Lightening the Load

Briefing to
Honorable Delores M. Etter
Assistant Secretary of the Navy
(Research, Development and Acquisition)

September 2007
**Report Documentation Page**

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

<table>
<thead>
<tr>
<th>1. REPORT DATE</th>
<th>SEP 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. REPORT TYPE</td>
<td></td>
</tr>
<tr>
<td>3. DATES COVERED</td>
<td>00-00-2007 to 00-00-2007</td>
</tr>
<tr>
<td>4. TITLE AND SUBTITLE</td>
<td><strong>Lightening the Load</strong></td>
</tr>
<tr>
<td>5a. CONTRACT NUMBER</td>
<td></td>
</tr>
<tr>
<td>5b. GRANT NUMBER</td>
<td></td>
</tr>
<tr>
<td>5c. PROGRAM ELEMENT NUMBER</td>
<td></td>
</tr>
<tr>
<td>5d. PROJECT NUMBER</td>
<td></td>
</tr>
<tr>
<td>5e. TASK NUMBER</td>
<td></td>
</tr>
<tr>
<td>5f. WORK UNIT NUMBER</td>
<td></td>
</tr>
<tr>
<td>6. AUTHOR(S)</td>
<td></td>
</tr>
<tr>
<td>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</td>
<td><strong>Naval Research Advisory Committee, 875 North Randolph Street Suite 1230, Arlington, VA, 22203-1995</strong></td>
</tr>
<tr>
<td>8. PERFORMING ORGANIZATION REPORT NUMBER</td>
<td></td>
</tr>
<tr>
<td>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</td>
<td></td>
</tr>
<tr>
<td>10. SPONSOR/MONITOR’S ACRONYM(S)</td>
<td></td>
</tr>
<tr>
<td>11. SPONSOR/MONITOR’S REPORT NUMBER(S)</td>
<td></td>
</tr>
<tr>
<td>12. DISTRIBUTION/AVAILABILITY STATEMENT</td>
<td><strong>Approved for public release; distribution unlimited</strong></td>
</tr>
<tr>
<td>13. SUPPLEMENTARY NOTES</td>
<td></td>
</tr>
<tr>
<td>14. ABSTRACT</td>
<td></td>
</tr>
<tr>
<td>15. SUBJECT TERMS</td>
<td></td>
</tr>
<tr>
<td>16. SECURITY CLASSIFICATION OF:</td>
<td></td>
</tr>
<tr>
<td>a. REPORT</td>
<td>unclassified</td>
</tr>
<tr>
<td>b. ABSTRACT</td>
<td>unclassified</td>
</tr>
<tr>
<td>c. THIS PAGE</td>
<td>unclassified</td>
</tr>
<tr>
<td>17. LIMITATION OF ABSTRACT</td>
<td><strong>Same as Report (SAR)</strong></td>
</tr>
<tr>
<td>18. NUMBER OF PAGES</td>
<td>43</td>
</tr>
<tr>
<td>19a. NAME OF RESPONSIBLE PERSON</td>
<td></td>
</tr>
</tbody>
</table>

*Standard Form 298 (Rev. 8-98)*

Prepared by ANSI Bal Z39-18
“We are careful not to load a mule with more than a third of his own weight.”

- Col. S.L.A. Marshall
*The Soldiers Load* (1950)
The Problem

- Squad Leader
- Rifleman

<table>
<thead>
<tr>
<th>Year</th>
<th>Recommended Assault Load</th>
<th>Actual Assault Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>60</td>
<td>140</td>
</tr>
<tr>
<td>1920</td>
<td>40</td>
<td>120</td>
</tr>
<tr>
<td>1940</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>1960</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>1980</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>2000</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>2020</td>
<td>60</td>
<td>20</td>
</tr>
</tbody>
</table>

% Body Weight for Average Marine

- Recommended Assault Load
- Actual Assault Load
Outline

• Problem
• TOR
• Membership
• Study Approach
• Options
  - Lighten the load
  - Transfer the load
  - Enhance human performance
  - Establish a systems approach
• Recommendations
• Actions
Terms of Reference: Objectives

• Assess the elements of the combat load carried by today’s Marine
• Identify the primary weight and volume contributors
• Identify and evaluate technology initiatives
• Consider changes in operations, logistics, and training to reduce this burden without having an unacceptable impact on combat effectiveness, safety, or tactics.
Panel Membership

Mr. Jack Bachkosky – Chair
Former Deputy Under Secretary Defense for Advanced Technology

Dr. A. Michael Andrews II – Vice Chair
VP, L-3 Communications; Former Army Deputy Assistant Secretary and Chief Scientist

Dr. Robert Douglas
Member, Army Science Board

BGen James M. Feigley, USMC (Ret.)
Former Commander Marine Corps Systems Command

RADM Lew Felton, USN (Ret.)
Former Chief Engineer, Naval Sea Systems Command

Dr. Frank L. Fernandez
Consultant; Former Director, Defense Research Projects Agency

MajGen Paul Fratarangelo, USMC (Ret.)
NRAC Associate

Dr. Anna Johnson-Winegar
Former Deputy Assistant to the Secretary of Defense for Chemical and Biological Defense

VADM Rudy Kohn, Jr, USN (Ret.)
Former Commander, Naval Air Force, US Pacific Fleet

Mr. Norman Polmar
U.S. Naval Institute

Mr. Dick Rumpf
Former Principal Deputy Assistant Secretary of the Navy/Acting Assistant Secretary of the Navy (Research, Engineering and Systems)

Dr. John C. Sommerer
NRAC, Vice Chair; Director, S&T, Johns Hopkins Applied Physics Laboratory

Dr. Walt Williamson
Chair, Department of Engineering, Texas Christian University

Study Sponsor
LtGen James F. Amos, USMC
Deputy Commandant for Combat Development & Integration

Executive Staff
Major Brian Christmas, USMC
Executive Secretary, Fires, Maneuver & Integration Office, Combat Development & Integration

Mr. Greg Kesselring – Consultant
USMC (Ret.), Contractor, Marine Corps Warfighting Lab
Study Approach

• Understanding the problem
• Briefings, reports, and discussions
• Sub-panels
  - Reduce the weight
  - Transfer the load
  - Enhance human performance
  - Systems approach
• Analyzed data
• Examined alternatives
• Developed recommendations and actions
Briefing Topics

• Overview from Army Science Board, PEO Soldier, Distributed Operations, etc.
• LTL Perspective: Organization/Command/Policy
• LTL Perspective: Allies
• Recent Combat Experience Panels
• Marine Corps and Army Lessons Learned
• Experimentation
• Logistics
• PM Current Equipment Status and Plans
• Training
• Technology: ONR, DARPA, Army, MCWL, etc.
## Marine Rifleman Loads

<table>
<thead>
<tr>
<th>Load Description</th>
<th>Recommended Load*</th>
<th>Current Rifleman’s Load**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assault Load</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(In the Fight)</td>
<td>50 lb 30% of body wt based on Avg Marine (169 lb)</td>
<td>97 lb 57% of body wt</td>
</tr>
<tr>
<td>Conduct combat operations indefinitely with minimal degradation in combat effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Approach March Load</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Getting to the Fight)</td>
<td>76 lb 45%</td>
<td>123 lb 73%</td>
</tr>
<tr>
<td>Conduct 20-mile march within 8 hours maintaining 90% combat effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Existence Load</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited movement within confines of transportation platforms and limited marching from landing zone into secure area</td>
<td>127 lb 75%</td>
<td>167 lb 99%</td>
</tr>
</tbody>
</table>

* MIL-STD-1472F
** Information received from MCCDC, Quantico
Load Impacts Performance

Marching Distance in 8 Hours

Curve based on Goldman
Metabolic Energy Cost Model
March 1988
Marine Rifle Squad

13 Marines plus 1 Corpsman
Individual Assault Load

Actual Assault Loads

<table>
<thead>
<tr>
<th>Role</th>
<th>Load in Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rifleman</td>
<td>97 lb</td>
</tr>
<tr>
<td>Automatic Rifleman</td>
<td>117 lb</td>
</tr>
<tr>
<td>Assistant Automatic Rifleman</td>
<td>114 lb</td>
</tr>
<tr>
<td>Fire Team Leader</td>
<td>132 lb</td>
</tr>
<tr>
<td>Squad Leader</td>
<td>134 lb</td>
</tr>
<tr>
<td>Corpsman</td>
<td>97 lb</td>
</tr>
</tbody>
</table>

50 lb Recommended Maximum Assault Load
Squad Assault Load

- Total squad load w/Corpsman
  ~1,620 lb

- Squad load
  ~900 lb more than recommended
Top Level Findings

- Individual Marine assault load varies from about 97 to 135 lb vs. 50 lb recommended maximum
- Total Squad Assault load is about 1,620 lb, about 900 lb over recommended maximum Squad load
- Squad and individual equipment are designed and procured independently and are not considered as a system
- Most optimistic outcome of all S&T efforts may result in:
  - ~ 300 lb potential weight savings per squad
  - ~ 300 lb potential weight transfer per squad
  - ~ 300 lb that still needs to be carried or eliminated through tactics
- Over-matching threats exist and will persist
- PM MERS does not have the directive authority, capability or resources necessary to execute systems engineering process
Lightening the Load

Future Ammunition

Future Rifleman

Future Fuel Cell
Reducing the Weight: Investment

- **ONR**
  - $33M in 40 programs (Marine as a system, power, sensors and electronics, warrior performance and protection, and materials)

- **Army**
  - ~$75M for PPE, comms, power, weapons, ammo, food human performance

- **DARPA**
  - Funding levels undetermined
  - Power, load transfer and human performance

- **Navy and Air Force**
  - Funding levels undetermined
  - Load consideration for Corpsmen, Riverine Ops, Seabees, Security

Lightening the Load is about 1% of the DOD S&T Investment
### Reducing the Weight: S&T Forecast

<table>
<thead>
<tr>
<th>Category</th>
<th>~ Individual Weight Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPE – Advanced Materials (nanotechnology)</td>
<td>4 to 6 lb</td>
</tr>
<tr>
<td>Weapons and Ammo – Caseless Ammo and Lightweight Weapon</td>
<td>5 lb</td>
</tr>
<tr>
<td>Integrated Optics</td>
<td>3 to 7 lb</td>
</tr>
<tr>
<td>Overall Marine Systems Integration</td>
<td>2 lb</td>
</tr>
<tr>
<td>Advanced Batteries</td>
<td>1+ lb</td>
</tr>
</tbody>
</table>

Possible Savings of ~ 10 to 20 pounds per Marine (~300 per squad but would still be ~ 600 pounds overweight)
## S&T Weight Reduction Potential

<table>
<thead>
<tr>
<th>Role</th>
<th>Load in Pounds</th>
<th>Recommended Assault Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rifleman (3)</td>
<td>97 lb</td>
<td>77 lb</td>
</tr>
<tr>
<td>Automatic Rifleman (3)</td>
<td>117 lb</td>
<td>97 lb</td>
</tr>
<tr>
<td>Assistant Automatic Rifleman (3)</td>
<td>114 lb</td>
<td>94 lb</td>
</tr>
<tr>
<td>Fire Team Leader (3)</td>
<td>112 lb</td>
<td>114 lb</td>
</tr>
<tr>
<td>Squad Leader (1)</td>
<td>132 lb</td>
<td>114 lb</td>
</tr>
<tr>
<td>Corpsman (1)</td>
<td>134 lb</td>
<td>97 lb</td>
</tr>
</tbody>
</table>

Squad remains ~ 600 lb overloaded

50 lb Recommended Assault Load
Transferring The Load
Transferring the Load: Offload

(14) Squad Members
- Gas Mask ~6 lb
- MREs ~4 lb
- Gortex ~4 lb
- Face Paint < 1 lb
- Patrol Pack ~2 lb

(4) Fire Team / Squad Leaders
- Gas Mask Voice Adapter < 1 lb
- 9 of 18 M203 Grenades ~7 lb

(3) Assistant Automatic Riflemen
- 1 of 2 Drums 5.56 mm ~7 lb

Assault Squad can transfer ~ 300 lb
Transferring the Load: Offload

Manned/Unmanned Ground Vehicles

- Marine Corps in process of fielding a manned Internally Transportable Vehicle (ITV)
  - Off-board power and a node in the communications network are considered

- Army/DARPA/Allies have invested heavily in unmanned followers and mules

- Provide small unit leaders organic access
Transferring the Load: Offload

Manned/Unmanned Aviation Vehicles

- Marine aviation has capability to provide direct support to small units – limited by number of platforms
  - Support designated squads as primary customers

- Navy/Army/DARPA are investing in unmanned air vehicles for cargo loads of 30 to 300 lb
Offload Weight Potential Savings

After S&T and Offload Weight Reductions

<table>
<thead>
<tr>
<th>Role</th>
<th>Load Reduction</th>
<th>Load After Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rifleman (3)</td>
<td>61 lb</td>
<td>77 lb</td>
</tr>
<tr>
<td>Automatic Rifleman (3)</td>
<td>81 lb</td>
<td>97 lb</td>
</tr>
<tr>
<td>Assistant Automatic Rifleman (3)</td>
<td>70 lb</td>
<td>94 lb</td>
</tr>
<tr>
<td>Fire Team Leader (3)</td>
<td>88 lb</td>
<td>112 lb</td>
</tr>
<tr>
<td>Squad Leader (1)</td>
<td>90 lb</td>
<td>114 lb</td>
</tr>
<tr>
<td>Corpsman (1)</td>
<td>61 lb</td>
<td>77 lb</td>
</tr>
</tbody>
</table>

Squad remains ~ 300 lb overloaded

50 lb Recommended Assault Load
• **Combat effectiveness**
  - Impacted by numerous factors, including fatigue, psychological stress, nutrition, environmental conditions, etc.

• **Physiological Models and Metrics**
  - Adequate models do not exist that incorporate combat effectiveness parameters and predict human performance
Enhance Human Performance: Options

• Nutrition
  - First Strike Rations provide more calories and carbohydrates to boost energy
  - Caffeine supplements now included in MREs
  - Other supplements (tyrosine, quercetin, etc.) are being studied

• Physical training
  - Functionally designed to address operational environment
  - Tailored to individual

• Ergonomics
  - Research programs to balance the load and assess fatigue contribute to understanding the decrements in performance

Nutrition, ergonomics and physical training...only marginal difference
• Advanced tactical concepts (e.g. Combat Hunter) may permit reducing the combat load

• Early indications point to a possible reduction in squad operational risk
  – Presents an opportunity to reduce weight that compensates for risk

• Advanced immersive training simulators will further advance tactical changes
  – Presents high fidelity conditions that enable higher standards for performance
  – Provides further opportunities to decrease risk induced weight burdens
A Fundamental Change To Lighten The Load Is Needed!

(More game changing concepts like “Combat Hunter”)

To further reduce squad weight in the near term, and accommodate changing needs without increasing weight.
An Example: Game Changing Concept

• A Squad that can rapidly:
  - Find the enemy through advanced ISR in complex terrain
  - Fix the enemy location with precision
  - Finish the enemy (organically or with other resources)

...can then decrease their load

...and accommodate new challenges without increasing individual Marine weight

Weight ↓ = ↑ Performance
• Current sequential development process is ineffective…Change is needed!
• Requires a new approach to systems development
  - Parallel / integrated development of tactics, technology and training; experimentation; iteration
  - System level models to allow tradeoffs between weight and other squad combat performance variables…and to design experiments

“Game changing approaches require game changing processes.”
Systems Approach
Current Acquisition Approach

- Seven program managers contribute to squad equipment/weight
- PM MERS was created to provide systems engineering for the squad
- Systems engineering “drives the balanced development of systems products”
Marine Rifleman

Lightweight Kevlar Helmet

Ballistic Eye Protection

Hydration Device with Water Purification System

Fire Retardant Gloves

First Aid Kit

Fragmentation Grenades Smoke Grenade M16 Magazines

Bayonet Scabbard

Knee Pads

AN/PVS-14 Night Vision

Personal Radio (Headset and Radio)

Ballistic Hearing Protection

Tactical Vest w/Small Arms Protection Inserts (PPE)

Rifle Combat Optic

Elbow Pads

AN/PEQ-2A Laser Pointer

M16A4 Rifle w/ Sling

M9 Bayonet

Digital Camouflage Uniform

Not Shown:
- Grip Pod on M16A4
- Cooling Vest
- Fire Resistant Balaclava
- Load Bearing Equipment
- Gas Mask

November 2006
Systems Engineering Process

- Effectiveness Requirements Analysis
- Trade Studies; Effectiveness Analysis
- Performance Analysis
- Support Design; Interface control

• Modeling and Simulation Tools to support Systems Engineering Process are inadequate
• Very limited experimental data available
Systems Approach: Findings

- PM MERS does not have the directive authority necessary to execute an effective systems engineering process.

- Data and system level models are needed for development of requirements and implementation of systems engineering process.

- Data and system level models on relationship of squad equipment weights to mission effectiveness – do not exist.

- PM MERS is unable to conduct trade-off analysis to reduce squad load and/or increase squad effectiveness. Areas include:
  - Weapons (range, accuracy)
  - Survivability
  - Mobility
  - Sensors / situation awareness
  - Logistic responsiveness
  - Immediate fires
Present and Future Trade-Offs

Dedicated ISR

Helmet Integration including Fused Optics
Lighter Weapon using Caseless Ammunition
Lighter Body Armor

Single Power Source Weapons Marine

Integrated, Multi-Band Communications

Physical and Operational Training

Performance Enhancement Supplements Available

MULE with Battery Recharging and Comm Hub Capability

Dedicated Assault Support / Resupply
Systems Approach Conclusions

• **PM MERS** was established as a program office to *institute systems integration* but has not fully matured due to a *lack of authority, resources, and capabilities*

• *Reductions in weight* will not be realized without a *systems engineering approach*

• A *disciplined systems engineering approach is mandatory* as we move toward the future Marine and introduce new capabilities into the squad as a system

• *Trades of weight vs. new capabilities* must be conducted to ensure projected weight reductions *enabled through S&T and weight transfer* are not eroded
Recommendations

• **Science & Technology**
  - Protect current investment – IT IS THE FOUNDATION
  - Increase Marine Corps engagement with ONR and interaction with DARPA
  - Increase efforts to reduce load and improve Marine Rifle Squad lethality, survivability, mobility and training

• **Models**
  - Assess impact of load on individual combat effectiveness
  - Perform Marine / Squad system level trade offs
  - Provide Small Unit Leaders load planning tools to assess impact of load, environment, physiological status on combat effectiveness

• **Experiments**
  - Collect data required to populate, calibrate the models
  - Conduct Limited Objectives Experiments (LOE) focused directly on tactical concepts and support technologies to reduce squad weight
  - Concurrently analyze training and future technologies required to implement promising concepts

• **Management**
  - Recognize and develop Marine Rifle Squad as a system
Actions

- **ASN (RDA)**
  - Increase ONR investment in Lightening the Load
  - Advocate appropriately funded, multi-service S&T program for Lightening the Load with DDRE

- **CMC**
  - Engage with the Director DARPA to nominate Program Managers and Marine Liaison Officer
  - Establish partnership with DARPA on advanced ISR, lethality, tactics to reduce weight, improve survivability and combat effectiveness

- **DC CD&I**
  - Establish maximum load weights for the Marine and the Rifle Squad
  - Ensure Integration Divisions and MCWL are effectively coordinating with ONR
  - Annually review all Marine Corps programs at ONR

- **COMMARCORSYSCOM**
  - Assign total “Squad as a System” management authority to PM MERS
  - Provide resources to create effective “Squad as a System” systems engineering capability

- **CNR / VCNR**
  - Develop, validate and deliver three models to MARCORSYSCOM:
    - Squad combat effectiveness as a function of load, terrain, environment and other pertinent parameters
    - Impact of load on individual performance (endurance, mobility, combat effectiveness, etc.)
    - Models for system trade of studies (ISR capability, lethality, weight, mobility, survivability, etc.)
  - Capitalize on all unmanned vehicle developments to satisfy organic needs of the Marine Rifle Squad
“We were ordered to wear everything everywhere in the mountains all the time...Even if you were in great shape, you couldn’t keep up with the enemy.”

- Commanding Officer,
  1st Bn, 3rd Marines
  14 Nov 2006
“Ounces equal pounds and pounds equal pain.”

- Marine Corps NCO Lessons Learned Conference August 2005