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NASA Johnson Space Center

Advanced Resistive Exercise Device (ARED) Flight Software (FSW): A Unique Approach to Exercise in Long Duration Habitats

ARED flight instrumentation software is associated with an overall custom designed resistive exercise system that will be deployed on the International Space Station (ISS) – *see figure 0.* This innovative software application fuses together many diverse and new technologies into a robust and usable package. The software takes advantage of touchscreen user interface technology by providing a graphical user interface on a Windows based tablet PC, meeting a design constraint of keyboard-less interaction with flight crewmembers - *see figure 3.* The software interacts with modified commercial data acquisition (DAQ) hardware to acquire multiple channels of sensor measurment from the ARED device. This information is recorded on the tablet PC and made available, via International Space Station (ISS) Wireless LAN (WLAN) and telemetry subsystems, to ground based mission medics and trainers for analysis. The software includes a feature to accept electronically encoded prescriptions of exercises that guide crewmembers through a customized regimen of resistive weight training, based on personal analysis. These electronically encoded prescriptions are provided to the crew via ISS WLAN and telemetry subsystems – *see figure 1.* All personal data is securely associated with an individual crew member, based on a PIN ID mechanism.

ARED instrumentation FSW provides users with instantaneous relevant exercise feedback. Fundamentally useful information is presented to the user in an intuitive and natural format. Automated "exercise prescription" guidance is given tabularly, while interactive data feedback includes repetitions, load settings, and customizable threshold goals. Historical exercise data is kept and made available, as is a detailed help mechanism that can describe the ~30 different exercises that the ARED exercise hardware is capable of accommodating - *see figure 3.*

The ARED instrumentation FSW design paradigm will further enable touch screen/tablet PC technologies, unobtrusive data collection methods, and automated data availability (for ground-based analysis). The Graphical User Interface (GUI) design has the potential of enabling a new level of utility for exercise subsystems, as well as other crew guided applications. The electronic "prescription" paradigm/mechanism offers a new level of collaboration between crew, doctors, and trainers, and bio-medical analysts.

While this software provides exercise guidance and feedback to crewmembers, it is simultaneously (and non-invasively) allowing ground analysts to assess crewmember biological exposure to the weightless ISS environment. This knowledge will provide key information in the area of health maintenance in long duration, weightless environments such as a moon base or a Mars mission.

NASA's recently formed Exploration Systems Division, Human System Research and Technology Development Program has emphasized research, technology development and demonstration for ensuring the health, habitation, safety and effectiveness of crews in and beyond low Earth orbit. This initiative further emphasizes information in exploration biology, which will identify and define the scope of problems which will face future human space explorers during long periods of exposure to space. The ARED instrumentation FSW paradigm can clearly contribute to achieve these future NASA program goals.

ARED instrumentation FSW has the potential to extend the state-of-the-art/practice of commercial exercise equipment instrumentation/feedback mechanisms, in addition to long duration space based habitats. Of the commercial exercise systems that currently exist with instrumentation subsystems, very limited feedback mechanisms are currently employed. The ARED design represents a more intuitive and non-invasive approach to collecting and presenting user exercise feedback. Additionally, the potential for the ARED instrumentation FSW paradigm to be useful in the medical community is high. The guidance and feedback mechanisms could easily serve such areas as hospitals, clinics, gymnasiums, athletic training, and physical therapy. The Department of Defense could conceivably deploy this technology on its fleet of naval submarines. The target ISS environment shares many similarities to a submarine environment, which features long periods of isolation in physically restrained space.

It should be noted that ARED instrumentation FSW followed a rigorous software development process that is consistent with the Capability Maturity Model (CMM) level 3, and received certification of that rating from the SEI in 2004. The project served as a pioneer at JSC in the area of software process improvement, and was recently certified by the SEI at Capability Maturity Model - Integrated (CMMI) level 2.

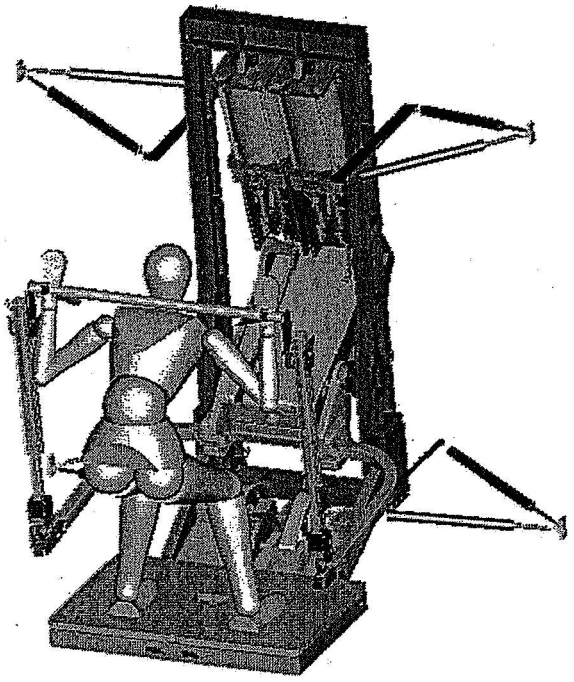

Figure 0. "ARED – Advanced Resistive Exercise Device"

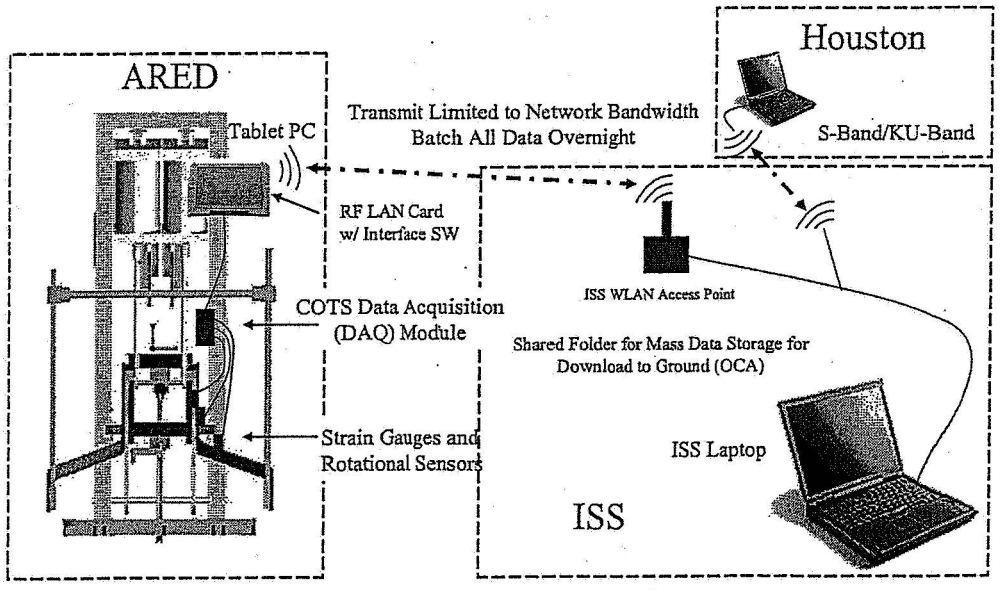

Figure 1. "ARED Instrumentation Subsystem"

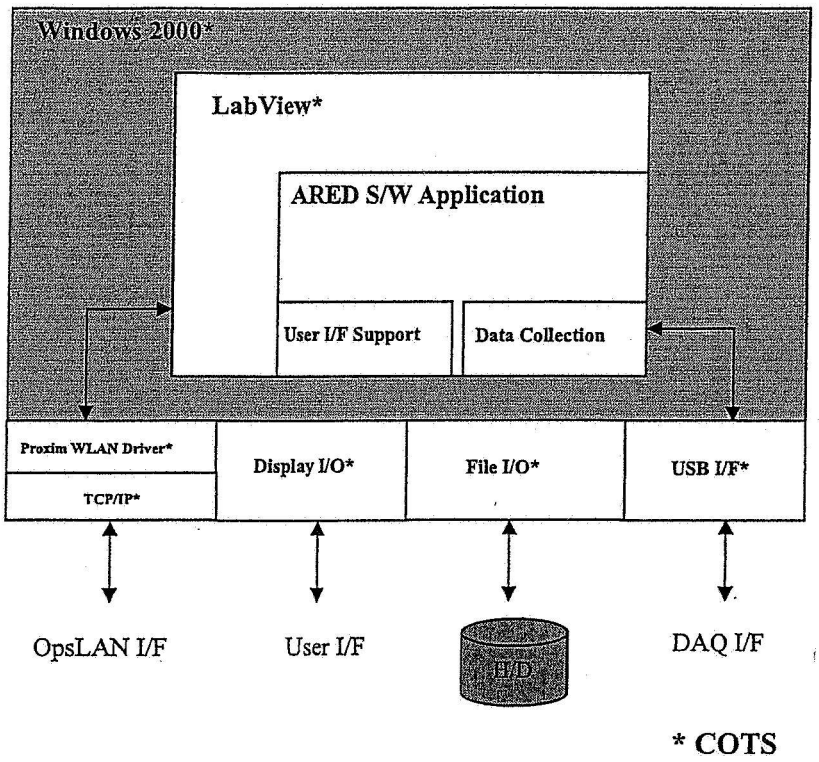

Figure 2. "ARED FSW Architecture"

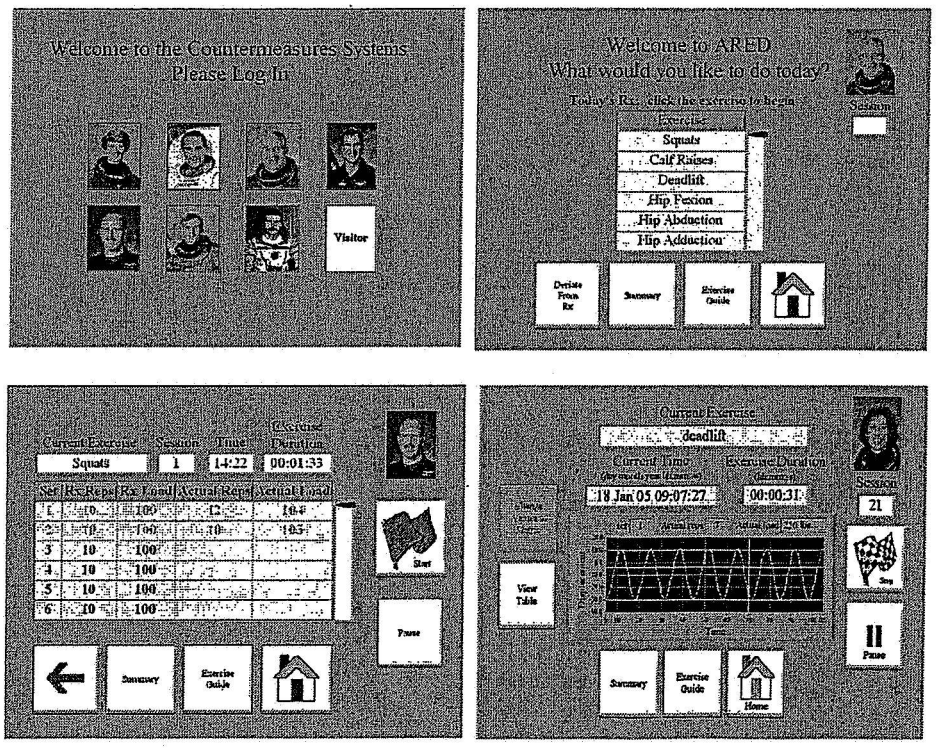

Figure 3. "ARED User Interface"