



May 2017

PERSONAL PROTECTIVE EQUIPMENT

Army and Marine
Corps Are Pursuing
Efforts to Reduce the
Weight of Items Worn
or Carried in Combat

GAO Highlights

Highlights of [GAO-17-431](#), a report to congressional committees

Why GAO Did This Study

Army and Marine Corps ground combat personnel have long worn a variety of PPE such as vests, armor, and helmets to help protect them from operational risks. The two services have documented the advanced protection capabilities of current PPE systems, but identified that the armor contributes to the total load burden—or cumulative weight of items typically worn or carried. In addition to PPE, personnel typically carry food, water, ammunition, communications equipment, and other items.

House Report 114-537, accompanying a bill for the National Defense Authorization Act for Fiscal Year 2017, included a provision for GAO to review Army and Marine Corps efforts to reduce the weight of PPE and other equipment worn or carried in combat.

This report describes (1) the current operational requirements associated with PPE, and how those requirements contribute to the total load burden on Soldiers and Marines in combat environments; and (2) the coordination between the Army and the Marine Corps regarding efforts to reduce the weight of PPE and the total load burden on personnel.

GAO reviewed Army and Marine Corps documentation related to PPE, total load burden on combat personnel, and weight reduction initiatives; and interviewed service researchers and program officials.

What GAO Recommends

GAO is not making recommendations in this report. DOD provided technical comments on a draft of this report, which GAO incorporated as appropriate.

View [GAO-17-431](#). For more information, contact Cary Russell at (202) 512-5431 or russellc@gao.gov.

May 2017

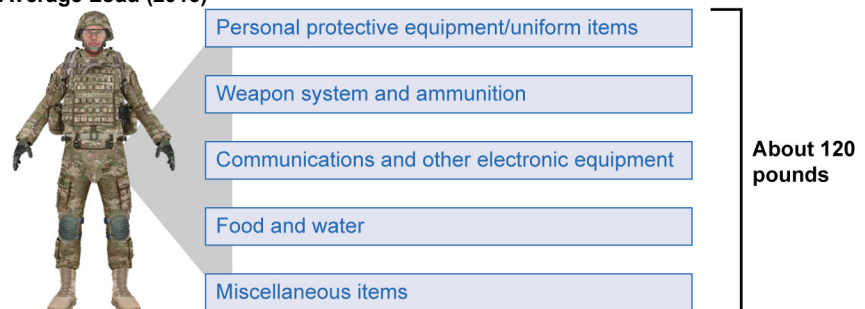
PERSONAL PROTECTIVE EQUIPMENT

Army and Marine Corps Are Pursuing Efforts to Reduce the Weight of Items Worn or Carried in Combat

What GAO Found

The Army and Marine Corps have developed requirements for personal protective equipment (PPE) to address operational threats in ground combat environments, but this PPE has increased in weight over time and has added to the total load burden on personnel. PPE primarily consists of hard armor plates, soft armor plate carrier vests, and combat helmets. Army and Marine Corps officials stated that the PPE provides significant additional protection when compared with equipment used prior to operations in Iraq in the 2000s. However, they also noted that providing this level of protection adds significant bulk and weight to the total load on Soldiers and Marines, which could impede mobility and hinder combat effectiveness. According to service-provided data, the typical total load in 2016 for Army and Marine Corps ground combat personnel averaged about 119 and 117 pounds, respectively, of which the primary PPE represented about 27 pounds based on equipment sizes (see figure). Officials stated that these totals have increased over time based on the incorporation of new PPE and other equipment.

Army and Marine Corps Ground Combat Personnel Total Load Contributors and Approximate Average Load (2016)



Sources: © 2015 Filo LLC (image); GAO analysis of Army and Marine Corps data. | GAO-17-431

Recognizing that the weight of PPE and other equipment could have negative effects on personnel performance, the Army and the Marine Corps have coordinated and developed goals for PPE-related weight reductions and are pursuing some efforts to reduce overall load burdens on personnel. The two services coordinate through formal working groups and informal methods to develop and improve PPE. Army and Marine Corps officials stated that while they prioritize protection and operational capabilities when developing PPE, they have overarching goals of reducing weight, in addition to improving the form, fit, and function of equipment. These goals have led to reductions in the weight of some PPE. The Army is also developing a goal and plan to reduce the weight of hard armor plates by 20 percent by identifying and eliminating excess ballistic protection. In addition, the Army and Marine Corps are pursuing other efforts to reduce the weight of PPE, such as by giving commanders the option to employ varying levels of PPE at their discretion and studying the effects of integrating PPE with overall combat loads. Finally, the Army and Marine Corps are exploring research initiatives that may reduce the total load on ground combat personnel, such as improvements to logistics and aerial delivery capabilities, load transferring systems, and other enhancements to equipment.

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May 5, 2017

Congressional Committees

For decades, Army and Marine Corps ground personnel have worn various forms of personal protective equipment (PPE), including early versions of vests, steel armor, and helmets to reduce operational risks. Today, ground personnel operating in combat environments use a PPE system consisting of hard and soft armor designed to address contemporary threats.¹ The Army and Marine Corps have documented the advanced protection capabilities of current PPE systems but note that the armor is bulky and contributes to the total load burden—that is, the cumulative weight of items typically worn or carried. In addition to PPE, these items can include ammunition, food, water, communications equipment, and items related to a weapon system, among other things. In 2009 we reported on procedures for evaluating performance requirements during the preliminary design testing of hard armor plates and found that the Army did not always follow established testing protocols or maintain internal controls over the integrity and reliability of testing data.² We recommended that the Army document all key decisions to clarify or change testing protocols and provide for an independent peer review of testing protocols. The Army generally concurred with and implemented these recommendations.

House Report 114-537, accompanying a bill for the National Defense Authorization Act for Fiscal Year 2017, included a provision for us to review Army and Marine Corps efforts to reduce the weight of PPE and other equipment worn or carried by ground combat personnel.³ This report describes (1) the current operational requirements associated with PPE, and how those requirements contribute to the total load burden on Soldiers and Marines in combat environments; and (2) the coordination

¹ This report describes the PPE items typically worn by dismounted Soldiers and Marines in combat environments, including the combat helmet, soft armor (Kevlar® and other textile materials) plate carrier vests, and hard armor (ceramic composite) plates.

² GAO, *Warfighter Support: Independent Expert Assessment of Army Body Armor Test Results and Procedures Needed Before Fielding*, [GAO-10-119](#) (Washington, D.C.: Oct. 16, 2009).

³ See H.R. Rep. No. 114-537, at 57-58 (2016).

between the Army and Marine Corps regarding their efforts to reduce the weight of PPE and the total load burden.

To describe the current PPE operational requirements for personnel operating in combat environments, we reviewed relevant documentation, including guidance and requirements provided by the Army's Program Executive Office-Soldier and the Marine Corps Systems Command.⁴ We also met with program managers from these offices to discuss the PPE requirements and procurement processes. Additionally, we met with relevant program managers from the Army and Marine Corps to discuss the primary equipment expectations for ground personnel, key load factors, and PPE weight changes since 2003. To describe the weight and how PPE contributes to the load burden on personnel we collected available weight data for the PPE and other equipment worn or carried by personnel in 2016—the most current data available at the time of our review. We also collected available data and documents from the early 2000s—prior to operations in Iraq that resulted in PPE changes—for the purposes of reviewing changes in weight over time. To assess the reliability of the data used to describe the weight of PPE and other equipment in this report, we discussed with relevant program managers topics related to how the data were collected, managed, and checked for accuracy and completeness. We also compared the weight data from the Army and Marine Corps for similar PPE and other equipment to identify any outliers in the weight data provided. We did not find any outliers in the weight data or identify any obvious errors. Therefore, we found the data to be sufficiently reliable for the purposes of describing the weight characteristics of PPE and examples of expected load totals on Soldiers and Marines.

To describe coordination efforts between the Army and Marine Corps related to weight reduction and equipment improvements, we obtained and analyzed working group charters and discussed with program managers how the Army and Marine Corps formally and informally share research and development information for PPE and other equipment. We also met with relevant officials to discuss their communication mechanisms, goals, plans, and research efforts that could potentially

⁴ For the purposes of this report, operational requirements for PPE refer to those protective standards, parameters, and specifications used by the services to guide development and address identified threats. The Army's Training and Doctrine Command and the Marine Corps' Deputy Commandant for Combat Development and Integration, generate specific operational requirements for soldiers and marines respectively.

reduce, offset, or better manage the weight of PPE or other equipment.⁵ For those weight reduction initiatives identified by the Army and Marine Corps, we obtained and analyzed research related documentation and interviewed project managers to understand the potential for weight reduction, development phases, and any available budget-related data. We also discussed efforts to reduce total load burden with research officials currently assessing the effects of weight on personnel performance. The weight reduction initiatives described in this report represent examples and not the totality of options or efforts being considered or researched. A complete list of offices and agencies we met with during this review is available in appendix I.

We conducted this performance audit from June 2016 to May 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Personnel from each of the services utilize a variety of PPE based on factors such as the operational environment, job description or occupation, and commander discretion.⁶ For example, Army and Marine Corps ground combat personnel utilize soft and hard body armor designed to protect against specific small arms, fragmentation, and other unconventional threats, such as improvised explosive devices. Likewise, personnel with aviation based occupations or explosive ordinance disposal responsibilities, and those operating in extreme climates or maritime environments have specific PPE options for their specific assignments. During ground combat operations in Iraq and Afghanistan in the 2000s, Soldiers and Marines typically wore tactical vests or plate carriers with hard armor ballistic inserts, a combat helmet, and other miscellaneous items such as eye protection and gloves. This PPE, added to the other items that personnel typically carry or wear in operational

⁵ For the purposes of this review, we excluded data associated with Army and Marine Corps special operations personnel based on differing requirements for PPE and other equipment.

⁶ This report focuses on the PPE used by Army and Marine Corps ground combat personnel but the Navy and Air Force also have specific PPE requirements and utilize a variety of equipment.

environments (weapon systems, food and water, communications equipment, and other items), cumulatively represent the total load burden on personnel.

The total load varies to some degree between the Army and the Marine Corps, and the services use specific load categories for mission-planning purposes. For example, the Army uses three combat loads, *fighting* (lightest), *approach march* (mid), and *emergency approach march* (heaviest), based on a number of factors, including mission duration and purpose, the likelihood of resupply, climate, and other characteristics that affect equipment and supply decisions.⁷ Similarly, the Marine Corps uses the following categories for mission and load-planning purposes: *fighting* (lightest), *assault* (mid), and *sustainment* (heaviest).⁸ According to Army guidance and Marine Corps documentation, the two services generally use these load parameters as a guide for determining the most appropriate equipment and supply levels required to meet mission objectives.

The services each have program offices that develop, acquire, and field PPE and other equipment based on generated and approved operational requirements for Soldiers and Marines. For example, Program Executive Office Soldier develops specifications, and acquires equipment, including PPE, based on capability requirements produced by the Army's Training and Doctrine Command. Similarly, the Marine Corps Systems Command develops, acquires, and fields PPE and other equipment to address operational requirements developed by the Capability Development Directorate of the Deputy Commandant for Combat Development and Integration. The service program offices typically collaborate with each

⁷ See generally Army Field Manual No. 21-18, *Foot Marches* (June 1, 1990). The Army fighting load generally includes minimum equipment necessary for direct combat operations (including weapon systems, PPE, and reduced amounts of ammunition). The approach march load includes fighting load items plus additional equipment necessary for prolonged dynamic operations until resupply is available. The emergency approach load represents the heaviest load for personnel movements and is generally used only when air and ground transportation is unavailable.

⁸ The Marine Corps fighting load includes those items essential to the accomplishment of immediate combat operations (including PPE, common assault equipment, and weapon systems). The assault load includes the fighting load equipment plus additional items necessary for individual mission characteristics. The sustainment load contains all items required for extended operations. "2016 FMID Individual Marine and Reinforced Rifle Squad Combat Load Report," Feb. 10, 2016.

other and partner with industry providers to research, design, and develop PPE and other equipment.

Current PPE Requirements Are Designed to Address Operational Risks but Also Contribute to the Total Load Burden on Ground Combat Personnel

Performance Parameters and Protection Standards Guide the Development of Primary PPE

The Army and the Marine Corps have developed requirements for PPE to address operational threats but these requirements contribute to the total load burden on ground combat personnel. The services expect ground combat personnel to wear a combination of equipment developed to meet these requirements, including hard armor plates, soft armor plate carrier vests, and combat helmets, as shown in figure 1.⁹ According to Army and Marine Corps program managers, these items individually provide specific functions that together form a protective system for personnel.

⁹ Hard armor plates refer to the enhanced small arms protective inserts, and the enhanced side ballistic insert. Other PPE items include eye and ear protection, gloves, knee pads, and protective undergarments.

Figure 1: Primary Personal Protective Equipment and Approximate Weight Specifications (2016)



Source: © 2015 Filo LLC (image of soldier), U.S. Army and U.S. Marine Corps (images of individual equipment); data provided by Army and Marine Corps. | GAO-17-431

Note: The equipment in figure 1 represents the primary personal protective equipment worn by both Soldiers and Marines in combat environments. The enhanced combat helmet, enhanced small arms protective insert, and enhanced side ballistic insert hard armor plates are shared between the Army and the Marine Corps. The weight specifications presented are approximate figures based on service-provided data for size medium equipment. These totals are subject to change based on updates, modifications, or improvements implemented by the services.

According to Army and Marine Corps documentation, the current system was initially developed and fielded to address specific threats facing personnel operating in Iraq (Operation Iraqi Freedom) in 2003. Officials stated that the two services conducted capability and threat assessments in this theater to determine how best to mitigate threats without hindering mobility or combat effectiveness. The services have documented these assessments and protection requirements in PPE guidance, technical documentation, and acquisition specifications, which include the size, weight, coverage area, protective standards, and other key parameters for each primary PPE component.¹⁰ These documents standardize PPE expectations and operational requirements for Soldiers and Marines. Officials noted that they are able to change PPE requirements or standards to meet evolving needs, incorporate technological advancements, or modify goals. Additionally, they provide industry partners with specifications needed to develop equipment. While the services have produced individual PPE guidance and technical documentation, officials noted that they jointly develop protection requirements and acquire some of the primary PPE components. For example, the Army and Marine Corps jointly acquired modern hard armor plates and have coordinated on the development and acquisition of the enhanced combat helmet. The two services also have similar standards for the soft armor plate carrier vests, but Marine Corps officials noted that because each service has some unique operational requirements, they developed and acquired this item separately.

¹⁰ Examples of primary PPE requirements documentation include (1) Marine Corps, Family of Body Armor (FBA) Operational Requirements Document (ORD) Change 8 (Mar. 30, 2012); (2) Marine Corps, Urgent Statement of Need (SON) for the Enhanced Combat Helmet (ECH) (Mar. 2, 2009); (3) Department of the Army, Operational Requirements Document (ORD) for Modular Body Armor (Mar. 4, 1996); (4) Department of the Army, Capability Production Document for Soldier Protection System (SPS) Integrated Head Protection System (IHPS) (Feb. 1, 2016).

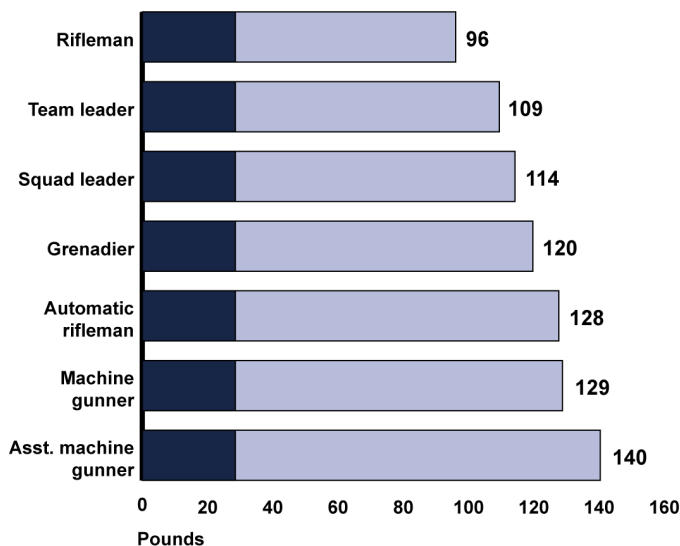
PPE Systems Increase the Total Load Burden on Ground Combat Personnel, Which Could Hinder Combat Effectiveness

Army and Marine Corps officials we met with stated that the body armor that was fielded to meet current threats provides significant additional protection when compared with previously available equipment. However, they also noted that providing this level of protection adds significant bulk and weight to the total load on Soldiers and Marines, which could impede mobility and have other adverse effects. Both Marine Corps guidance and Army capability requirements indicate that PPE should provide adequate protection levels without hindering mobility or combat effectiveness.¹¹ The primary PPE (hard armor plates, soft armor vest, and combat helmet) currently used by both Army and Marine Corps personnel averages approximately 27 pounds (for size medium equipment), and adds to the weight of other uniform items and equipment worn or carried by personnel. The cumulative weight of all uniform items and other equipment expected to be carried or worn by personnel in operational environments represents the total load and can vary according to individual position (e.g., squad leader, rifleman, grenadier) and mission characteristics (see figure 2).

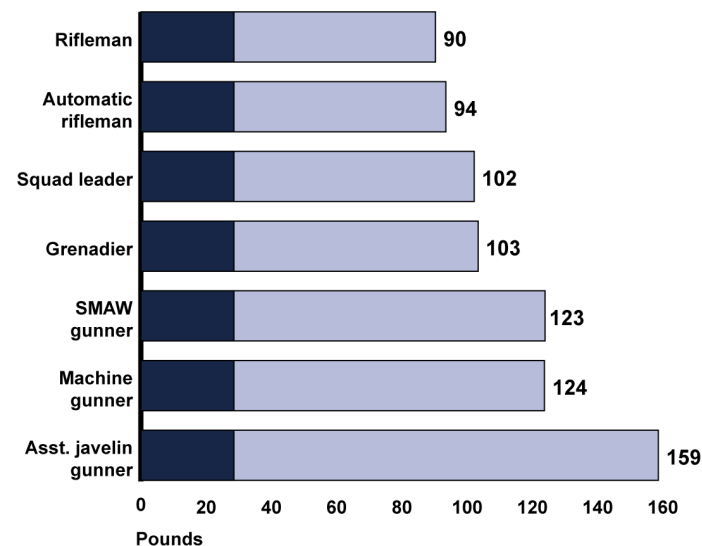
¹¹ See Marine Corps, *Policy for Implementation of Individual Marine Mobility Attribute* (Mar. 25, 2016); Army Capability Production Document for Soldier Protection System (SPS) Vital Torso Protection (VTP) (June 25, 2015).



Figure 2: Examples of Approximate Army and Marine Corps Total Loads by Position (2016)

Army Approach March Load »



Marine Corps Assault Load »



 Primary personal protective equipment (about 27 pounds)
 Other (food, water, ammunition, uniform items, weapon systems, communications equipment, etc.)
 SMAW Shoulder-launched Multipurpose Assault Weapon

Source: GAO analysis of Army and Marine Corps data. | GAO-17-431

Note: The Army approach march load and the Marine Corps assault load include those items typically required for immediate combat operations plus additional equipment such as food, water, and additional ammunition to sustain operations (until resupply is available). Army and Marine Corps officials said that these loads were typically used by ground combat personnel but may vary based on mission characteristics and other factors such as the range of PPE sizes.

According to program managers we met with, the typical total load on personnel has increased since about 2003 based on the incorporation of new PPE systems and other equipment that is designed to enhance personnel performance or protection capabilities. According to 2016 Marine Corps data, a typical load is expected to be approximately 90 to 159 pounds, or an average of 117 pounds, depending on the individual function within the squad. Similarly, Army ground personnel are expected to wear and carry approximately 96 to 140 pounds, or an average of 119 pounds, depending on individual roles. These can vary based on individual PPE sizes and other equipment variations. However, the expected totals for Army ground combat personnel generally align with actual load totals ranging from 96 to 151 pounds, reported by personnel recently operating in Afghanistan.

However, program officials also explained that excessive loads can have negative effects on personnel mobility, lead to earlier fatigue onset, and exacerbate the risk associated with high temperature operational environments. Army Field Manual 21-18, published in 1990, recommends that the fighting load not exceed 48 pounds and that the approach/march load not exceed 72 pounds.¹² According to program managers, the Marine Corps does not have specific load thresholds or maximums, but documentation identifies that loads in excess of 30 percent of body weight for ground combat personnel increase the likelihood of detrimental performance effects. Medical researchers from the services whom we met with agreed that these are some of the risks associated with substantial combat loads, and stated that they have attempted to correlate load burdens with detrimental performance and increased injury risks. For example, the Naval Health Research Center in San Diego, CA, collected injury data from personnel operating in Afghanistan and Iraq between 2011 and 2013 and concluded that excessive loads may have exacerbated the reported injuries. Service officials said that they are studying these potential effects on personnel performance, but also stated that the available load guidelines could be outdated and not reflective of current PPE systems and other capability enhancing equipment. Additionally, they note that these thresholds may not be appropriate for all personnel and that load thresholds or limits could restrict commander flexibility in the field by potentially impairing their ability to properly outfit personnel to meet mission requirements. Nonetheless, officials from both services stated that they continually seek ways to reduce the weight of PPE and reduce or offset the overall loads on personnel while maintaining operational capabilities and protection standards.

¹² Army Field Manual No. 21-18, Foot Marches, para. 2-7 (June 1, 1990). Army officials expect an update to this manual in 2017.

Army and Marine Corps Have Coordinated on PPE-Related Weight Reductions and Are Pursuing Efforts to Reduce Overall Load Burdens on Personnel

Army and Marine Corps Coordinate to Develop and Improve PPE

Army and Marine Corps officials coordinate through formal and informal working groups that seek to develop and improve PPE. For example, two to four times annually the services hold a Cross-Service Warfighter Equipment Board, which allows Army and Marine Corps representatives, along with members of the other military services, to share developments and advancements made to PPE and other individual equipment. The Army and Marine Corps also participate in the Personal Protective Equipment Capabilities Development Integrated Product Team, an interagency forum that shares information, such as injury data, research and development findings, material developments, technologies, and test methodologies, among key stakeholders involved in PPE development. In addition, the Army and Marine Corps work together on the development and procurement of PPE, such as the hard armor plates and the enhanced combat helmet that meet both services' needs.

Informally, the Army and Marine Corps regularly communicate on a variety of PPE-related research, technology advancements, and planning efforts. Officials from both Army and Marine Corps program offices explained that coordination is mutually beneficial based on similar equipment needs for ground combat personnel. Officials noted that they have collaborated on the development, management, and procurement of current hard armor plates since their inception in the early 2000s. Additionally, in August 2016 we observed a Marine Corps-sponsored industry event focused on the next iteration of the enhanced combat helmet, where an Army engineer participated and shared with vendors the Army's perspective on weight reduction priorities for the helmet. Army and Marine Corps officials stated that they collaborate with vendors to gather input for the development of PPE.

Army and Marine Corps Prioritize Protection Capabilities but Have Reduced the Weight of Some PPE and Have Plans for Additional Reductions

Army and Marine Corps program managers said that when developing or improving PPE and other equipment, they prioritize protection and operational capabilities, and that they have overarching goals of reducing weight, and improving form, fit, and function of equipment. These overarching goals have led to some improvements and reductions in the weight of some PPE. For example, the Army and Marine Corps have made updates and redesigned aspects of their respective soft armor vests, which according to program managers have resulted or will result in weight savings of up to approximately 40 to 50 percent, or about 6 to 7 pounds when compared with previous versions. In addition, according to Marine Corps documentation, the service is incentivizing industry partners to produce lighter equipment and systems by incorporating weight reduction as a part of the source selection process for the enhanced combat helmet.

Further, in 2016 the Army began developing a goal and subsequent plan to reduce the weight of hard armor plates by 20 percent, or about 2 pounds, by identifying and eliminating excess ballistic protection parameters and potentially updating testing methodologies.¹³ Officials said that protection standards have largely prevented significant reductions to date; however, they believe that the plates may be over-designed and heavier than necessary, based on actual operational threats and PPE performance data collected in Iraq and Afghanistan. According to research officials, updates would allow for weight reductions without increasing the ballistic risk to personnel. According to Army officials, the plan is currently pending approval by senior Army officials. If approved, researchers expect to develop new hard armor plates, with reduced weight, in fiscal year 2019.

The Army and Marine Corps are also pursuing other efforts to reduce the weight of PPE. For example, the Army and Marine Corps are promoting PPE scalability as an approach to realize near-term weight reductions. PPE scalability allows Soldiers and Marines to vary the levels of PPE worn, from minimal protection or no PPE to a maximum level whereby Soldiers and Marines utilize all available PPE. The Army and Marine Corps have categorized these protection levels based on configurations of all available PPE, and officials said that potential weight reductions could be realized if commanders were to adjust protection levels (amount

¹³ The RAND Corporation also recommended in 2012 that DOD review and potentially update its body armor testing methodologies to ensure that armor plates are not over-designed.

of PPE utilized) based on an evaluation of environment, threat, and mission characteristics. However, Marine Corps officials noted that commanders may be reluctant to increase operational risk by reducing PPE protection levels.

Finally, Army and Marine Corps researchers are exploring ways to better integrate individual equipment to provide improved functionality and potentially save weight. The Army's Warrior Integration Site and the Marine Corps' Marine Expeditionary Rifle Squad research the integration potential of all individual equipment worn by Soldiers and Marines. According to officials with whom we met, the two services see their analyses potentially resulting in improvements to the weight, form, and function of Soldier and Marine equipment. One analytical method used by both the Army and the Marine Corps entails load effect assessment programs that use instrumented obstacle courses to gather data and evaluate mobility and functions based on various combat loads that personnel experience (see figure 3 and associated video). Officials explained that these data and analyses help them identify specific equipment that could or should be improved. While these efforts may have implications for reducing the load burden of Soldiers and Marines, the main goal for both organizations is to improve personnel performance by providing better integration and function for equipment commonly utilized by Soldiers and Marines.

Figure 3: Marine Corps Load Effects Assessment Program Course



Source: U.S. Marine Corps. | GAO-17-431

To view a video of the Marine Corps Load Effects Assessment Program, see <http://gao.gov/products/GAO-17-431>.

Army and Marine Corps Are Exploring Other Research Initiatives to Reduce the Total Load Burden on Ground Combat Personnel

Army and Marine Corps researchers are exploring initiatives—such as improvements to logistics and resupply capabilities, load transfer technologies, lighter ammunition, and reduced battery usage—that may decrease the total load burden on ground combat personnel.

- **Improved Logistics and Resupply Capabilities.** Researchers at the Natick Soldier Research Development and Engineering Center said that they are exploring new technologies and systems that could provide improved logistics support for squads in the form of precise and on-demand resupply. Army officials noted that personnel loads are affected by confidence levels in resupply and logistics support. For example, squads that are more confident in resupply may be more willing to carry less ammunition, water, food, and other supplies, thus reducing the total weight carried by personnel. Therefore, developing new aerial delivery systems capable of providing small- and medium-sized payloads with precision could enable Soldiers and Marines to carry not more than the necessary equipment and supplies. The Marine Corps has implemented one of these systems, the Joint Precision Airdrop System, which was developed by the Army's Aerial Delivery Directorate at the Natick Soldier Research Development & Engineering Center. This system is designed to accurately deliver (within 150 meters) up to 700 pounds of supplies to personnel operating in inaccessible environments. A Marine Corps program official stated that the system would likely alter planning and allow personnel to forgo packing excess food, water, ammunition, and other supplies. They also stated that the procurement and sustainment costs for all units of this system totaled approximately \$850,000 for fiscal years 2013 through 2016.
- **Load Transfer Technologies:** The Army and Marine Corps are evaluating both manned and unmanned load transfer technologies capable of travelling with units or squads (see figure 4). These technologies may allow Soldiers and Marines to offload some items such as food, water, or ammunition. For example, the Marine Corps is currently employing 144 MRZR all-terrain vehicles capable of traveling with squads and transporting up to 1500 pounds of personnel, equipment, and supplies. Marine Corps officials stated that the total acquisition and sustainment costs for all the vehicles are projected to be approximately \$15 million between fiscal years 2016 and 2018. Similarly, the Army is in the process of developing an unmanned or optionally-manned squad support vehicle capable of traveling with dismounted personnel and carrying up to 1000 pounds of equipment. The prototypes include both tracked and wheeled variants. Army officials stated that they plan to pursue this as an official program and

field the vehicles in fiscal years 2020 and 2021. In addition, the Defense Advanced Research Project Agency supported similar research and development efforts by designing and testing the Legged Squad Support System, which researchers stated had the intended capability to carry up to 1,000 pounds of equipment and travel semi-autonomously with squads and fire teams. While the Army and Marine Corps are not currently pursuing this specific system, they plan to test additional unmanned ground systems with similar load transferring and mobility capabilities.

Figure 4: Examples of Manned and Unmanned Load Transferring Systems



Legged Squad Support System



Marine Corps MRZR All-Terrain Vehicle



Squad Mission Support System

Sources (left to right): U.S. Marine Corps, U.S. Marine Corps, (C) 2012 Lockheed Martin Corporation. | GAO-17-431

- **Lighter Ammunition:** Army and Marine Corps program managers are developing lightweight technologies and monitoring third-party research related to the development of polymer-case ammunition for commonly used .50 caliber, 7.62 mm, and 5.56 mm rounds. According to program managers, transitioning to polymer based ammunition casing could reduce ammunition weight by as much as 20 to 35 percent based on the weight difference between lighter polymer casing and traditional brass casing. The Marine Corps began testing a polymer-case .50 caliber round in March 2017, which could replace legacy ammunition without modifying the .50 caliber weapon systems currently in use. However, significant weight savings for personnel would require implementing this technology for smaller-caliber rounds with lightweight polymer-case compatible weapon systems, and officials noted that these investments would likely hinder near-term implementation.
- **Reduced Battery Usage:** The Army and Marine Corps are researching potential hardware and software changes that could reduce the energy demand for some commonly carried electronics

and thus reduce energy usage and weight associated with batteries. For example, Army researchers stated that they are evaluating systems that harvest energy from Soldiers' movements and solar technology that could be used to power communications systems and other battery-driven equipment. Additionally, officials noted that they are monitoring private-sector technology developments that could reduce the weight of batteries by 20 percent while providing the same amount of energy as those batteries currently used. Marine Corps program officials explained that they are also developing a single radio with the same capability as is provided by two separate radios currently used by Marines. Officials stated that this new radio may reduce the need to carry excess batteries. However, Army and Marine Corps officials noted that battery demand and its associated weight continue to pose a significant challenge. For example, Army program managers said that squad leaders currently carry approximately 8 pounds of batteries to power a variety of optics, communications systems, and other equipment.

Agency Comments

DOD provided technical comments on a draft of this report, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees and to the Secretary of Defense, the Secretaries of the Army and the Navy, and the Commandant of the Marine Corps. In addition, the report will be available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-5431 or russellc@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.

A handwritten signature in black ink, reading "Cary Russell". The signature is fluid and cursive, with the first name "Cary" and last name "Russell" clearly distinguishable.

Cary Russell
Director, Defense Capabilities and Management

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Thad Cochran
Chairman
The Honorable Richard Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Kay Granger
Chairwoman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Agencies and Offices with Whom We Met During This Review

- Army
 - Assistant Secretary of the Army for Acquisition, Logistics and Technology, Program Executive Office Soldier, Product Manager Soldier Protection and Individual Equipment
 - Training and Doctrine Command, Maneuver Center of Excellence, Capabilities Development and Integration Directorate, Soldier Requirements Division, Soldier Systems Branch
 - Training and Doctrine Command, Maneuver Center of Excellence, Capabilities Development and Integration Directorate, Maneuver Battle Lab, Experimentation Branch
 - Natick Soldier Research, Development, and Engineering Center, Warfighter Directorate
 - Natick Soldier Research, Development, and Engineering Center, Aerial Delivery Directorate
 - U.S. Army Research Institute of Environmental Medicine
- Navy and Marine Corps
 - Naval Health Research Center
 - Office of Naval Research, Expeditionary Maneuver Warfare and Combating Terrorism Department
 - Marine Corps Combat Development Command, Futures Directorate, Marine Corps Warfighting Laboratory
 - Program Executive Office Land Systems, Program Manager, Light Tactical Vehicles
 - Marine Corps Systems Command, Program Manager Infantry Weapon Systems, Product Manager Infantry Combat Equipment
 - Marine Corps Systems Command, Program Manager Infantry Weapon Systems, Product Manager Reconnaissance and Amphibious Raids
 - Marine Corps Systems Command, Program Manager Ammunition
 - Marine Corps Systems Command, Program Manager Marine Expeditionary Rifle Squad
 - Marine Corps Systems Command, Program Manager Marine Air-Ground Task Force Command Control & Communications
 - Deputy Commandant, Combat Development and Integration

**Appendix I: Agencies and Offices with Whom
We Met During This Review**

- Headquarters, U.S. Marine Corps, Fires and Maneuver Integration Division
- Other Department of Defense Organizations
 - Defense Advanced Research Projects Agency

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Cary Russell, (202) 512-5431 or russellc@gao.gov

Staff Acknowledgments

In addition to the contact named above, Alissa Czyz (Assistant Director), Larry Juneke (Assistant Director), Alexandra Gonzalez, Amie Lesser, Sean Manzano, Michael Shaughnessy, Michael Silver, Grant Sutton, and Cheryl Weissman made key contributions to the report.

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