HealthGrid: Grid Technologies for Biomedicine

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United Nations/Zambia/European Space Agency
Regional Workshop on the Applications of GNSS
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Telemedicine & Advanced Technology Research Center
Cutting Edge Medical Technology
Col. Jeffrey Roller, MD, Director

“Insanely great ideas are our number one priority”
Thank you!
Agenda

- Telemedicine Advanced Technology Research Center (TATRC) organization
- HealthGrid: Grid Technologies for Biomedicine
- Biomedical ICT Applications for GNSS in Sub-Saharan Africa
- Future opportunities
TATRC Mission

Apply physiological and medical knowledge, advanced diagnostics, simulations, and effector systems integrated with information and telecommunications for the purposes of enhancing operational and medical decision-making, improving medical training, and delivering medical treatment across all barriers.

The program scope is to identify, explore, and demonstrate key technologies and biomedical principles required to overcome technology barriers that are both medically and militarily unique.
Real Medical Technology … For The Real World

BMIS-T
Dreams Digital Ambulance
BRSS

Chest Tube Simulator
Smallpox Inoculation
STAT-Care

Digital X-ray
Medical Robotics
Retinal Imaging
TATRC is a network of public-private partnerships working together to improve military-civilian healthcare.
Let’s talk Grid and Biomedical

Technical architecture for scalable secure interoperable information
Value of HealthGrid

**Wide area communication**
- Networks finally have enough bandwidth
- Networks are the 21\textsuperscript{st} Century highway system
- Analogy of road system in 19\textsuperscript{th} Century

**Access to Data Resources**
- Complexities of interaction has caused a data tsunami
- Future is mobile device fusion
  - Circuit density + network capacity
  - RFID/Nanotechnologies/biosensors
## Bandwidth and Data

<table>
<thead>
<tr>
<th>Bandwidth Unit</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megabyte (Mb)</td>
<td>Book</td>
</tr>
<tr>
<td>Gigabyte (Gb)</td>
<td>DVD</td>
</tr>
<tr>
<td></td>
<td>Truck full of paper with a whole lot of latency</td>
</tr>
<tr>
<td>Terabyte (Tb)</td>
<td>1 million books</td>
</tr>
<tr>
<td></td>
<td>All the text in the U.S. Library of Congress ($1000)</td>
</tr>
<tr>
<td>Petabyte (Pb)</td>
<td>All us.edu library holdings</td>
</tr>
<tr>
<td></td>
<td>One fMRI brain image 4.5 Pb</td>
</tr>
<tr>
<td>Exabyte (Eb)</td>
<td>All the works ever spoken in the history of humanity</td>
</tr>
</tbody>
</table>

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Ref: Hal Varvian, UC Berkley
Digitization of Biomedicine

Moore’s Law

Transistors per chip
In millions

Registered genetic base pairs
In millions

Source: Intel Corp.

Source: GenBank
**Internet Hosts**

**High-income countries**
- 16% population
- 7% burden of disease
- 89% health spending
- 94% Internet hosts

**Low-income countries**
- 84% population
- 93% burden of disease
- 11% health spending
- 6% Internet hosts

Source: ITU 2000
To identify or develop real technologies to enhance situational awareness in bio-defense

Research that applies algorithms and analysis to data where it is needed, when it is needed

Integrate bio-event detection solutions and effector systems

Creating Innovative Solutions
TATRC/PEPFAR Ethiopia Project

- Key Issue: Inability to access information
  - Continuity of care/data management
  - Build human capacity
  - Logistics management

- Technology needs
  - Portable Electronic Health Record
  - Wireless mesh network/self-powered data transmission
  - Remote Video Teleconferencing
  - Inventory tracking/RFID
TATRC Interagency Agreement with PEPFAR

President’s Emergency Plan for AIDS Response

- Health and Human Services (CDC)
- Department of Defense
- Peace Corp
- USAID

Applied operational research to move technology innovation into practice
Landscape Epidemiology Technologies

- Learning Resource Centers
- BMIST
- Remote self-powered wireless networking infrastructure
- Easy to use, field-deployable clinical devices
Learning Resource Centers: Human Capacity Building

- Books to electronic media
- Words to pictures to streaming media (video)
- Procedural simulation
- Plastic head phantom for dentistry/anesthesiology
- Phlebotomy
- Manikins with computer based physiological systems
- Team learning
- Virtual Reality
- 3D visualization
- Computer Games
Some specialties disappearing
Video for remote learning

Collaboration Grid
Procedural Based Learning
Team based learning - with manikin

- Patient under anesthesia lapses into cardiac arrest
Virtual Emergency Room

Multiple users (players)
One 3D space
Landscape Epidemiology Technologies

- Learning Resource Centers
- BMIST
- Remote self-powered wireless networking infrastructure
- Easy to use, field-deployable clinical devices
BMIST-J is the approved Joint solution for the Department of Defense surveillance need at the forward area of care with more than 10,000 in use world-wide.

BMIST-J provides all-in-one suite of mobile applications that empower providers via access to critical medical information and powerful clinical & decision support tools to accurately create an electronic health record.

Synchronizes with Joint health surveillance and medical information systems from the earliest echelons through chronic care provided by the Veterans Administration.
Mobile CAC Card Reader

Interface can be enabled

Smart Card reader compatible with ISO 7816 smart cards, including US DoD Common Access Card (CAC)
• Provides Basic Hybrid Adaptive Beam forming Array (HAB) to PDA

• Enable first responder Army medics to input, control, store, and retrieve medical data via speech in high-noise environments using a portable computer platform
Wireless Sensors

- Multiple patient monitoring
- Multimedia electronic health record
Blood Information Program (BIP)
Built on the BMIST Architectural Standard

BIP is currently be used by our blood teams worldwide

Wireless inventory System
Imbedded References

Better Quality of Care

Provides all-in-one suite of mobile applications that empower blood teams via access to critical information and powerful decision support tools to manage blood inventories

Includes:
- Blood Inventory Program
- Blood report generator
- Transfusion/Disposition Module
Pocket Travax is a handheld tool that allows users to locate hospitals or clinics that can provide needed emergency services by country location or GPS coordinates. Providing travelers information for medical emergencies, eventually providing dynamic/real-time local capabilities data.
Landscape Epidemiology Technologies

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InteleCell™ - Wireless Sensor Device

- Remotely deployable, **rugged smart sensors** monitor many locations:
  - Sensor: Water, air, weather, soil, video, biosensors
  - Processor: Small, low power computer, can control devices/actuators
  - Wireless: Up to 14 miles between stations (40 miles directional), sensor network can cover hundreds of miles
  - GPS-Enabled: automatically knows location, sensors can be mobile
  - Uplink: Local Internet, Cellular, Satellite

- **Any sensor** (analog, digital, serial, ...) easy to integrate
  - Many labs developing new sensors - we make it easy to deploy and integrate these devices and get them out of the lab and into the field
  - Typically deploy nonspecific, continuous, low-cost simple physical sensors (*change detectors*), then use specific tests when anomaly detected
  - Currently designing cheap, specific biochemical sensor module-
    - rugged, sensitive/specific, multiagent, reusable

- **Secure** transmission: Authentication + Encryption (256-bit AES)
- **Frequency**: Transmit on-schedule, on-event, on-demand
- **Future-proof**: Remotely upgradeable while deployed in the field
- Advanced power management:
- **Self-Powered** (*3 years without recharge*, indefinite with solar recharge)
InteleNet Overview- Limahuli Testbed
Landscape Epidemiology Technologies

- Learning Resource Centers
- BMIST
- Remote self-powered wireless networking infrastructure
- Easy to use, field-deployable clinical devices
Clinical Devices

- Patient Monitoring
  - Vital Signs
  - Drug therapy compliance

- Laboratory Instrumentation
  - Diagnostic Testing
  - Digital Microscopy for Tele-Pathology

- Bio-Sensors
  - Water, Air and Environment Quality
  - Measurements for Disease Vectors

- Visualization
Systems Medicine

Population, Person, Organ, Tissue, Cell, Protein, Molecules

Courtesy: Peter Hunter, University of Auckland
Consilience the unity of knowledge

- Bridging of technologists & medical providers
- Learn the languages of science & technology
  - Engineering
  - Physics
  - Biomedicine
  - Physicians & Care Providers
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