

Aerospace Medicine Grand Rounds

**Report on National Space
Biomedical Research Institute**

Jeffrey P. Sutton, M.D., Ph.D.

Director, NSBRI

April 24, 2007

UTMB

USRA



Overview

- **NSBRI is a non-profit organization competitively engaging ~70 U.S. universities to work on space biomedical projects in partnership with NASA**
- **Focus is on countermeasures and deliverables**
- **Institute partnership with NASA managed through Cooperative Agreement NCC 9-58 with Johnson Space Center**
- **Integrated into the NASA Human Research Program (HRP) Science Management Plan**
- **Steering Committee co-chaired by K. Laurini (Manager, HRP) and J. Sutton (Director, NSBRI)**
- **Acting COTR is J. Charles and Acting Deputy COTR is N. Pellis**



Value

- **Intellectual and institutional resources, leveraging the nation's investment in biomedical research and development, are brought to bear on solving problems for NASA**
 - High caliber and productivity of investigators
 - NIH biomedical funding to 12 consortium schools > \$3 B (U.S.)
- **Science and technology portfolio augments efforts within NASA laboratories**
 - ~ 60 NSBRI S&T peer reviewed projects
 - See www.nsbri.org
- **Help engage the external scientific community to utilize NASA resources (e.g., BNL; recommendation from 5-year review)**

Consortium Members

Baylor College of Medicine
Brookhaven National Laboratory
Harvard Medical School
The Johns Hopkins University
Massachusetts Institute of Technology
Morehouse School of Medicine
Mount Sinai School of Medicine
Rice University
Texas A&M University
University of Arkansas for Medical Sciences
University of Pennsylvania Health System
University of Washington



Value

- **Unique, national translational research and development program**
 - Model for a virtual academic institute partnered with government
 - ~250 investigators in ~20 states + international participation
 - Multidisciplinary teams
 - One third of projects have ties to industry + NSBRI Industry Forum
 - Active User Panel to help ensure operational relevance of portfolio
 - Some high risk/long lead time, high payoff projects
 - Peer review and ongoing assessments of progress (ESMC, pipeline)
 - Cost effective
- **Extensive education and outreach program**
 - Continuum of opportunities in education, training, outreach
 - 10 peer reviewed projects + conferences (e.g., Radiation CM Workshop, Int Med Summit)
 - Each S&T project has ~ 3 trainees



Countermeasure Readiness Levels

COUNTERMEASURE
OPERATIONS

COUNTERMEASURE
EVALUATION &
VALIDATION

COUNTERMEASURE
DEVELOPMENT

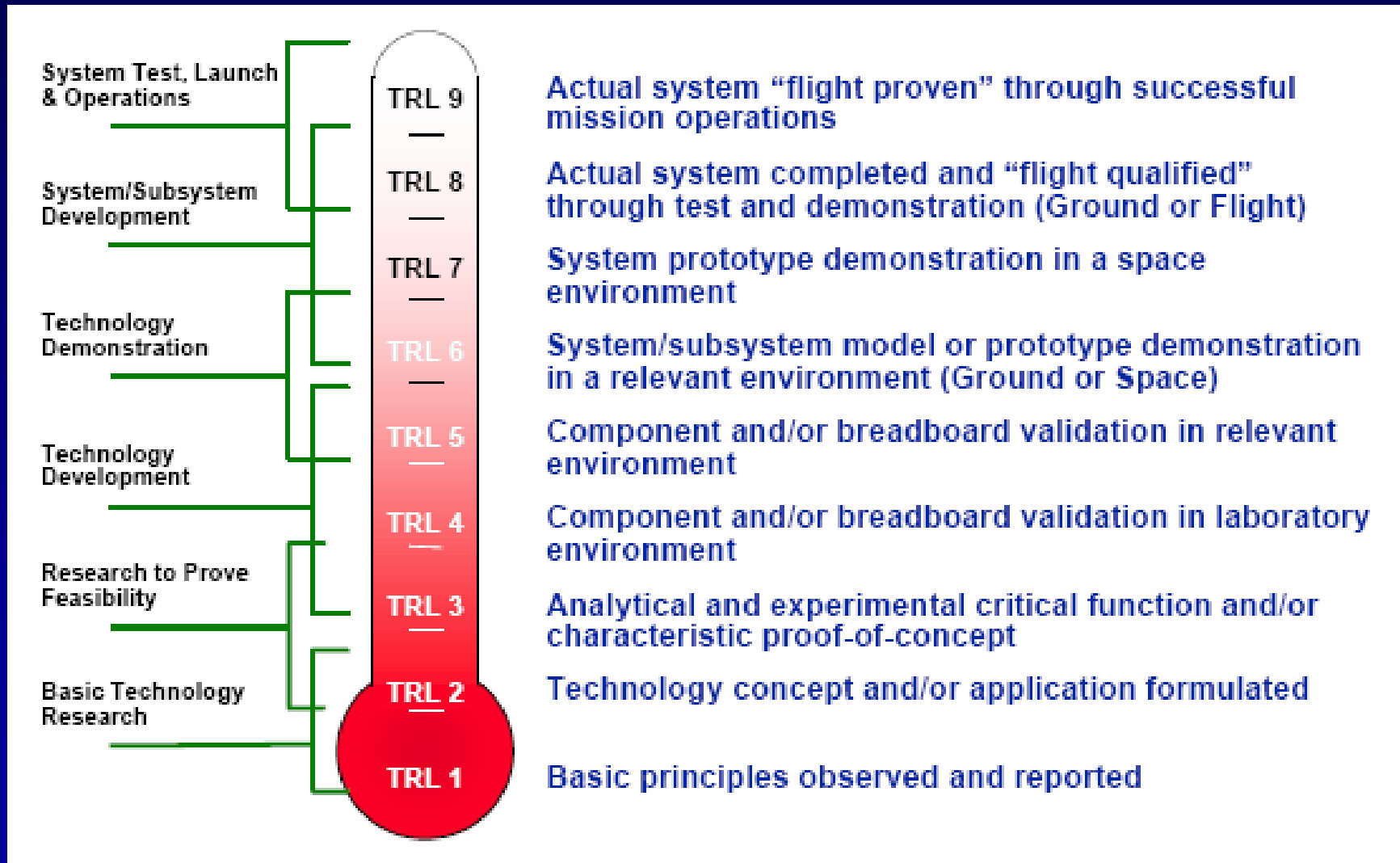
RESEARCH TO
PROVE FEASIBILITY

BASIC RESEARCH

1. Phenomenon observed and reported. Problem defined.
2. Hypothesis formed, preliminary studies to define parameters. Demonstrate feasibility.
3. Validated hypothesis. Understanding of scientific processes underlying problem.
4. Formulation of countermeasures concept based on understanding of phenomenon.
5. Proof of concept testing and initial demonstration of feasibility and efficacy.
6. Laboratory/clinical testing of potential countermeasure in human subjects to demonstrate efficacy of concept.
7. Evaluation with human subjects in controlled laboratory conditions simulating operational space flight environment.
8. Validation with human subjects in actual operational space flight to demonstrate efficacy and operational feasibility.
9. Countermeasure fully flight tested and ready for operational implementation.



Technology Readiness Levels





Roadmap Deliverable Categories

Knowledge Maturation

Standards

Requirements

Countermeasures

Human System Assessment/Diagnostic/Treatment Tools

Training and Credentialing

In-flight Protocols

Design Tools

Technologies

Components/Subsystems/Systems



Open Announcements for NSBRI Teams

2007	NSBRI-RFA-07-01	Research Opportunities Soliciting Ground-Based Studies for Human Health in Space
2007	NNJ07ZSA001N	Ground-Based Studies in Space Radiation
2005	NNH04ZUU003N	Research Opportunities Soliciting Ground-based Studies for Human Health in Space
2004	NRA 03-OBPR-04	Soliciting Ground-based Research Proposals for the Biomedical Research and Countermeasures Program
2004	NSBRI CFC-03-01	Call for Candidates for Team Leadership



Science & Technology Team Leaders

Bone Loss

Peter Cavanagh, Ph.D., D.Sc.
(Cleveland Clinic)

Cardiovascular Alterations

Benjamin Levine, M.D. (UT)

**Human Performance Factors,
Sleep and Chronobiology**

Charles Czeisler, Ph.D., M.D. (Harvard)

Muscle Alterations and Atrophy

Kenneth Baldwin, Ph.D. (UCI)

**Neurobehavioral and
Psychosocial Factors**

David Dinges, Ph.D. (Penn)

**Nutrition, Physical Fitness
and Rehabilitation**

Joanne Lupton, Ph.D. (Texas A&M)

Radiation Effects

Ann Kennedy, D.Sc. (Penn)

Sensorimotor Adaptation

Charles Oman, Ph.D. (MIT)

Smart Medical Systems

Lawrence Crum, Ph.D. (U Washington)

Technology Development

Jay Buckey, Jr., M.D. (Dartmouth)



Science and Technology Liaisons

Space Medicine

Jonathan Clark, M.D. (NSBRI/JSC)

Health and Science

Edna Fiedler, Ph.D. (NSBRI/JSC)

Radiation Effects

**Marcelo Vazquez, M.D., Ph.D.
(NSBRI/Brookhaven)**



Councils and Panels

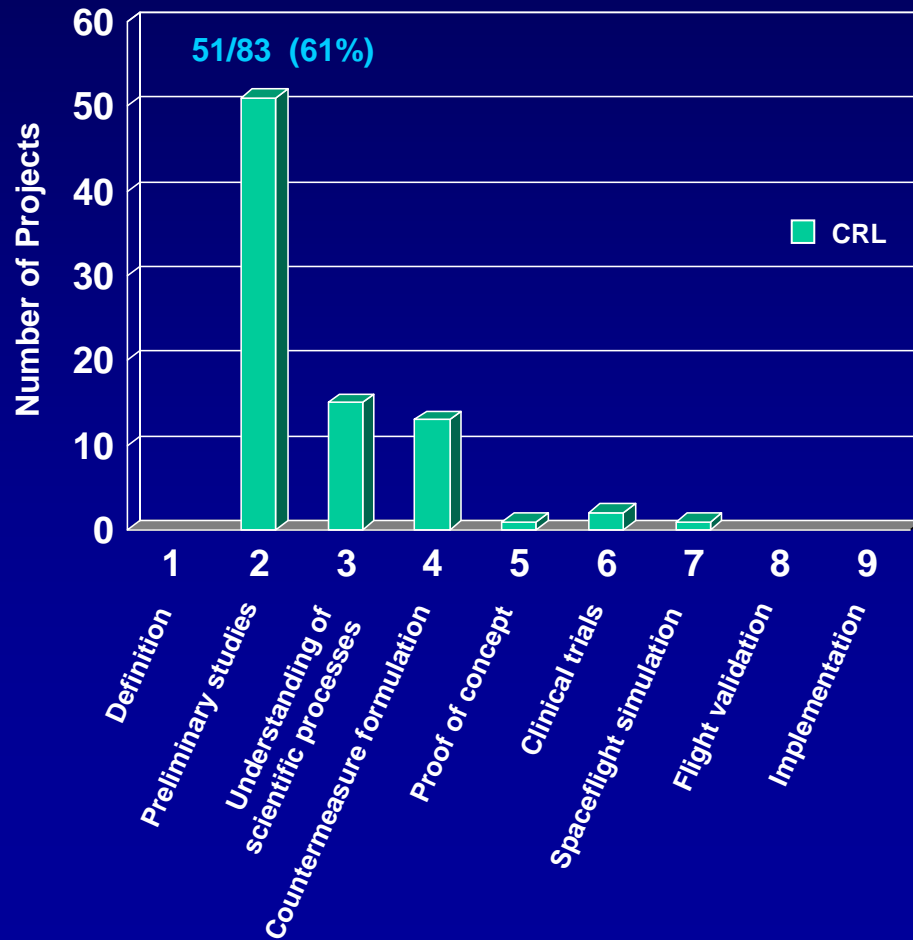
- **Board of Scientific Counselors**
 - Independent body of scientific evaluators
 - Functions in peer review and ongoing progress
 - Chair: **Irwin Rosenberg, M.D. (Tufts, IOM)**
- **External Advisory Council**
 - Independent advisory body
 - Functions in research and education portfolio development
 - Chair: **Stephen Doty, Ph.D. (Hospital for Special Surgery, NYC)**
- **User Panel**
 - Independent advisory body representing the NASA customer
 - Functions as resource for development of operationally relevant deliverables
 - Chair: **Leroy Chiao, Ph.D. (Former ISS Commander)**



Independent CRL/TRL Assessment of Science and Technology Portfolio

2001

88 projects
83 assigned CRL
TRL not assigned





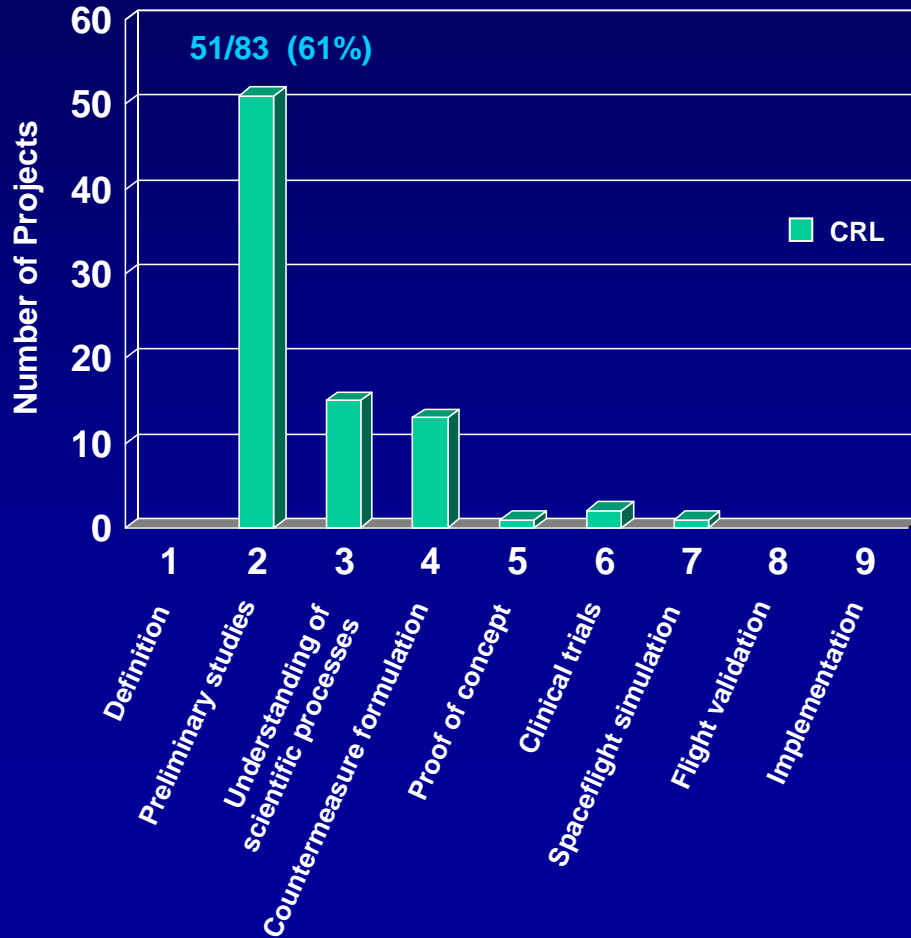
Independent CRL/TRL Assessment of Science and Technology Portfolio

2001

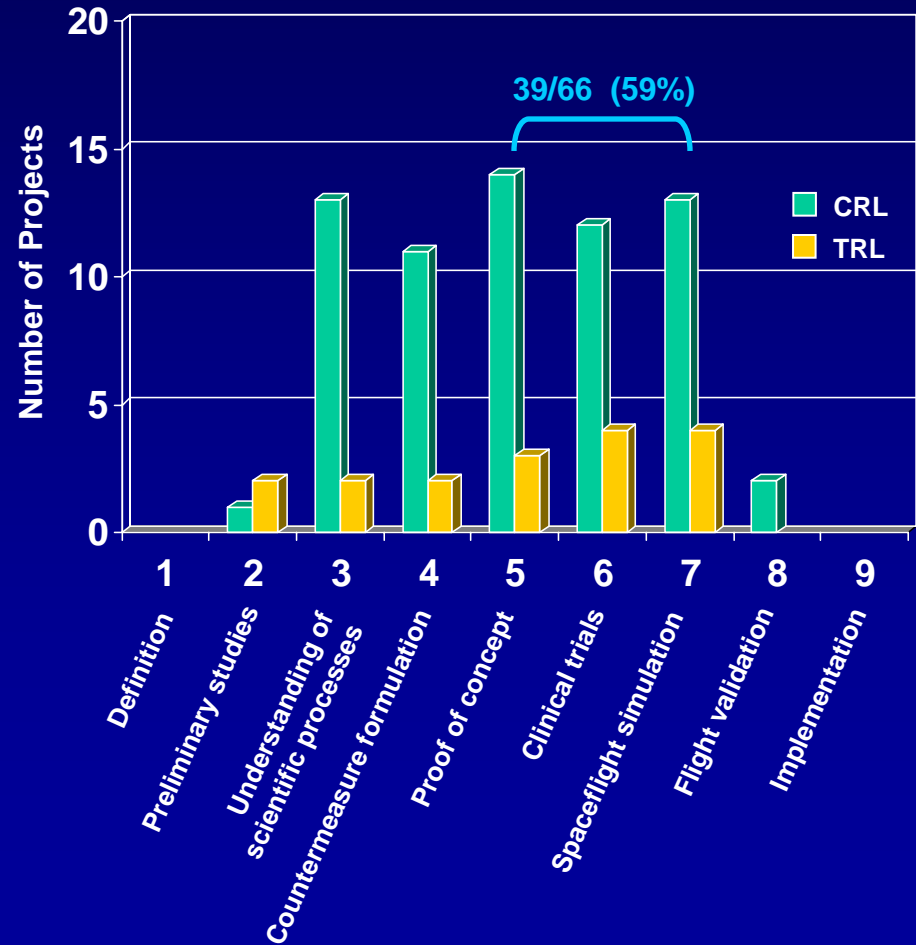
Same Reviewer

2005

88 projects
83 assigned CRL
TRL not assigned

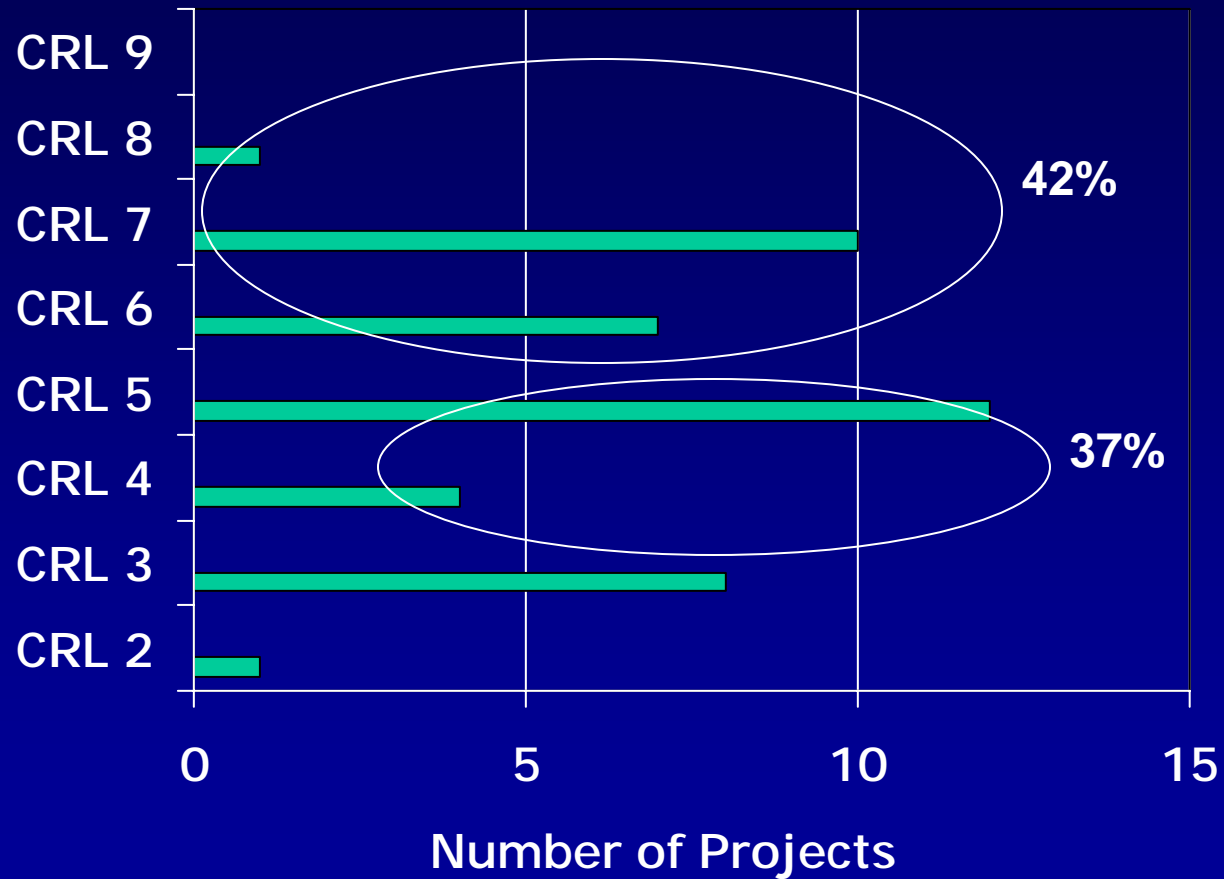


83 projects
66 assigned CRL or CRL/TRL
17 assigned TRL only



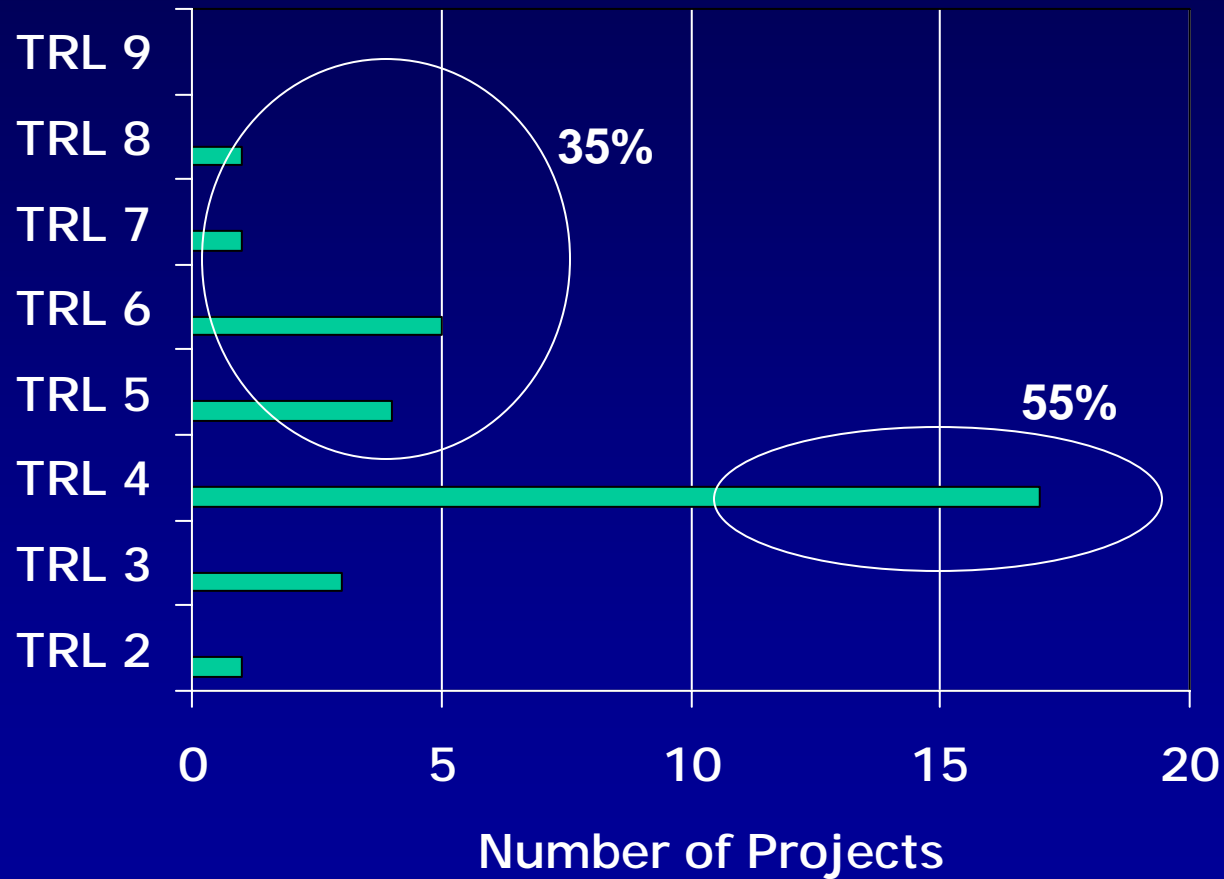


NSBRI Science & Technology Portfolio: Countermeasure Projects – April 2007





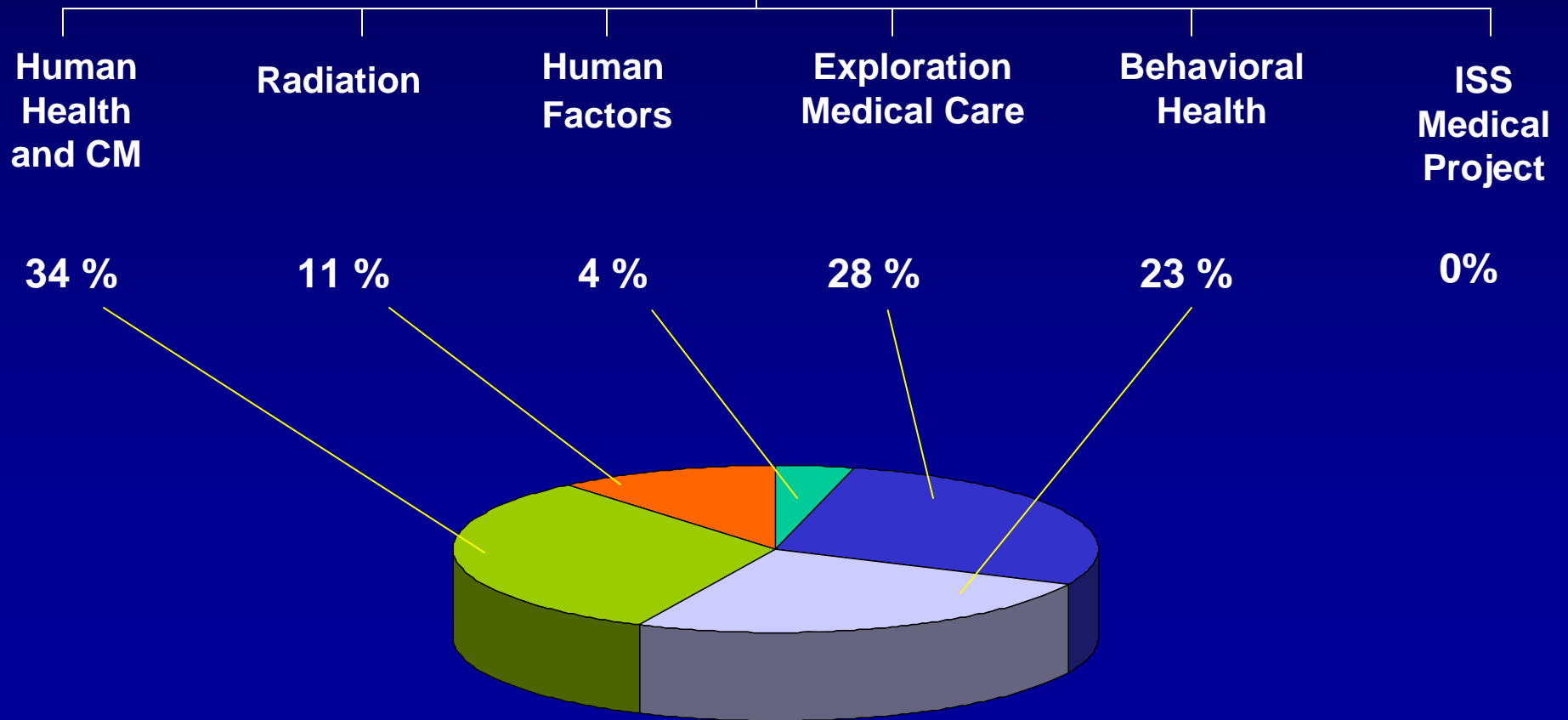
NSBRI Science & Technology Portfolio: Technology Projects – April 2007





NSBRI Mapping to NASA HRP

Human Research Program





Science and Technology

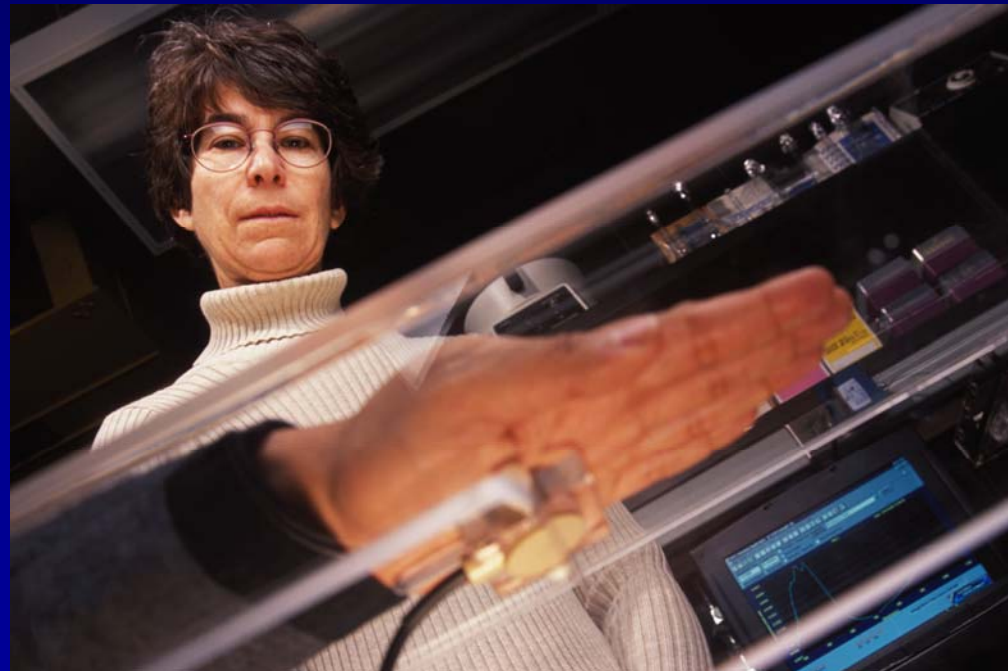
- Continued productivity (R&D – focus on deliverables for NASA, peer reviewed publications, patent filings, leveraging; Testing and Evaluation – working with NASA customers toward operational integration, use of analog environments, commercialization: licensing, start-up ventures, terrestrial applications)
- New opportunities with *Vision for Space Exploration*, turn-over in current portfolio, high priority gaps



Infrared Spectrometry Monitoring of Physiologic Parameters

- Needle-free blood and tissue measurements

Tissue oxygen measurement system:
US Patent No. 6,766,188



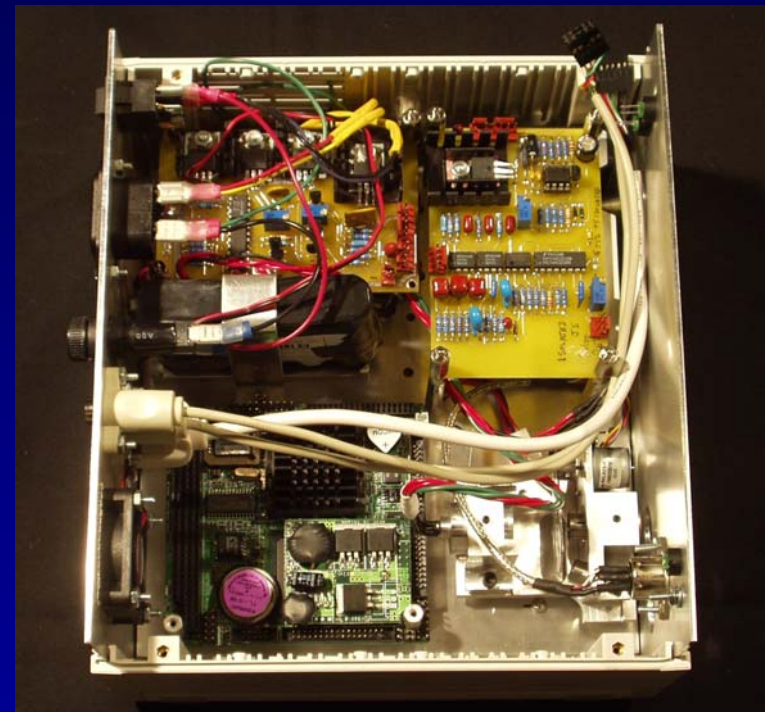
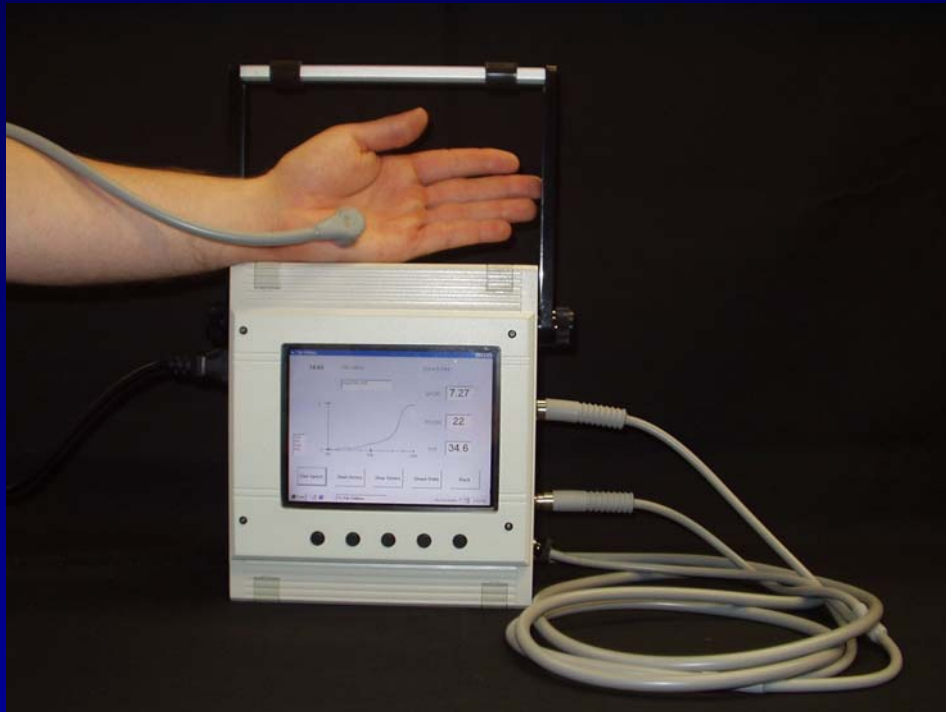
Babs Soller, Ph.D.

University of Massachusetts

NSBRI – Smart Medical Systems Team, ATL



Stable, Portable Instrument to Simultaneously Measure Muscle pH, PO₂ and Hematocrit



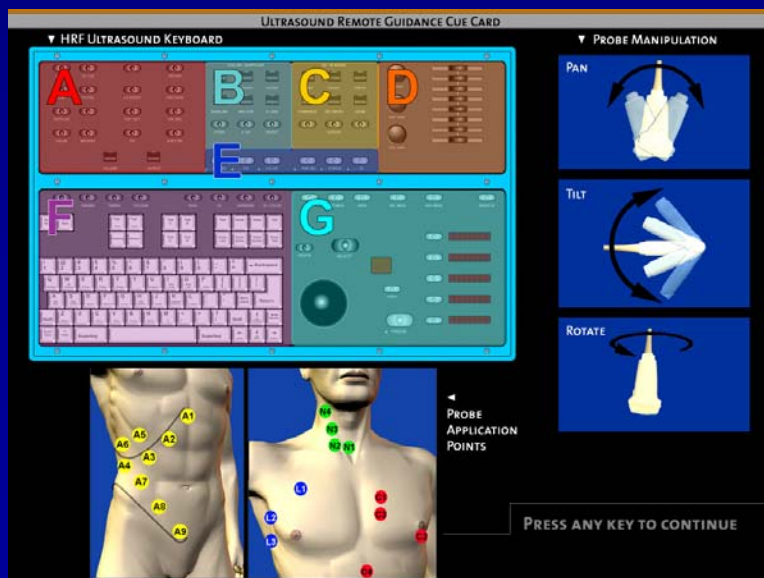
8 lbs - 8" W x 9" W x 5" D

Novel components include real-time reference system, compact optical bench and quick-start, lamp.



Ultrasound for Medical Diagnosis and Noninvasive Imaging

- Computer based just in time training product
- Provides effective training for crew on hardware and technique
- Provides computer-based information in-flight prior to scanning activity



Scott Dulchavsky, M.D.

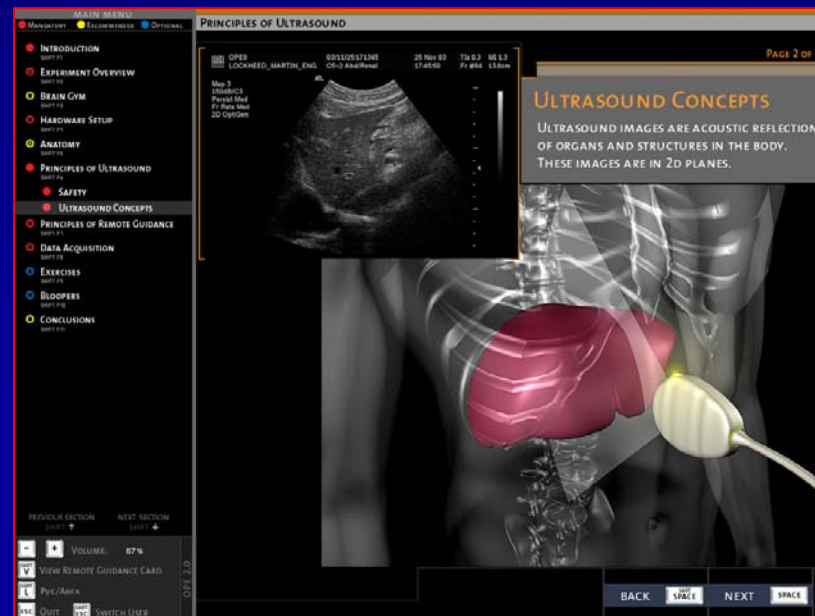
Henry Ford Health System

NSBRI – Smart Medical Systems Team



Ultrasound for Medical Diagnosis and Noninvasive Imaging

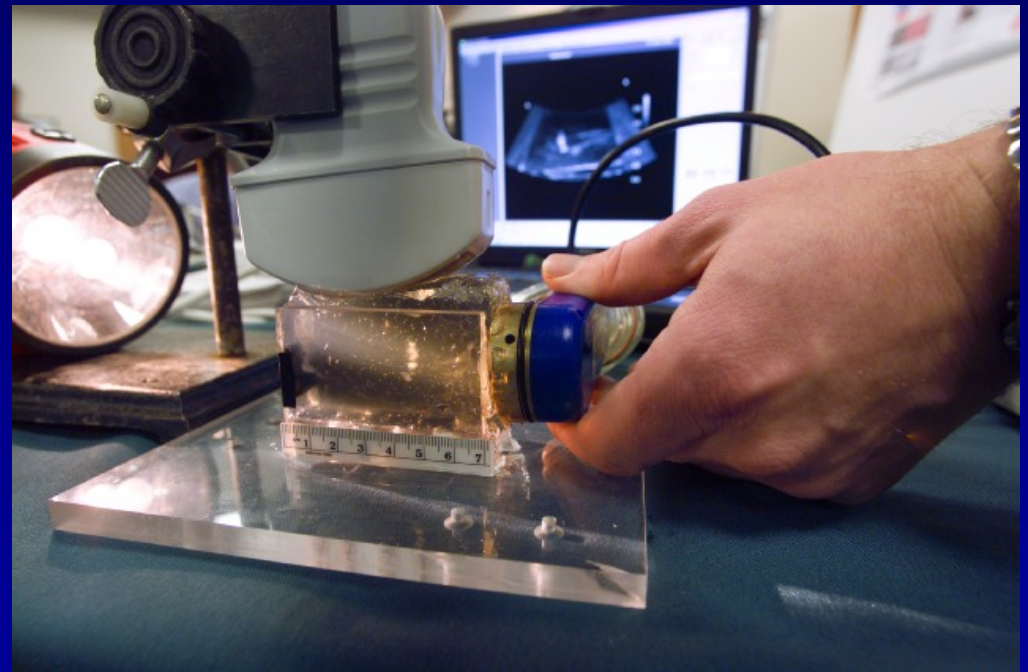
- Conducts activity with remote guidance from ground experts
- Diagnostic accuracy of ultrasound – catalogue of “space normal”
- Outreach activities to terrestrial care





Ultrasound Imaging and Treatment

- Surgery without scalpels and stitches using high intensity focused ultrasound (HIFU)



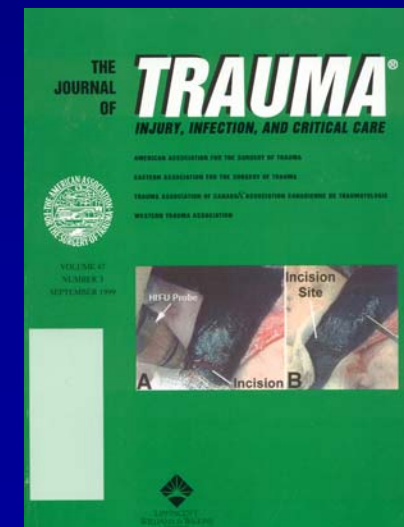
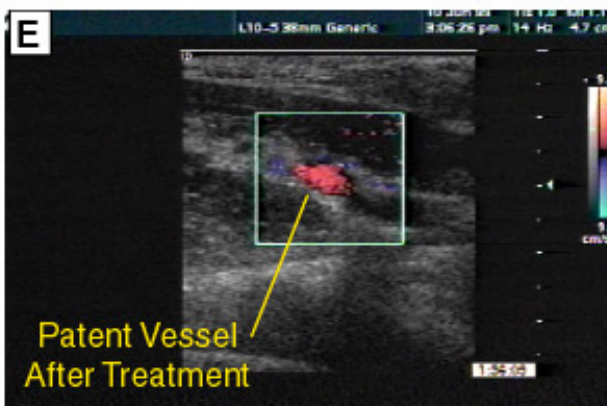
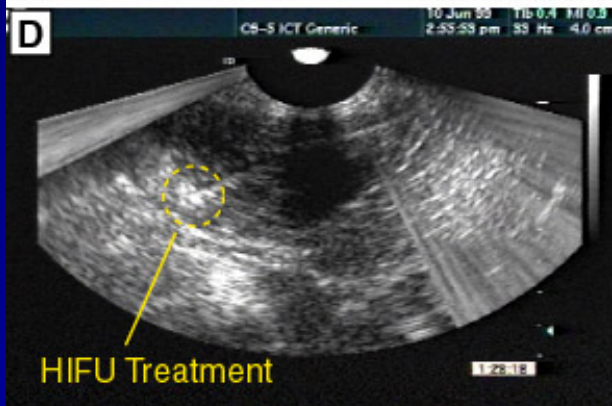
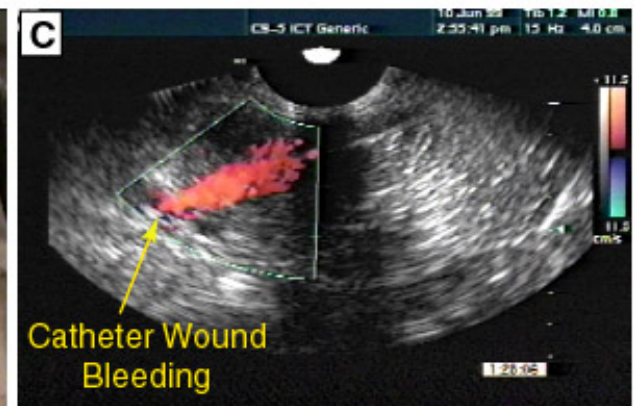
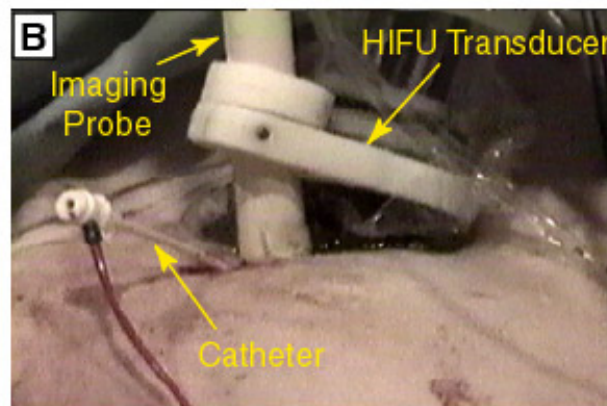
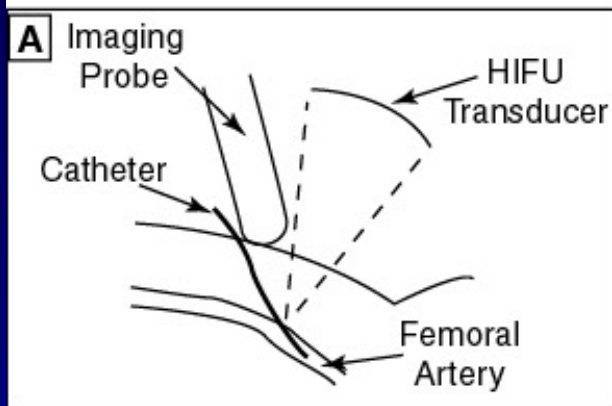
Larry Crum, Ph.D.

University of Washington

NSBRI – Smart Medical Systems Team, TL



Demonstration of Image-guided Transcutaneous Acoustic Hemostasis





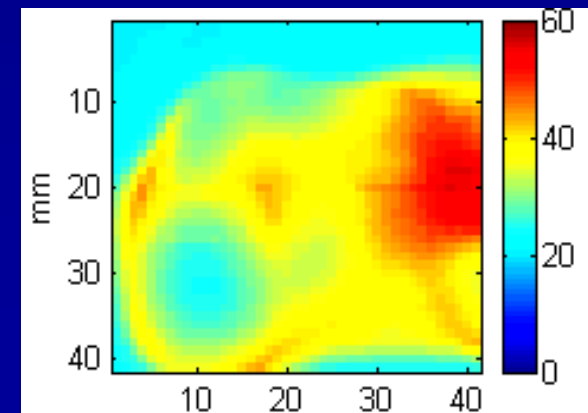
Portable Scanning Confocal Acoustic Device (SCAD)

- Using ultrasound attenuation and velocity at acoustic focal points that reflect the density and stiffness of biomaterials
- Real-time mapping at the region of interest in bone 2-D or 3-D
- Reduce error from soft-tissue and cortical shell
- Earth applications include the use of the device to monitor treatment for osteoporosis, which is estimated to affect 10 million individuals

Yi-Xian Qin, Ph.D.

New York – Stony Brook University

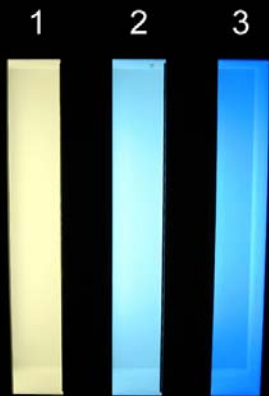
NSBRI – Technology Development Team, ATL





Treatment for Operational Success

- **Blue Light: Progress to optimize the light spectrum, particularly for 420-460 nm, to enhance human performance and mitigate sleep disruption**



Lamp output shown at left is generated by:

- 1) A commercially available white fluorescent lamp.
- 2) A blue-enriched lamp predicted to have twice the circadian potency.
- 3) A further blue-enriched lamp predicted to have four times the circadian potency.

Lamps provided courtesy of Philips Lighting, Eindhoven, The Netherlands

George Brainard, Ph.D.

Thomas Jefferson University

NSBRI- Human Performance Factors Team, ATL



Monitoring Technology - TOFMS

- Miniature time-of-flight mass spectrometer, for onboard analysis of chemical and biological substances, with scientific, medical and environmental applications for space and homeland security



Richard Potember, Ph.D.

Johns Hopkins Applied Physics Lab

NSBRI – Technology Development Team



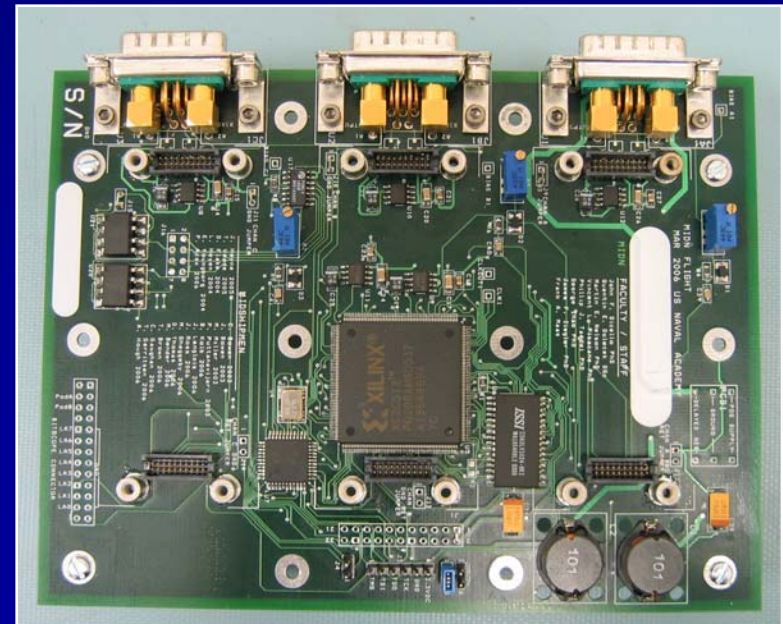
Monitoring Technology - Microdosimetry

- Development and in-flight testing of MIDN (MicroDosimeter iNstrument) to evaluate mixed radiation particle energy deposition
- Provides assessment of dose equivalent and effective dose, to determine radiation risk in real-time

Vincent Pisacane, Ph.D.

United States Naval Academy

NSBRI – Technology Development Team





Monitoring Technology - Microdosimetry

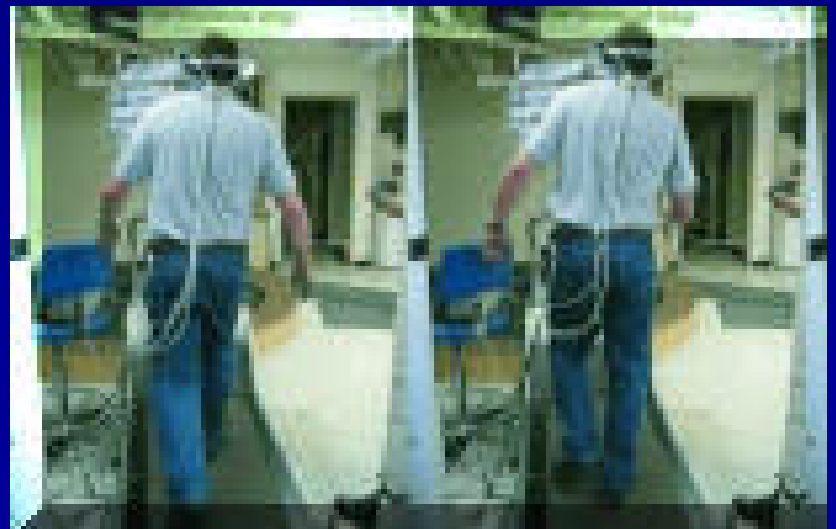
- **Successful Atlas 5 (AV-013) launch on 8 March 07, carrying United States Naval Academy/NSBRI-sponsored MIDN aboard MidSTAR satellite**





Training and Analog Model

- On-call galvanic vestibular stimulation (GVS) technology
- Mild perturbation (electrical stimulation +/- 5 mA) produces model of vestibular deconditioning
- Five veteran astronauts found the GVS device to mimic sensations of motion and unsteadiness similar to that experienced on landing day



Steven Moore, Ph.D.

Mount Sinai School of Medicine

NSBRI – Sensorimotor Adaptation Team



Medical Operations Support Team

- Patient simulator for training for medical emergencies in space
- Integrated team with an operational and clinical focus
- Deliverables include both skill set training for individuals and team resource management/crisis resource management tools for the entire flight control team



Hal Doerr, M.D.

Baylor College of Medicine

NSBRI / Wyle / JSC



Integrated Experiment: Analog Environment

- **Suite of Behavioral Health and Performance studies aboard NASA Extreme Environmental Mission Operations (NEEMO) 9 habitat**
- **Physiologic sensors, video analysis and cognitive testing evaluated crew response to challenges, decision making and problem solving under isolated conditions and during EVA**
- **Results impact design of technologies and countermeasures to assist in maintenance of optimal crew health and performance**
- **Collaboration leverages academia and government and industry**

David Dinges, Ph.D.

University of Pennsylvania School of Medicine

NSBRI - Neurobehavioral and Psychosocial Factors TL



NASA photo



Education as a Lifelong Process



Elementary, Middle, High School	Undergraduate	Graduate	Post-Graduate	Investigator •••
	University science and engineering courses	University science and engineering courses	Research through Mentor's grants	Research Grants
Teacher training				Workshops Conferences
Student curriculum	Summer internship with NASA	Research Program for curriculum development and research Ph.D.	Post-doctoral Fellowship Program	Continuing Medical Education
		Summer Internship with NASA		Mentoring of students
				Public Outreach



Education as a Lifelong Process



**Elementary,
Middle, High
School**

Undergraduate

Graduate

Post-Graduate

Investigator •••

Teacher
training

University
science and
engineering
courses

University
science and
engineering
courses

Research
through
Mentor's
grants

Research
Grants

Student
curriculum

Summer
internship
with NASA

Research
**Program for
curriculum
development
and research
Ph.D.**

**Post-doctoral
Fellowship
Program**

Workshops
Conferences

Continuing
Medical
Education

Mentoring
of students

Summer
Internship
with NASA

Public
Outreach



Open Announcements for Education and Outreach Program Opportunities

2006	NSBRI-RFP-06-01	Soliciting Postdoctoral Fellowship Applications
2005	NSBRI-RFP-05-02	Opportunity to Participate in Education and Public Outreach – Graduate Education
2005	NSBRI-RFP-05-01	Soliciting Postdoctoral Fellowship Applications
2004	NSBRI-RFP-04-02	Opportunity to Participate in Education and Public Outreach Activities (K-16 and Graduate Education)
2004	NSBRI-RFP-04-01	Soliciting Postdoctoral Fellowship Applications



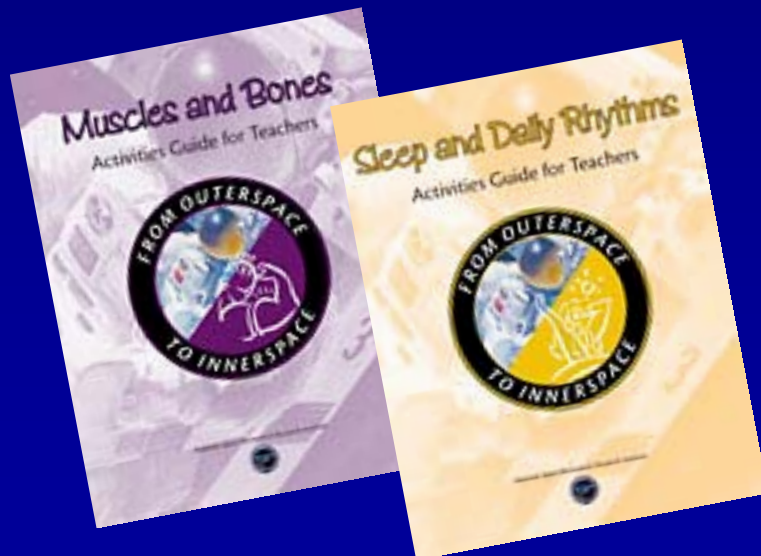
Stellar Award

- **20 April 2007 - Education and Outreach Program Team of the National Space Biomedical Research Institute received a Stellar Award from the Rotary National Award for Space Achievement Foundation**
- ***Citation: Performance as a nationally recognized, top-tier program that is pioneering new models for exemplary teaching, training and public outreach, in support of the Vision for Space Exploration***



Elementary, Middle, High School

- > 1,000 teachers have participated in NSBRI-sponsored professional development activities
- > 45,000 students impacted by NSBRI science education materials and laboratory activities
- Thousands of teachers reached through dissemination of Web-based resources





Undergraduate Education

- **University courses (~50 universities) and summer internships (18/75)**



Graduate Education

- **One year definition phase of new program completed in 2005**
- **2006 - Innovative graduate education program in space life sciences awarded to Texas A&M, MIT and Baylor College of Medicine**
- **Facilitates development of modules of course content to supplement existing accredited programs leading to Ph.D.**



Post-Doctoral Fellowship Program

- Third year of operation
- Annual solicitations – each fellowship lasts two years
- Popular program, excellent for career development, cost effective





First Class of NSBRI Post-Doctoral Fellows 2004 - 2006

- **Sophie Gaboyard, PhD, University of Illinois**
 - Present Position: Research Contractor at Institute of Neurosciences of Montpellier, France
 - 2006 Accomplishments: First place poster presentation at Chicago Neuroscience Meeting; poster presentation at the 7th Symposium on the Role of the Vestibular Organs in Space Exploration, ESTEC, Netherlands

- **Vesna Zderic, PhD, University of Washington**
 - Future Direction: Assistant Professor, George Washington University
 - 2006 Accomplishments: Recipient of the gold prize for Young Investigator Award at the World Federation of Ultrasound in Medicine and Biology Congress, Seoul



First Class of NSBRI Post-Doctoral Fellows 2004 - 2006

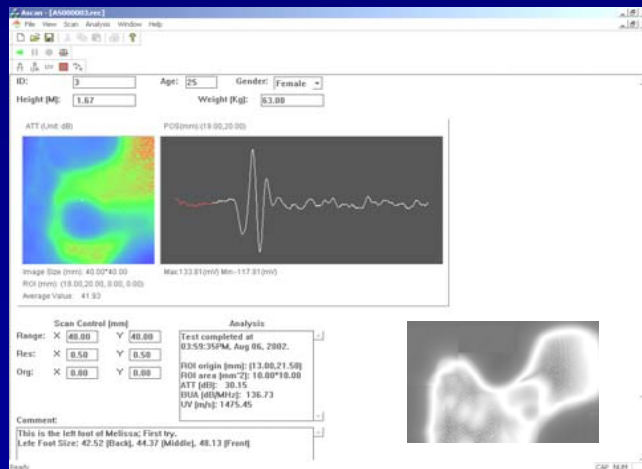
- **Andrew Judge, PhD, Boston University**
 - Present Position: Research Associate Scientist, Department of Applied Physiology and Kinesiology, University of Florida
 - 2006 Accomplishments: Invited to give a seminar at the University of Massachusetts, Amherst by Dr. Priscilla Clarkson

- **Luis Cardoso Landa, PhD, Mt. Sinai School of Medicine**
 - Assistant Professor at City College of New York, Department of Biomedical Engineering
 - 26 Sept 2006 paper in *Proceedings of the National Academy of Sciences, USA*



Continuing Medical Education

- Productive exchange of knowledge (2005-2006: 24 activities, 441 participants)
- Important for maintaining M.D. certification for flight surgeons and for investigators to obtain insight and feedback into operational aspects of countermeasure development



Photos courtesy of Yi-Xian Qin, Ph.D.



Public Outreach

- **NSBRI HQ has Communications and Public Outreach group**
- **Active Web site (~70,000 hits/month), news releases, newsletter**
- **Investigator community regularly featured in press, including television education programs**





Going Forward

- **Build upon NSBRI's demonstrated successes and its strong partnership with NASA to implement *The Vision for Space Exploration***
- **Validate flight-ready science and enabling technologies in space, including the International Space Station**
- **Foster connections to the Constellation Program to ensure involvement with the next generation of vehicle development**



Going Forward

- **Increase use of analog environment studies given limited access to space**
- **Increase partnering and commercialization efforts given the higher CRL/TRL portfolio and tangible Earth-based benefits resulting from NASA's investment in NSBRI**