The Development of a Novel Infrastructure for Biomedical Monitoring of Space Participants

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Introduction:

The emergence of commercial spaceflight provides an unprecedented opportunity to introduce individuals with various medical backgrounds to the spaceflight environment. In contrast to traditional astronauts, Space Participants (SPs) may range from being exceptionally healthy to having significant preexisting morbidity. Biomedical monitoring of SPs offers a chance to both refine medical risk assessment for potential SPs as well as advance medical research with regard to studying the effects of spaceflight on human physiology and pathophysiology [1], [2], [3]. Furthermore, biomedical monitoring provides a unique test bed for the development of novel physiologic monitoring devices and other medical technology.

We report upon the efforts of several working groups listed in Table 1 and propose the adoption of scalable software infrastructure designed to interface with an array of monitoring devices. Our approach functions as both a raw data archive of SP biomedical data and as a server to specific end users. A modern approach to the archive of raw biomedical SP data should accommodate existing data mining and analysis tools, peer-to-peer information sharing standards, as well as the incorporation of industry standard data formats for medical information storage. Any adopted approach should ensure capability of SP data with current electronic medical record keeping standards.

Sources of biomedical information: Our envisioned biomedical database infrastructure is designed to capture biomedical data from SPs by utilizing an array of existing and experimental hardware devices. We make reference to two concepts of data management that our infrastructure can support. Horizontal data management refers to individual SP biomedical information collected from their preexisting health record, progression through training, spaceflight, and post flight phases as shown in Figure 1. Vertical data management refers to serving the collective biomedical data from several SPs to distinct end users as shown in Figure 2. A working list of potential end users is included in Figure 3.

End Users: We surmise that the end users of biomedical data span a wide assortment of interested parties ranging from individual space participants, associated health care professionals, commercial spaceflight organizations, researchers, and even policy makers. We envision each distinct group of end users utilizing our infrastructure to gain access to specific, relevant data subsets based upon their needs. While social networking, modern data visualization tools, and peer to peer networking technology may be priority for individual SPs to reflect and review their spaceflight experience, the incorporation of data mining tools that enable efficient and powerful analysis of biomedical data may be more important for researchers and commercial space providers.

Software and Hardware Architecture: The software architecture will consist of a back-end and front-end system. The back-end server is designed to accept and securely store biomedical data from various hardware devices and space vehicle systems. In accordance with standards for clinical medical data storage we plan on utilizing data formats such as the continuing care record (CCR) and HL7 terminology when appropriate to describe disease states, diagnostic findings, and treatment administered. Additional options for back-end infrastructure development include leveraging electronic medical records infrastructure such as Google Health, Microsoft Health Vault, and open source personal health record software. Other options include building new systems incorporating novel object-oriented programming methods (such as COOP-ER) which, when coupled with a scientific database and associated FIND engine such as Omnidex, allow for anomaly and pattern detection within high dimensional datasets. The front-end infrastructure, an interface between the raw data and the end user, can be customized to utilize advanced search, filtering, data mining, data visualization, and peer to peer networking technology depending upon the specific end user.

Table 1:

Working Groups for Space Participant Biomedical Data Management: Key Focus Areas
Interface to Space Participants: Ownership of Biomedical Data, Privacy, HIPAA Compliance
Interface with the Research Community: Needs of Specific Researchers, Core Physiologic Parameters Conceptual Interfaces
Interface to Commercial Spaceflight Providers: Feedback and Integration with Space Vehicle Hardware, Certification and Testing
Hardware Infrastructure: Integration with Existing Biomedical Devices, Conceptual Interfaces
Software Infrastructure: Compatibility with Existing Data Archives, Leveraging Modern Health Record Technology, Development of a Real Time Data Acquisition Standard, Analytis, Graphical User Interface Development

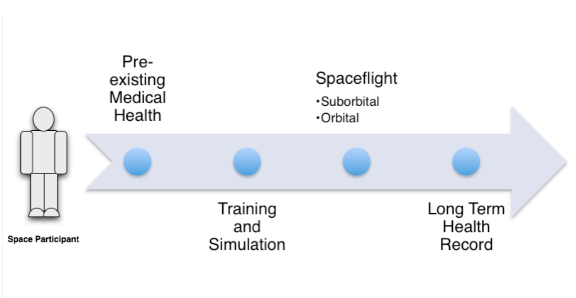

Figure 1. Horizontal Data Management

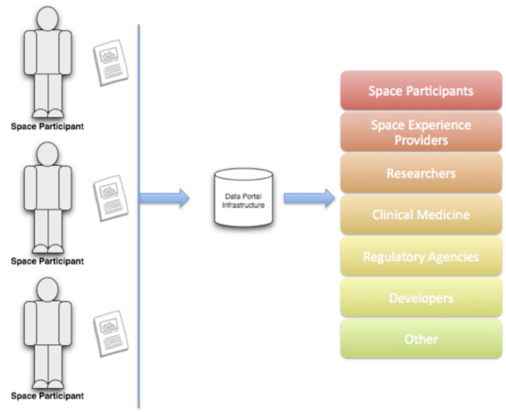

Figure 2: Vertical Data Management

Figure 3: Initial List of Proposed End Users for Biomedical Data

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