

# An Integrated Optimization System for Lightening the Load of Warfighters

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## PROBLEM STATEMENT

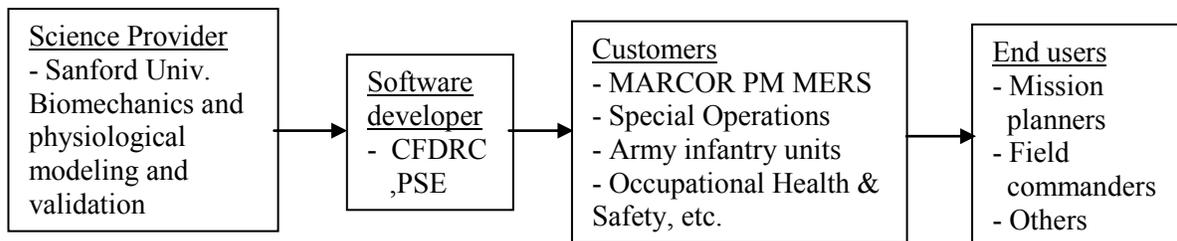
Warfighters are increasingly relying on technology equipment to ensure safety, mission effectiveness, and situational awareness. This equipment increases the capabilities of warfighters but also adds to their weight burden. According to the Naval Research Advisory Committee (NRAC) report by Bachkosky et al. (2007), the average Marine carries 97 to 135 pounds in assault load, far above the recommended weight of 50 pounds. The equipment provides the means for each warfighter to ensure self-protection, situational awareness, and precision lethality. However, these extreme loads could cause significant stress on the musculoskeletal system and lead to the physiological deficits of physical and mental fatigue and even injuries. Moreover, when the warfighter is exhausted by the demands of carrying heavy loads for extended periods, the result is decreased mobility and maneuverability, increased reaction time, and degraded overall performance. Therefore, it is highly desired to lighten the combat/mission load for warfighters.

The most straightforward way to lighten the load of warfighters is the science and technology (S&T) efforts for lighter weapons and equipments. However, this in general requires material technology breakthroughs and follow-up development work, which may need years to complete; in addition, such effort could only reduce the load by 10% to 20% by coarse estimate. Therefore, other approaches such as new tactics on mission planning are needed to lighten the load of warfighters. These new tactics of mission planning include modeling and simulation (M&S) effort to understand the effect of equipment on warfighter's performance and tradeoff analysis between equipment load (survivability, lethality, sustainability) and warfighter performance (mobility, maneuverability).

To address this need, we are in the process of **building a predictive software tool that can help field commanders to assess the negative effects of excessive equipment load on individual warfighters and to make informed decisions after evaluating the trade-off between the benefits and harms.**

### WHO CAN BENEFIT?

The software tool being developed addresses the needs of a field commander or mission planner of small military units, such as a Manager Marine Expeditionary Rifle Squad (MERS). The resultant software product will be used by them to conduct tradeoff analyses to design a squad with optimal combat effectiveness with respect to mission objectives while lightening the load for warfighters. The prime acquisition program for the target tool is MARCORPSYSCOM PM MERS (Program Manager Marine Expeditionary Rifle Squad). In addition, this technology will be directly applicable to most DoD branches, special operations forces, law enforcement, etc. This technology for modeling and simulation of human performance can also be applicable to civilian applications on occupational health and safety and thus will benefit medical rehabilitation device manufacturers, sports equipment manufacturers, and vehicle manufacturers, etc.



### BASELINE TECHNOLOGY

In general, field commanders plan missions by envisioning the mission tasks, warfighters to be deployed, and available equipment and then composing a team of warfighters with required capabilities (agility, survivability, lethality, etc.). To achieve mission objectives and ensure the safety of warfighters, the commanders tend to play safe and select extra equipment which may add less value towards achieving the mission objectives than others. However, the extra equipment load could induce substantial adverse effects that overshadow their benefits. Nonetheless, field commanders lack the essential knowledge on how extra equipment will impact the performance of warfighters during the course of the mission, especially for missions conducted in unfamiliar or extreme environments. The process of selecting equipment highly relies on commanders' experience and his knowledge of warfighter's physical condition, which sometimes could endanger the warfighters and fail the mission.

## TECHNOLOGY DESCRIPTION

The core technology of this work is modeling and simulation of warfighters' biomechanical and physiological performance during military tasks (such as patrol, running, jumping, etc.). The main goal is to accurately assess the effect of equipment load on the performance (e.g. joint loads, muscle loads, metabolism, fatigue, injury, etc.) of individual warfighters. Currently, similar modeling and simulation activities are mainly conducted by academia or military research labs because these studies require in-depth knowledge of biomechanics and physiology from the researchers. Furthermore, the results from these studies are not immediately useful for field commanders or mission planners. **Although some of the basic research is being performed in academia, there are no practical tools that can be used by mission planners.**

The joint team between CFDRC, Stanford Univ. and Pacific Science & Engineering (PSE), has the required expertise on biomechanics and physiology of human motion and is actively conducting modeling and simulation as well as experimental studies to evaluate equipment load effect on warfighters' performance. In addition, CFDRC is spearheading development of an easy-to-use software tool that can perform such simulations and present meaningful and useful information on graphic display to field commanders and mission planners.

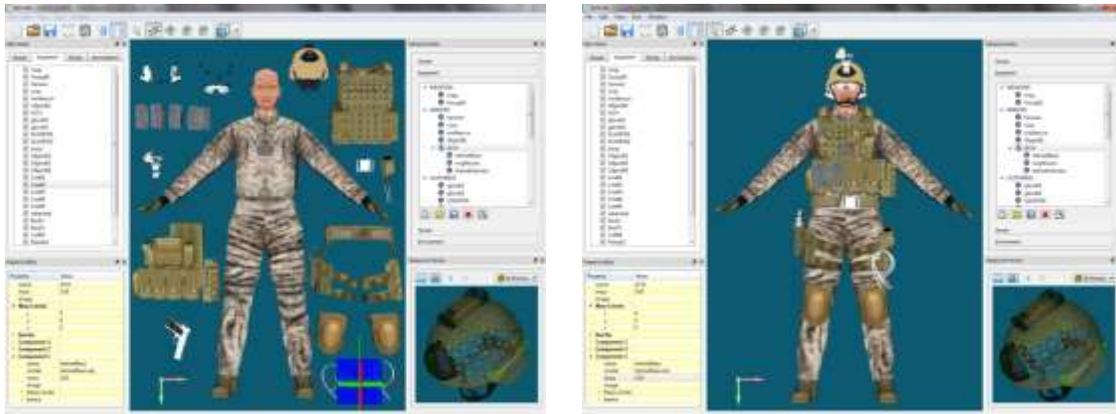
The key method of our technology is to conduct trade-off analysis between equipment load (survivability, lethality, sustainability) and warfighter performance (mobility, maneuverability) with detailed physical and physiological models of individual warfighters. A squad of warfighters, such as MERS, will be treated as a system since the squad members must act in concert to accomplish a mission. A system trade-off studies involving lethality, weight, mobility, survivability, etc., should be conducted to ensure the squad combat effectiveness for fulfilling missions while lightening the load. The goal is to produce an easy-to-use Squad Mission Planning System (SMPS) software, which can assist mission planners to make informed decisions. The Squad Mission Planning System (SMPS) software is an intelligent tool that provides valuable assessment regarding the tradeoff between the equipment load and the warfighter's performance, and it can be integrated into portable military computer devices that field commanders use.

Below is the Feature, Advantages, and Benefits (FABs) table of the product.

Feature	Advantage	Benefit
Physiological-based model	Based on experimental data	Accurate analysis
Warfighter specific	Model each warfighter individually	Considers the differences on anthropometry, strength, fitness of warfighters
Assessment of equipment effects and suggestion of equipment distribution	Sophisticated tradeoff analysis	Maximize squad performance while lightening individual equipment load
Cross-platform software development	Can be integrated to handheld devices or portable computers	Field commanders can use it for field missions
Open source free software (for DoD)	Collaborative development	No license fees, allows custom development and extension projects

### CURRENT STATE OF DEVELOPMENT

The software product currently being developed includes four major modules: human body dynamics, equipment database, warfighter motion prediction, and mission optimization. CFDRC has completed the first two modules and is actively working on the third one. The Stanford Univ. team has been conducting load carry experiments on many recruited subjects and evaluating the biomechanics and physiological effects of the load on the human body, which provide valuable data for model validation and improvement. The Pacific Science & Engineering (PSE) team is currently adapting their Mission Equipment Optimization Toolkit (MEOT) software for squad mission planning. In summary, we are in good standing to fulfill our technical goals and have solid plans to integrate the joint efforts to form the final software product.



Squad Mission Planning Software (SMPS): Equipment Database

## REFERENCES

ONR-STTR Technical Point of Contact (TPOC)  
Phone: 703-696-0364

## WHEN THE TECHNOLOGY WILL BE READY FOR USE

Our current technology development status is TRL 4. Representative models and software modules are tested, and subsystems or components are demonstrated and validated in relevant environment. What remains to be done is the completion of all modules, integration of these modules, and finally developed a fully functional software product, which will be ready for use before Dec. 2012.

The product will be delivered to ONR and other DoD branches with open source, providing a programming development platform for future extension and improvement.

## ABOUT THE COMPANY

**CFD Research Corporation (CFDRC)** is a technology leader in engineering simulations and innovative designs. CFDRC researches, develops, and provides innovative solutions for:

- Aerospace & Defense
- Biomedical & Life Sciences
- Energy and Materials

CFDRC develops cutting-edge technologies (software & hardware, designs and prototypes) with Federal agencies while providing for the highest possible leverage to our industry partners. CFDRC is a woman-owned Small Business, and is nationally recognized for successful commercialization of innovative technologies. CFDRC was founded in 1987, and has grown steadily over the years.

The Computational Medicine and Biology Division of CFDRC has extensive expertise in modeling human injury and protection, in particular the modeling of primary and secondary traumatic brain injury effects, lung blast injury, helmets and improved helmet pad protection, vehicle crew survivability, human body dynamics (lightening the load), and physiology. The CFDRC CMB team has been partnering with many organizations, including USAARL, WRAIR, MRMC, USMC, ONR and DARPA.