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<tr>
<td>UMB</td>
<td>Umbilical Cable</td>
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<tr>
<td>UL</td>
<td>Upper Left</td>
</tr>
<tr>
<td>UR</td>
<td>Upper Right</td>
</tr>
<tr>
<td>VME</td>
<td>Versa Module Eurocard</td>
</tr>
<tr>
<td>WMD</td>
<td>Weapon of Mass Destruction</td>
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