# Fort Detrick
# Frederick, Maryland


## Headquarters U.S. Army Medical Research and Materiel Command
## BG Eric Schoomaker, Commanding General

# Primer on TATRC's Medical Modeling & Simulation (MM&S) Portfolio: The *Serious* Side of Fun

## Cybertherapy 05
## Basel, Switzerland

## Presenter: J. Harvey Magee, Portfolio Manager

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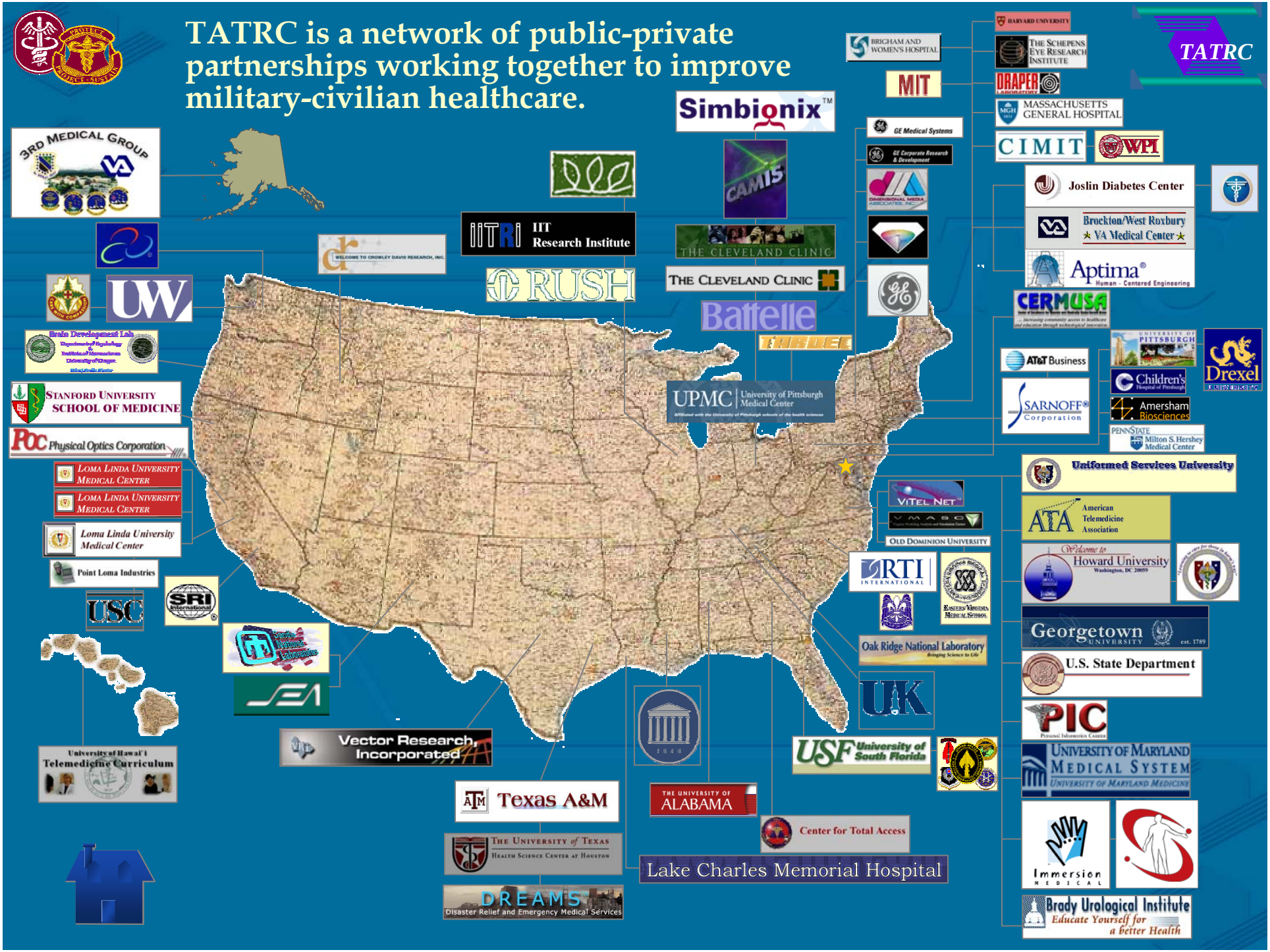
Col (USAF) Jeffrey Roller, MD, Director, TATRC

# TATRC is a network of public-private partnerships working together to improve military-civilian healthcare.



# Purpose

- Inform you of TATRC's 5-year journey into Medical Modeling & Simulation (MM&S) research

- Our purpose? To ***identify***, to ***develop***, and to ***integrate*** enabling technologies into ***SYSTEMS*** of medical training

# Outline

- Background
- Strategy
- Four categories of medical simulation & research (MM&S)
- Major strategic initiatives
- Predicted benefits

# Background

- Why did we start MM&S anyway?
- Why it is serious?


LÖWENWEISSE

# Why We Started – Reason #1

## *To Improve trauma training*

- **100,000 military medical personnel must practice battlefield trauma care skills***

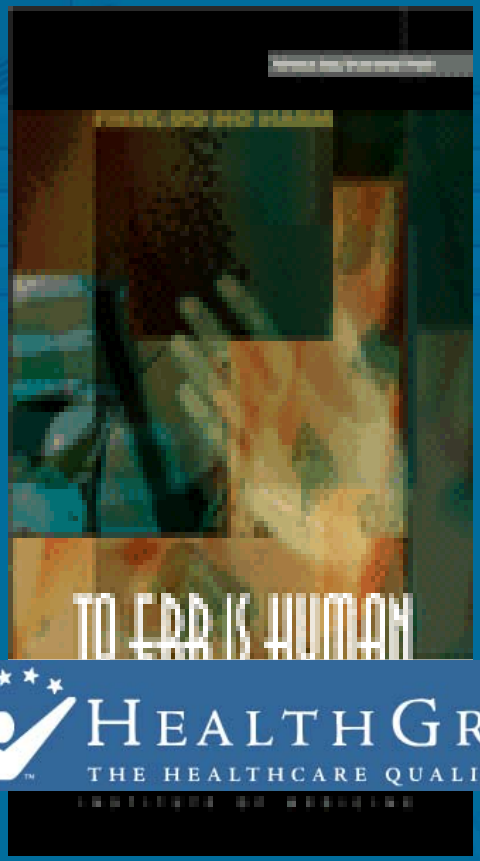
**(Source: GAO Rpt, NSIAD-98-75, DOD Training in Civilian Trauma Centers)**

  - Problem – not enough trauma patients
  - Solution – create "virtual patients"

- **Simulation revolutionized aviation and warfighting training…Why not medicine???**

# Why we Started – Reason #2

## ***To Reduce the errors***




- IOM report - 1999:
  >45,000 deaths due to errors - Medical errors 7th leading cause of U.S. death…
- HealthGrades, 27 Jul 04: 195,000 deaths/yr, $6B annual costs, 6th most common death
- ENT: 45 % report errors committed: 37% serious harm, 9% fatal

*"Classification and Consequences of Errors in Otolaryngology"*

-Rahul K. Shah, et al, *The Laryngoscope,* August 2004

Slide courtesy of Dr. Steve Dawson, CIMIT Simulation Group

# Why MM&S is Serious

- Health care has the power to heal or to harm.
- Residents may actually do what we teach!
- Simulated environments impact people. But…how???
- Medical simulation is hard to do right; just ask the engineers
- Medical simulation disrupts the norm
- Potential for medical cultural disruption
- The potential to revolutionize medicine is great.

# Messages to my Friends

**Common Perception**
**Medicine = Serious**

**Common Perception**
**Entertainment = Fun**

**Message to my Entertainment friends:**


**Message to my Medical colleagues:**

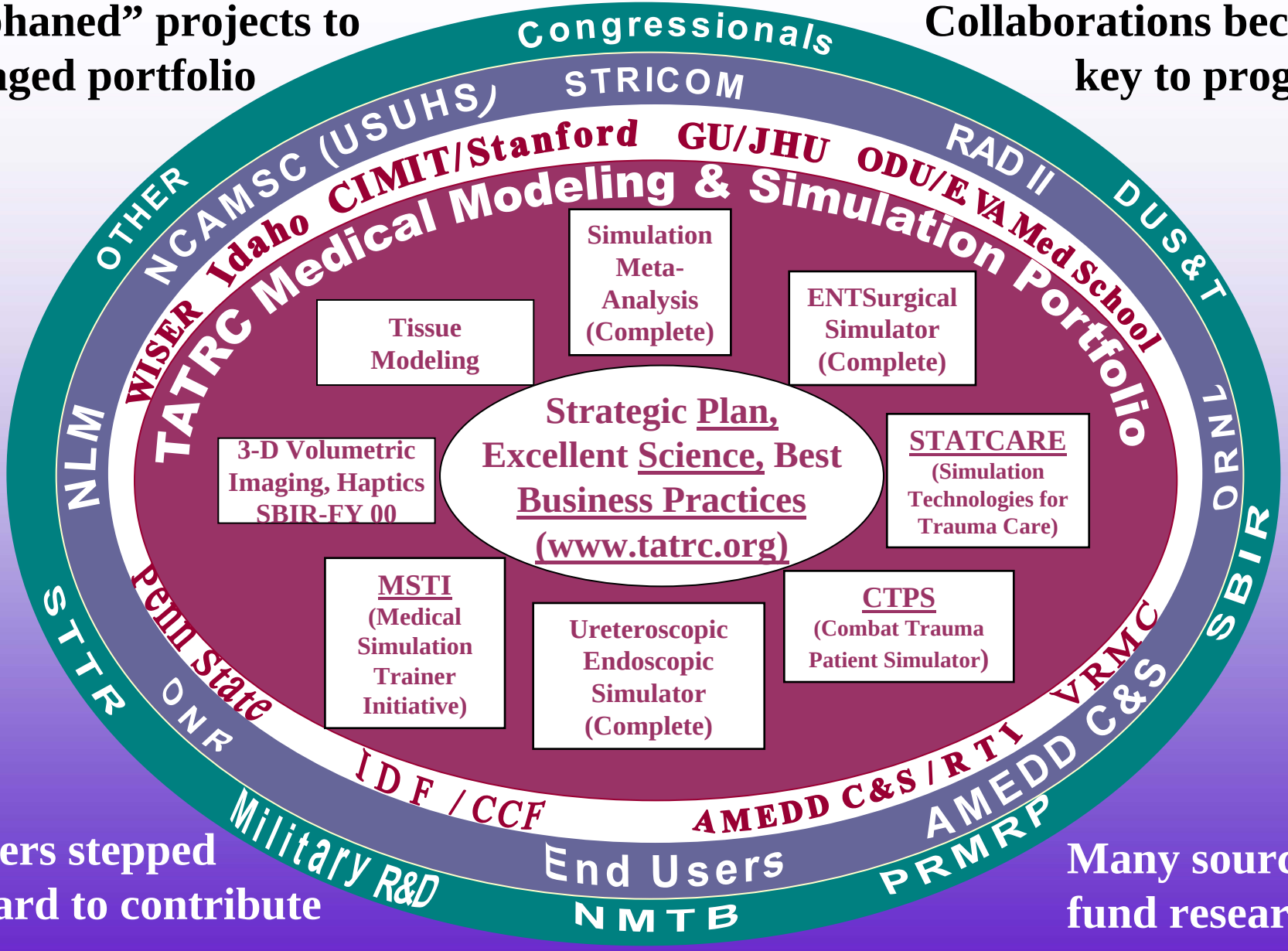
# What's the Strategy???

## PORTFOLIO

## COLLABORATIONS

**“Orphaned” projects to managed portfolio**

**Collaborations became key to progress**



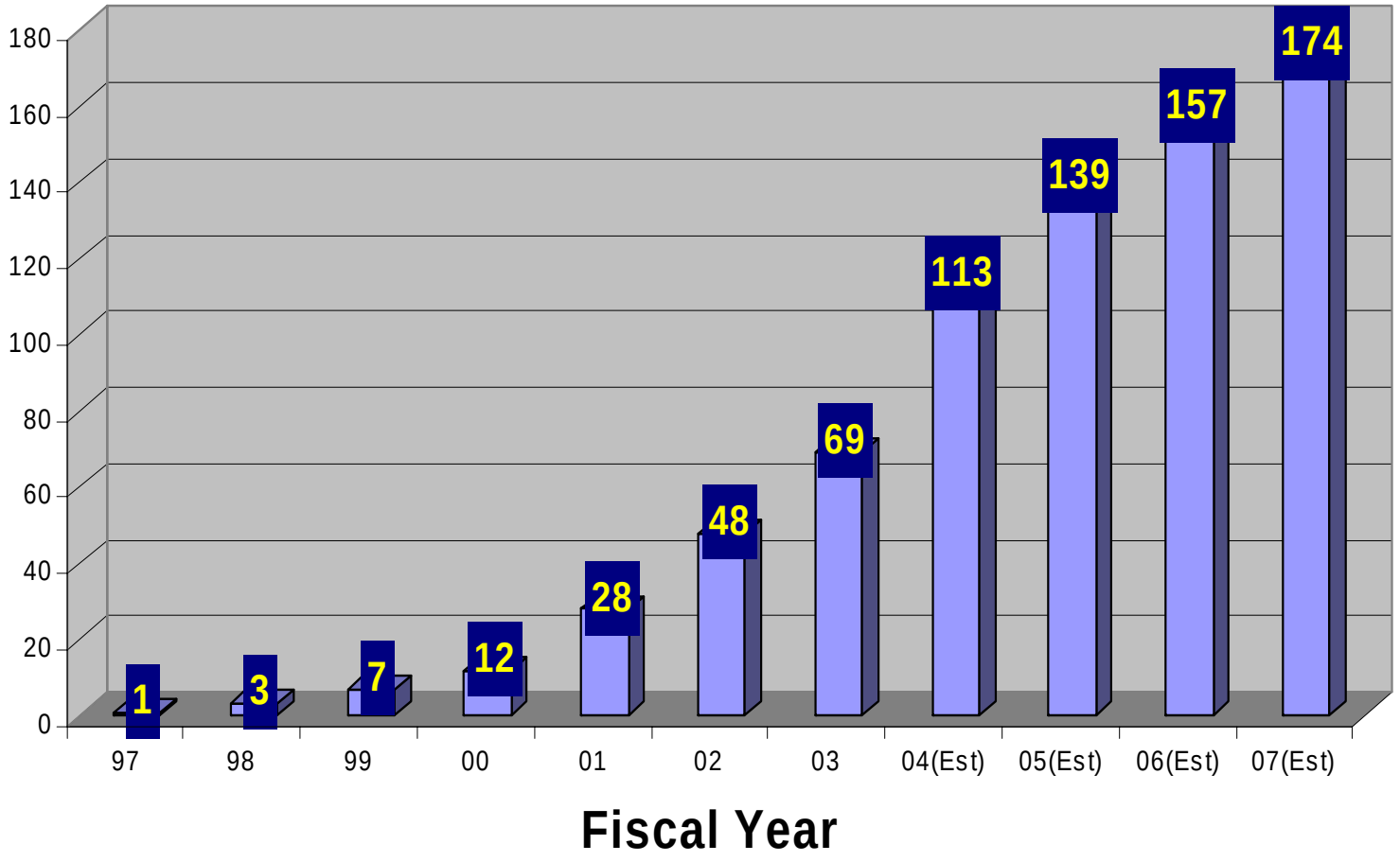

**Leaders stepped forward to contribute**

**Many sources fund research**

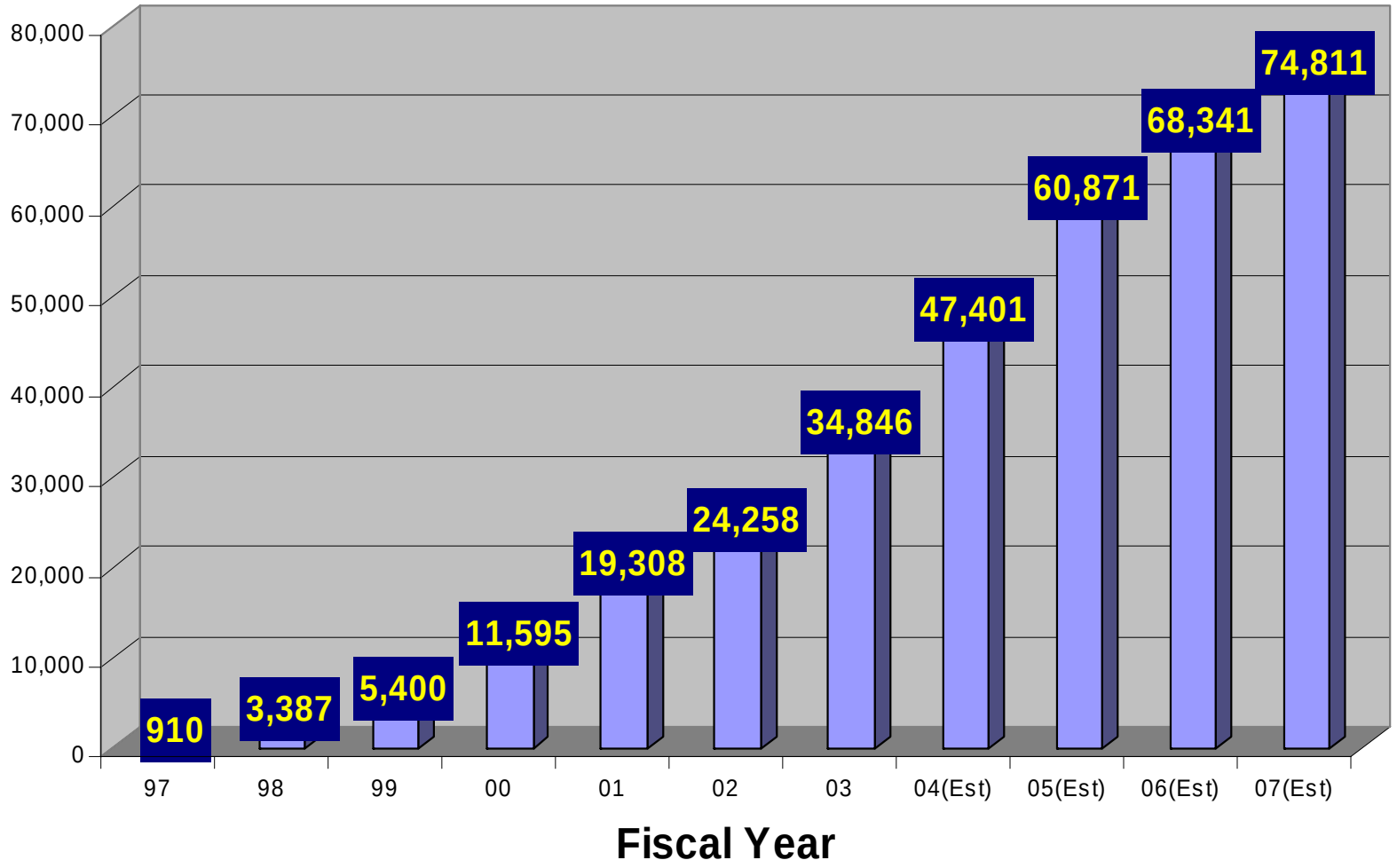
## RELATIONSHIPS

## FUNDING EFFORTS

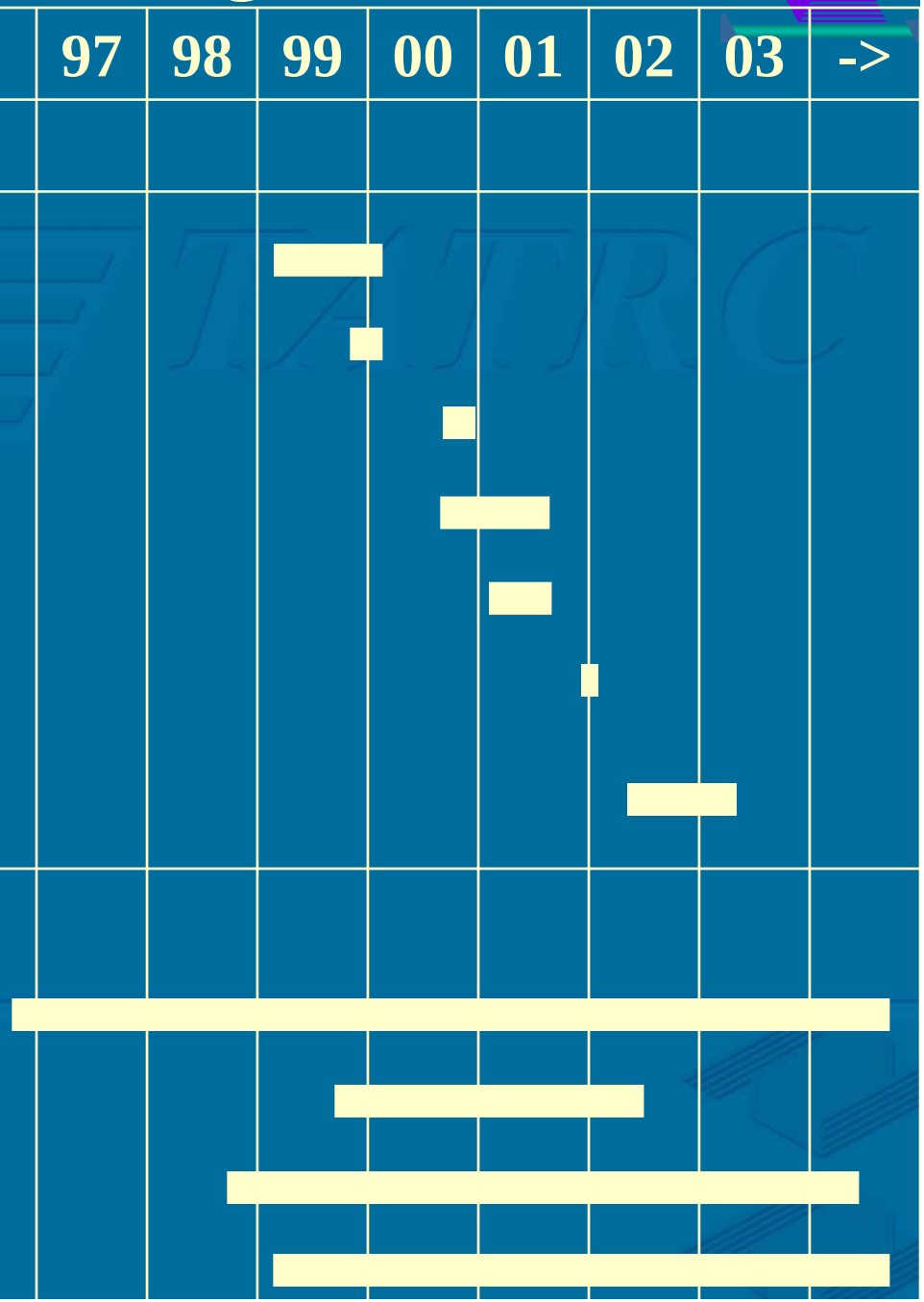
# # Cumulative Projects



# $ Cumulative Investment (000)



# Summary of Defining Events



# Defining Events

**Extensive meta-analysis conducted in 1999 to provide framework for development**

**Investigators: Howard Champion, M.D., Gerald Higgins, Ph.D.**

TATRC Report No. 00-03

TATRC
Telemedicine & Advanced Technology Research Center

Meta-Analysis and Planning of SIMTRAUMA:
Medical Simulation for Combat Trauma Training

By

Howard R. Champion, MD
Gerald A. Higgins, PhD
Tech Med
Annapolis, Maryland

March 2001



U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

# Defining Events

## Integrated Research Team – Feb 00

- **IRT convened government, academia, & industry**
- **Strategy resulted**
- **4 general areas for research identified**
- **Became basis of TATRC portfolio**

# Defining Events

TATRC

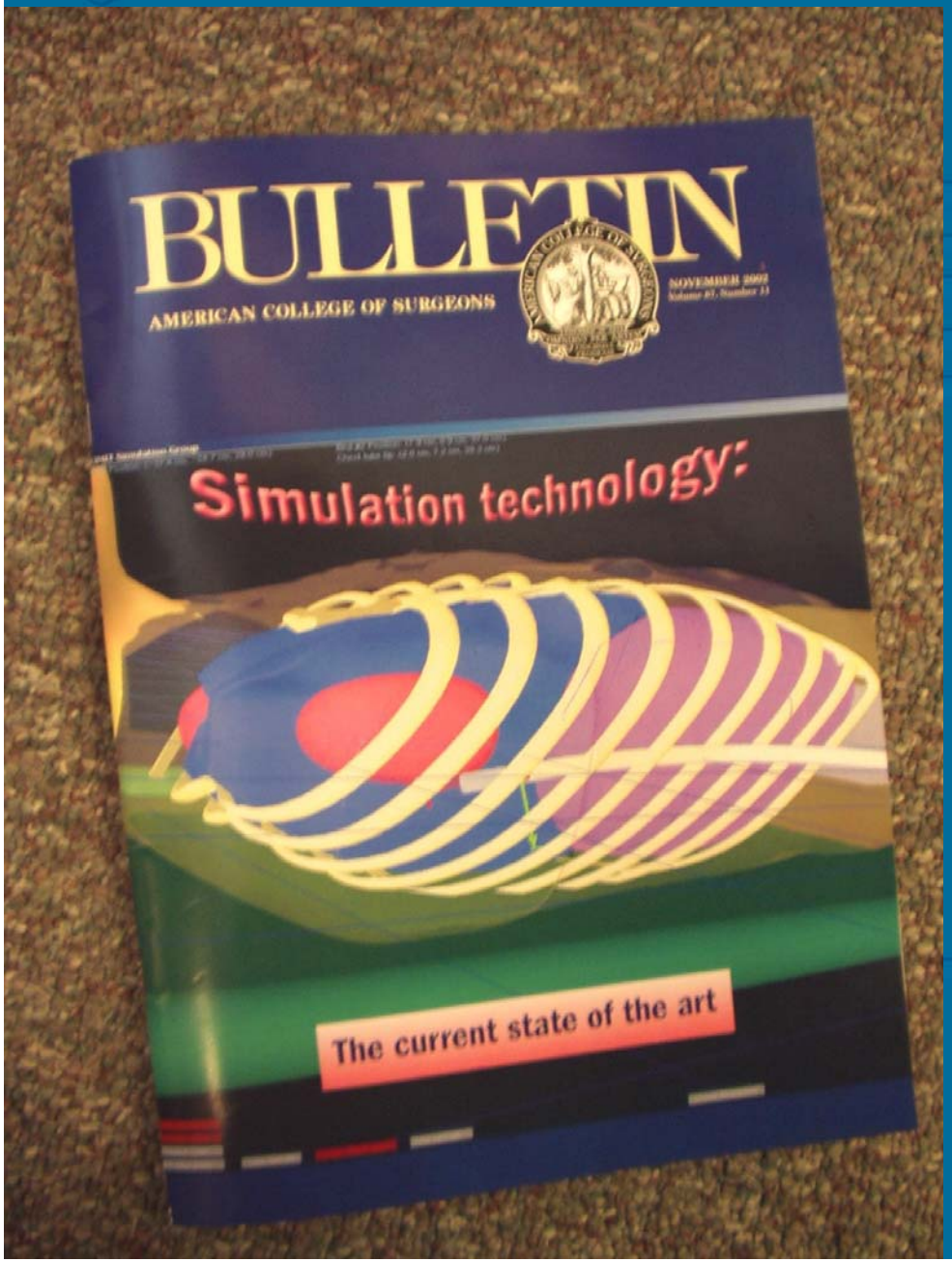
## Knights of the Simulation Roundtable – Jan 01

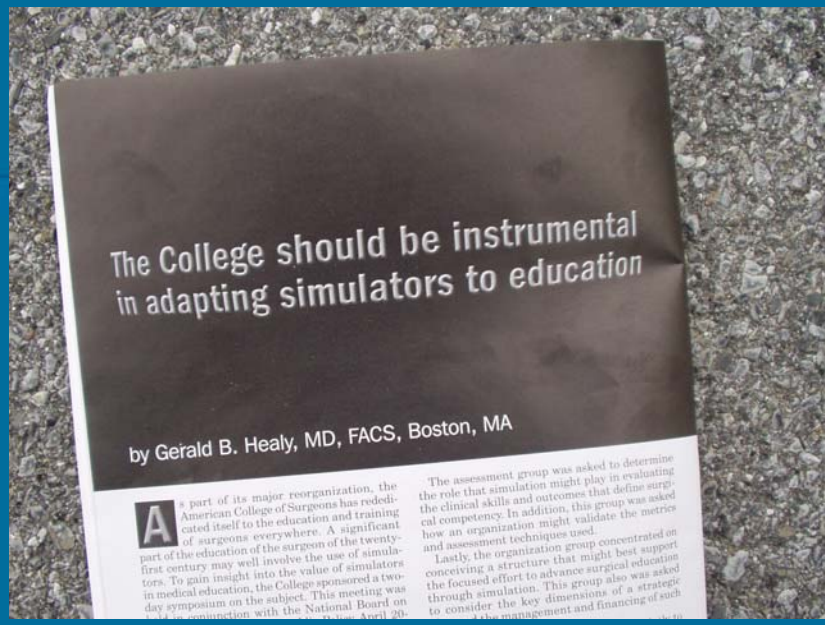
**Purpose: discuss enabling technologies for long term**

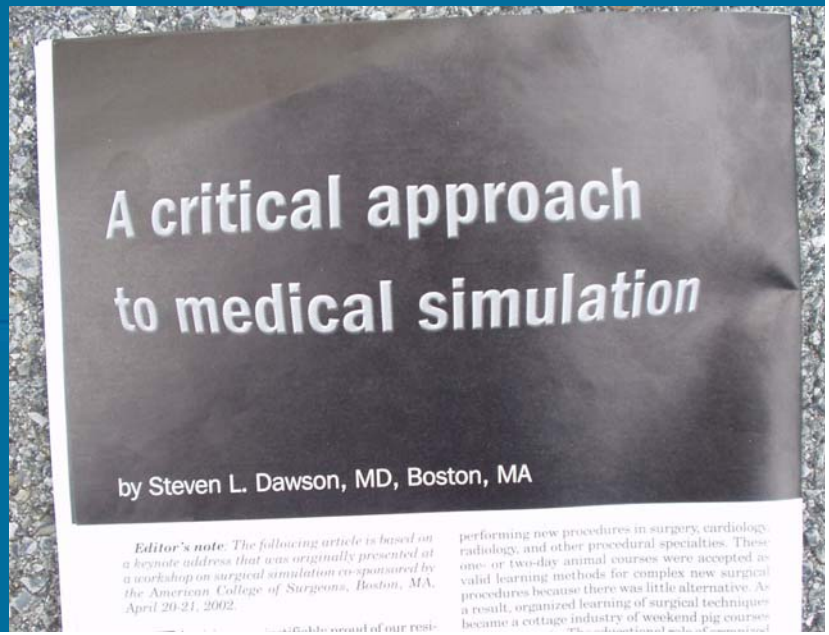
## Enabling technologies

- Real-time *in vivo* tissue property measurement
- Tissue-tool interactions
- Graphics, visualization
- Learning systems
- Metrics development and learning transfer & assessment
- Open source architecture

# Defining Events



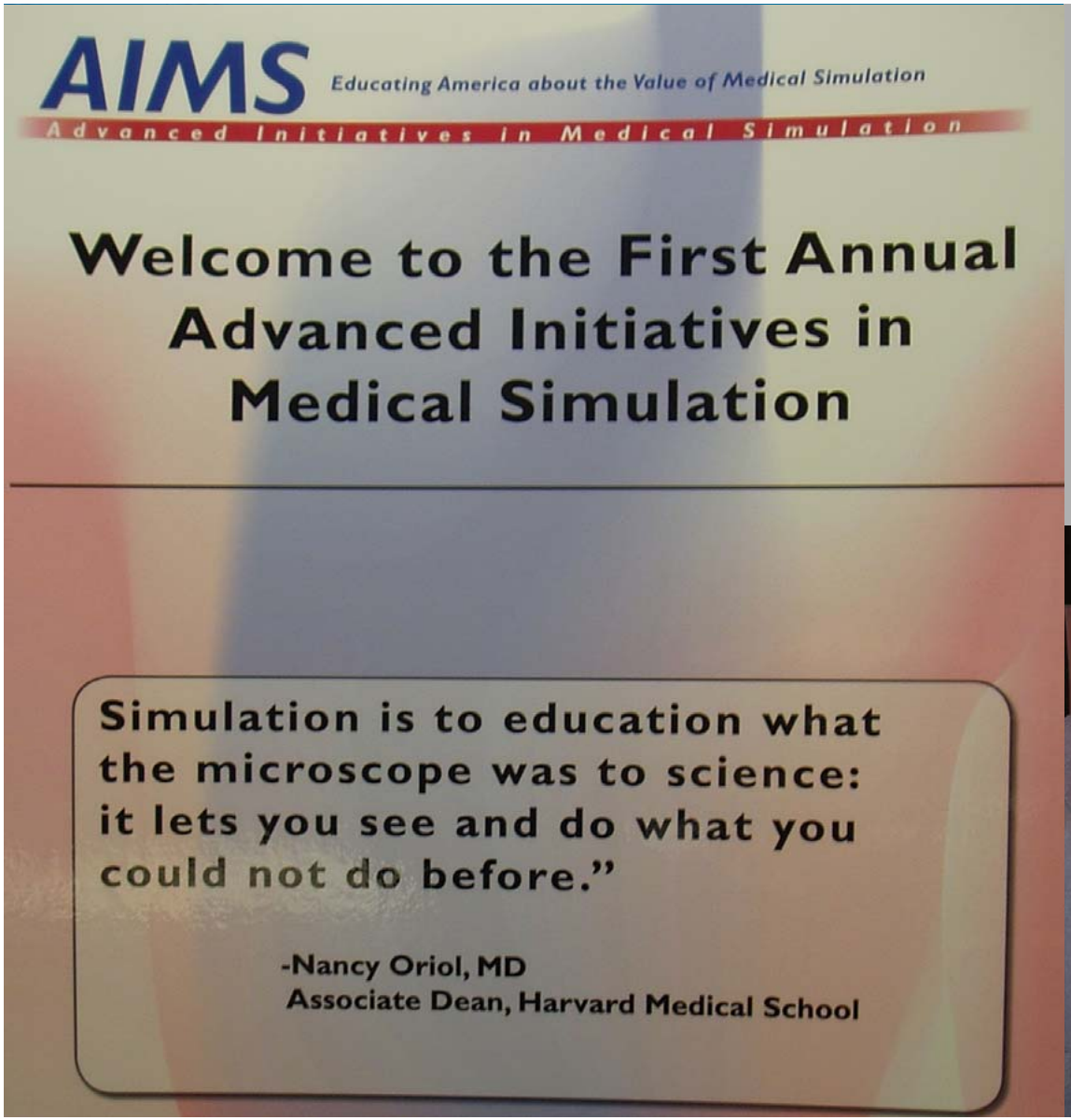
# Defining Events

- Recommendations to ACS Board of Regents (Apr 02)
  - Working premise: medical simulation would reduce surgical error by…
    - Screening
    - Initial training
    - Ongoing education
    - Maintaining proficiency
- Conclusions:
  - Simulators should be used well into the future to teach, refine, test surgical skills.

# AIMS

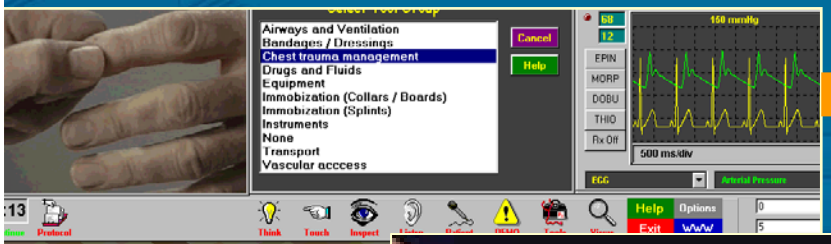
**Educating America about the Value of Medical Simulation**

Advanced Initiatives in Medical Simulation





# Multiple Needs, Multiple Technologies: 4 Categories of MM&S




PC-based Interactive Multimedia

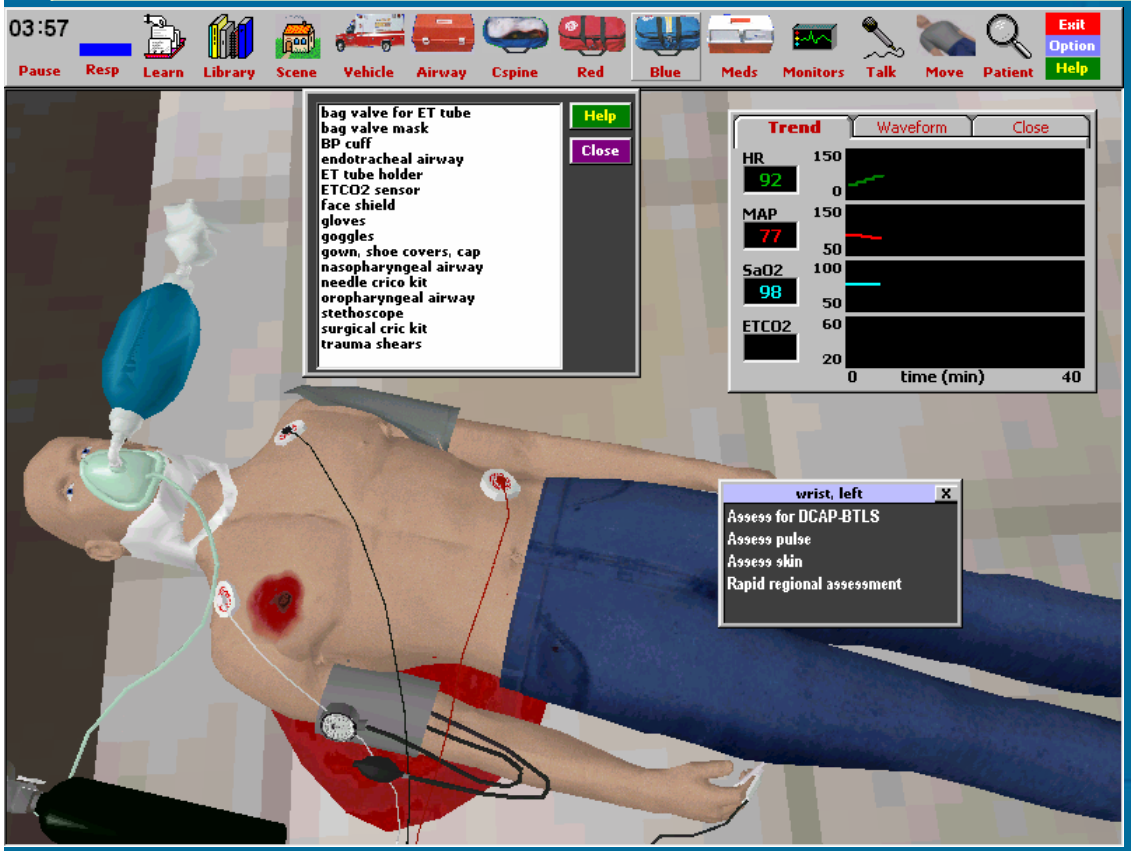
Digitally Enhanced Mannequins

Virtual Workbenches

Total Immersion Virtual Reality

# Development – PC Interactive Multimedia

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| STATCare | | | | | | | | |




Simulation Technologies for Advanced Trauma Care (STATCare),
by Research Triangle Institute
PI: Paul Kizakevich, M.S.

- Case-based scenarios
- Physiological & pharmacokinetic response to trauma and treatment
- Interactive
- Courseware, distance learning, reference materials

# Development – Digitally Enhanced Mannequins

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| •Combat Trauma Patient Simulation (CTPS) System | | | | | | | | |
| •SimMan™ mannequin to National Capital Area Medical Simulation Center for comparative assessment | | | | | | | | |

# Development – Digitally Enhanced Mannequins

TATRC

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Combat Trauma Patient Simulation (CTPS) System | | | | | | | | |

- COTS mannequins; GOTS components. e.g., SAWE/MILES
- Simulate battlefield injuries by type and category; monitor movement; compare interventions & outcomes at each level of care.

**Human Patient Simulator (HPS) & Combat Trauma Patient Simulation (CTPS), Program Management by USASTRICOM (Beth Pettitt, M.E.)**
**Vendor: Medical Education Technologies Inc (METI), PI: Ron Carovano, M.S.**

# Development – Digitally Enhanced Mannequins

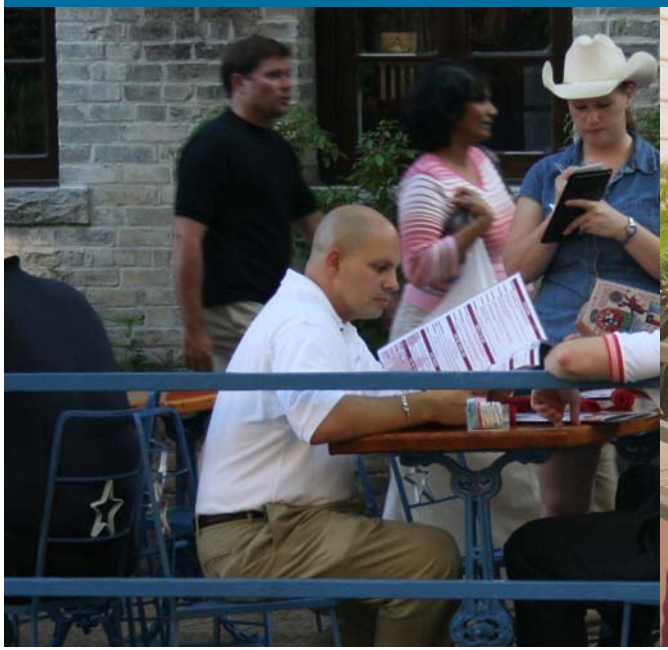
| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| SimMan™ Mannequin to National Capital Area Medical Simulation Center for Comparative Assessment | | | | | | | | |

- SimMan™ placed at National Capital Area Medical Simulation Center for assessment.
- Allows side-by-side comparison with other mannequins.

SimMan™, by Laerdal / Medical Plastics Laboratory (MPL)

# Winter Institute for Simulation Education Research (WISER)

- Univ of Pittsburgh Medical Center (UPMC)
- Outstanding job of integrating simula***TORS*** into educational ***curricula*** as part of simula***TION*** - based ***training***
- SimMedical spin-off for commercialization

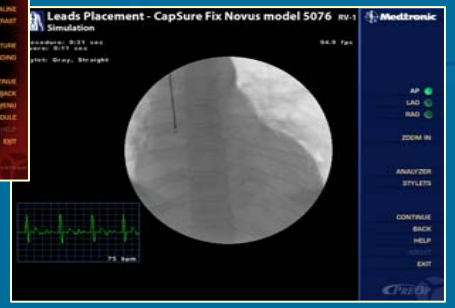


# Virtual Workbench-Part-Task Trainers

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| •Ureteroscope | | | | | | | | |
| •VIRGIL™ Chest Trauma | | | | | | | | |
| •Central Venous Catheter (Ph 1) | | | | | | | | |
| •Central Venous Catheter (Ph 2) | | | | | | | | |
| •Needle Thoracentesis (Ph 1) | | | | | | | | |
| •Needle Thoracentesis (Ph 2) | | | | | | | | |
| •Cath Insertion Workstation | | | | | | | | |
| •Exsanguinating Hemorrhage | | | | | | | | |
| •Advanced Ureteroscopic | | | | | | | | |
| •VR Demo | | | | | | | | |

# Virtual Workbench (Part-Task Trainers)

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Ureteroscopic Endoscopic Surgical Simulator – HT Med | | | | | | | | |


- Capability - Simulate kidney stone procedure. Real-time physiological modeling of tissue trauma. Tactile (haptic) feedback. Video and fluoroscopic views of ureters and calyx of kidney.

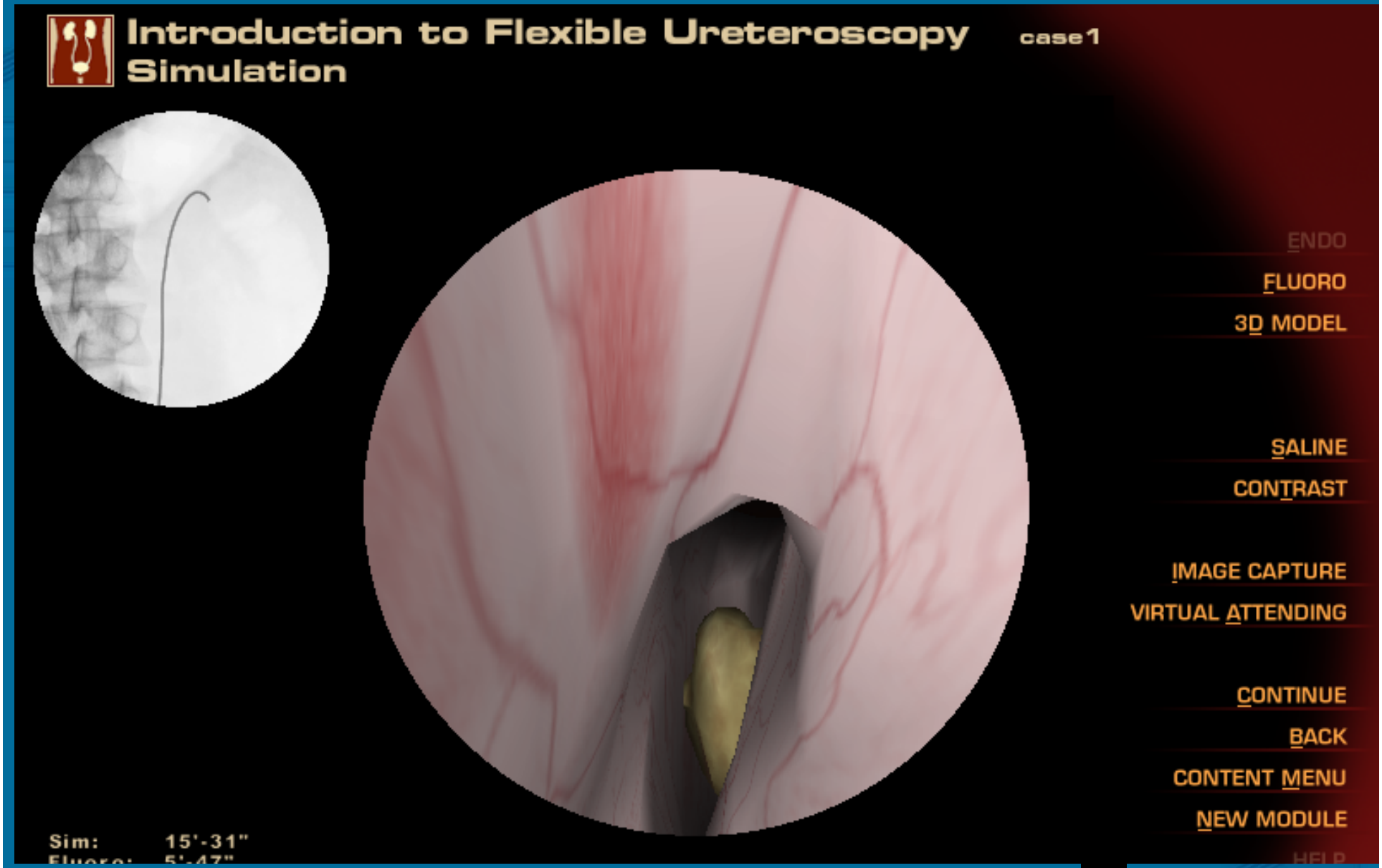
- Point – Technologies developed can be applied to other "part-task" medical simulators.

# Ureteroscope Endoscopic Surgical Training System

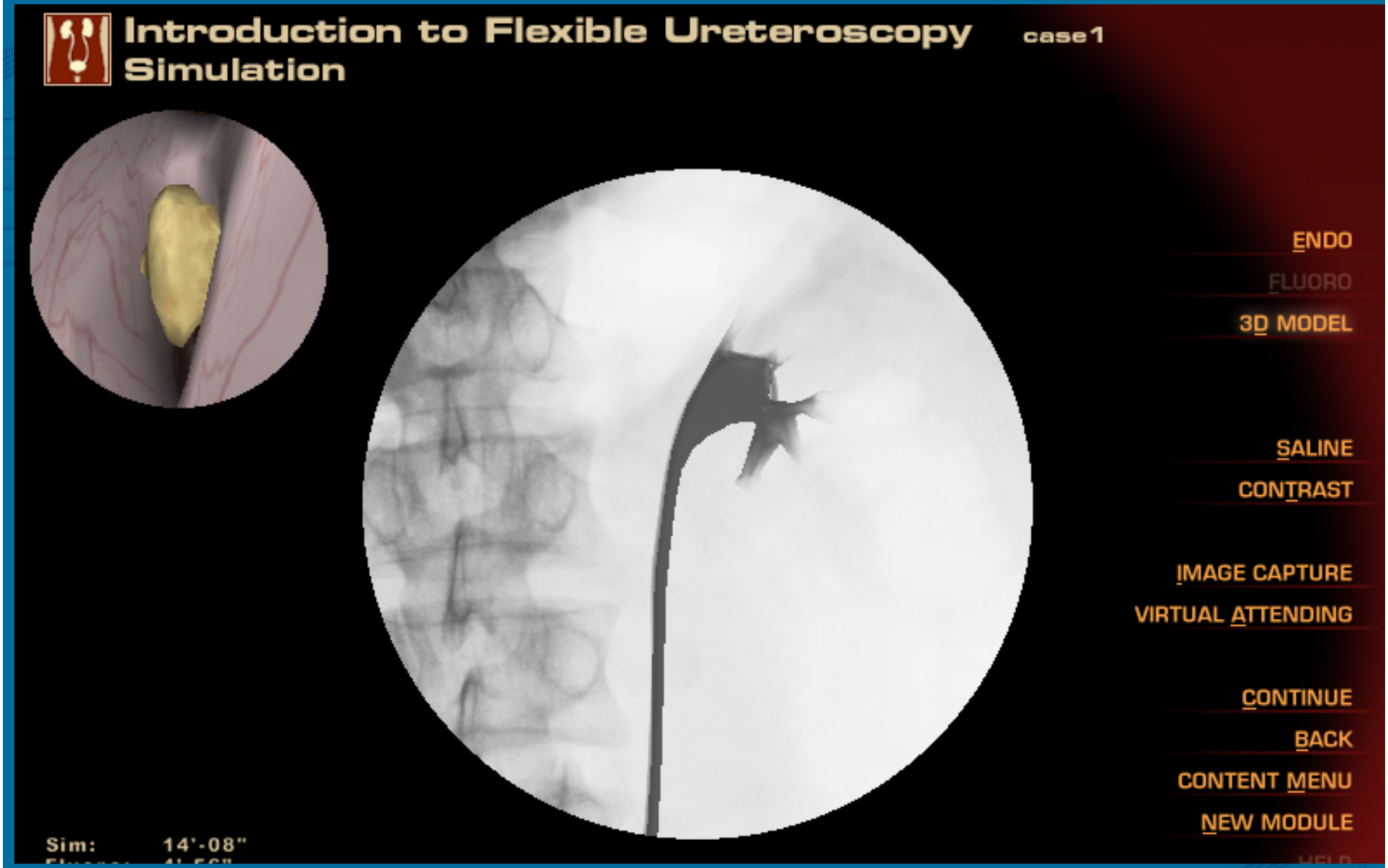
**Developer: HT Medical Inc. (now Immersion Medical)**

**Principal Investigator: Joe Tasto, M.D.**

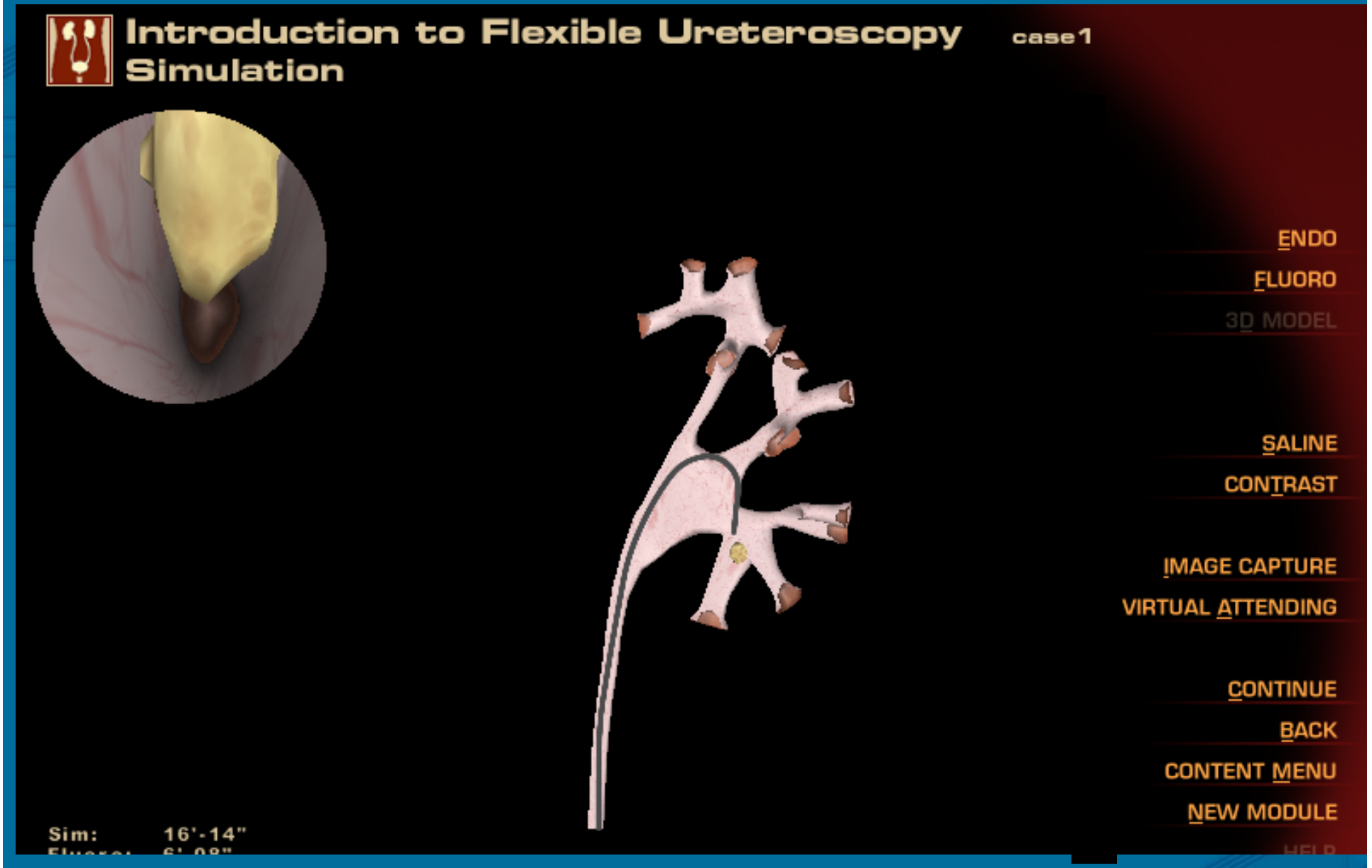
# Endoscopic View



# Fluoroscopic View



# 3D Model View



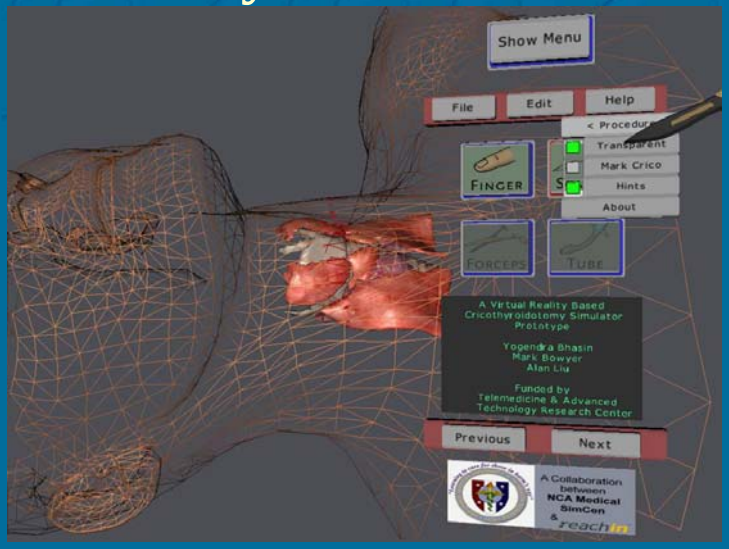
# Advanced Ureteroscopic Surgical Trainer (Transurethral Resection of the Prostate)



**Simbionix Corp**
**Cleveland, Ohio**
**Principal Investigator:**
**Yael Friedman, PhD**

# Cricothyroidotomy

- Emergency surgical procedure where an incision is made through the skin and cricothyroid membrance that allows for placement of an endotracheal tube into the trachea when airway control is not possible by other methods.
- Essential skill for medical readiness
- Current training limited
  - Animals have incorrect anatomy
  - Cadavers have incorrect physiology
  - Mannequins don't cover full range of anatomical variations






**Principal Investigator: Alan Liu, PhD,**
**National Capital**
**Area Medical Simulation Center**

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| VIRGIL™ Chest Trauma Training System – CIMIT | | | | | | | | |

It's a SYSTEM - mannequin with PC-based graphical interface, tracks internal position of chest darts & tubes during training, realistic force feedback. As scenarios become more difficult, system tracks progress & detects error patterns.

PI: Steve Dawson, M.D.

# Virtual Workbench (Part-Task Trainers)

VIRGIL® Chest Trauma Training System – CIMIT Simulation Group

# Virtual Workbench (Part-Task Trainers)

VIRGIL® Chest Trauma Training System – CIMIT Simulation Group

# “Enabling Technologies” becoming “Enabling Ideas”

- Training, yes, but more…
- Simulation as a medical ambassador, a good will emissary of the United States

TATRC


TOP TEN
WINNER
2003
VIRGIL™
CHEST
TRAUMA
TRAINING
SYSTEM
U.S. ARMY
TELEMEDICINE
AND ADVANCED
TECHNOLOGY
RESEARCH
CENTER

# Central Venous Catheterization

TATRC

## 3 - Sharps Insertion

- Clinician inserts the needle on anterior chest wall & accesses virtual blood vessel.
-Clinician inserts guidewire in needle to enter virtual blood vessel.

## 2 - Ultrasound Probe

- Clinician applies the ultrasound probe.
- Resultant ultrasound view appears in the simulation.

## 1 - Palpation

- Clinician palpates anterior chest wall on virtual patient.
- The virtual anatomy internal view reveals targeted blood vessel and surrounding structures.

Immersion Medical, Gaithersburg, MD; PI: Kevin Kunkler, MD

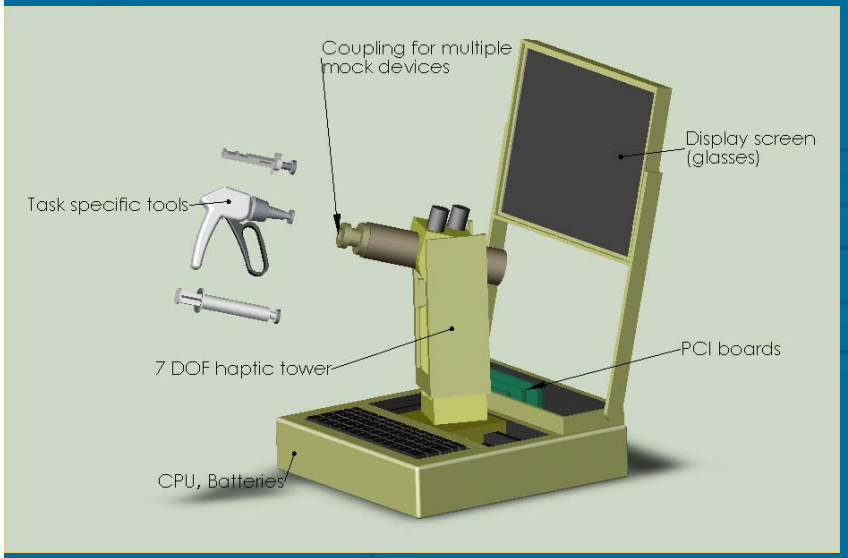
# Virtual Workbench (Part-Task Trainers)

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Exsanguinating Hemorrhage from Limbs – SimQuest | | | | | | | | |

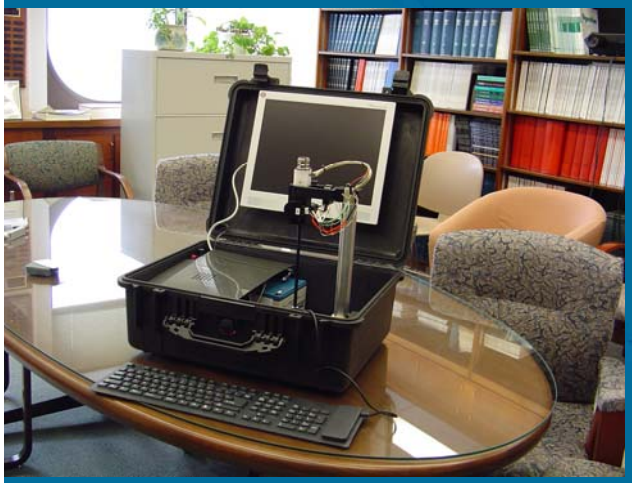
- 90% of all battle deaths occur before surgery can be accomplished.
- Objective – Develop a simulator to teach users, combatants and medical personnel how to apply a tourniquet to stop acute exsanguinating hemorrhage

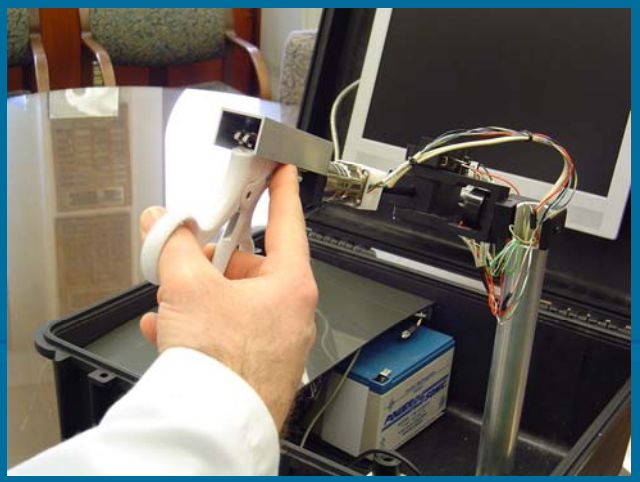
SimQuest International;
PI: Howard Champion, MD

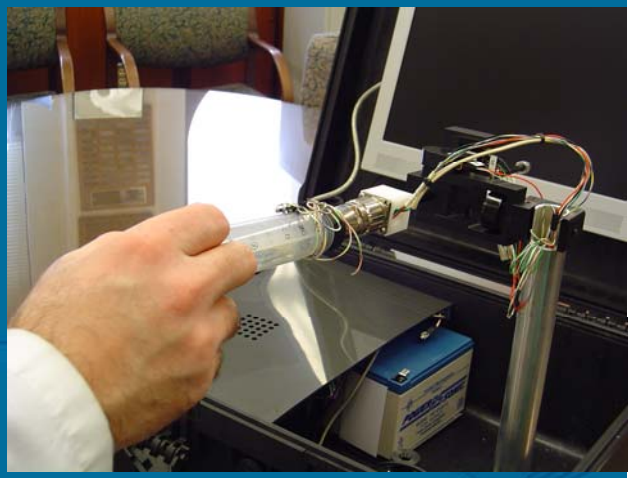
# "VR-Demo"




- **Problem: Skills (1) degrade, (2) may be lost at moment of need, (3) are needed for the unexpected**
- **Solution: portable, flexible, self-contained haptics-based simulator**
- **Benefits: Move training from lab to workplace & to critical situations for just-in-time training**

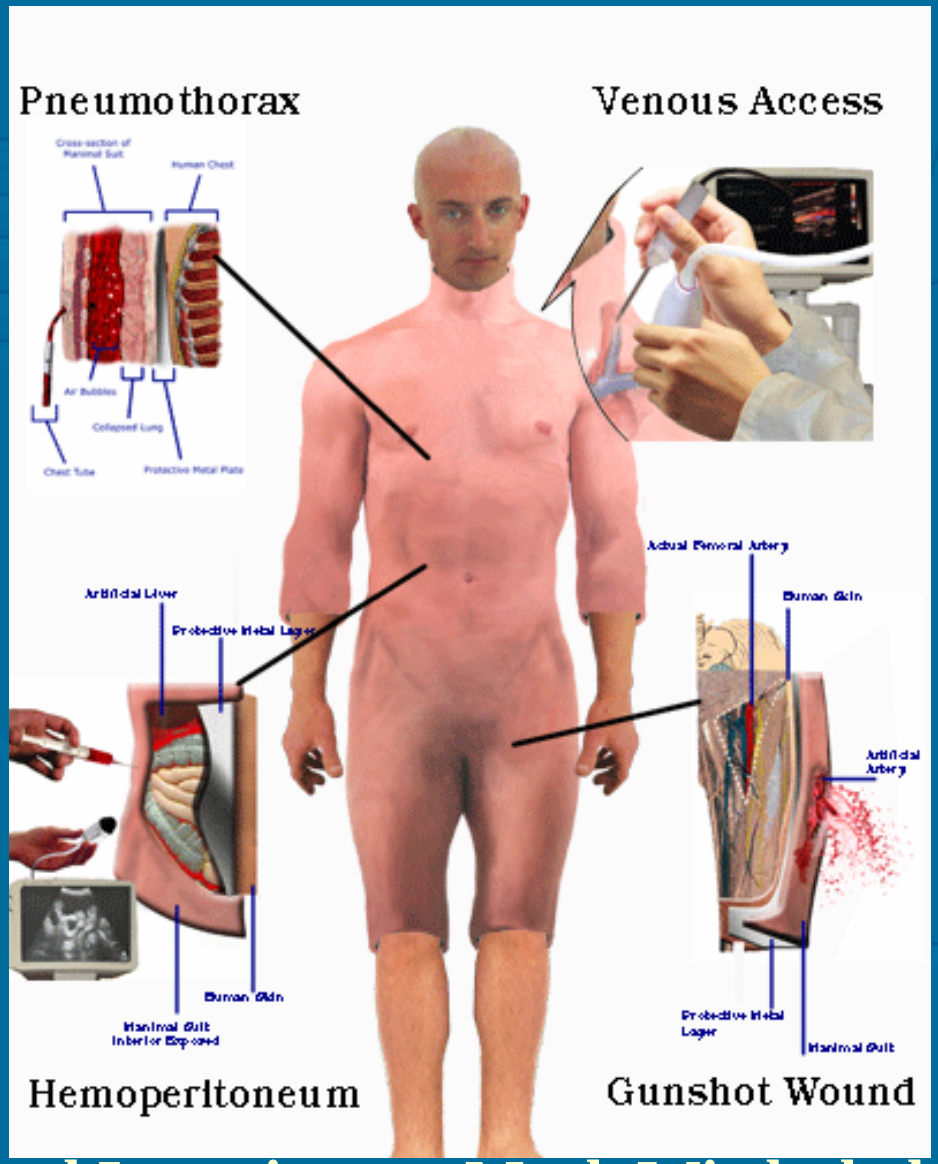






**Principal Investigator: Randy Haluck, MD, Penn State**

# Dynamic Injury Creation Simulation (Virtual Reality Medical Center, San Diego)




**Principal Investigator: Mark Wiederhold, MD**

# New Efforts – No "Pics" Yet

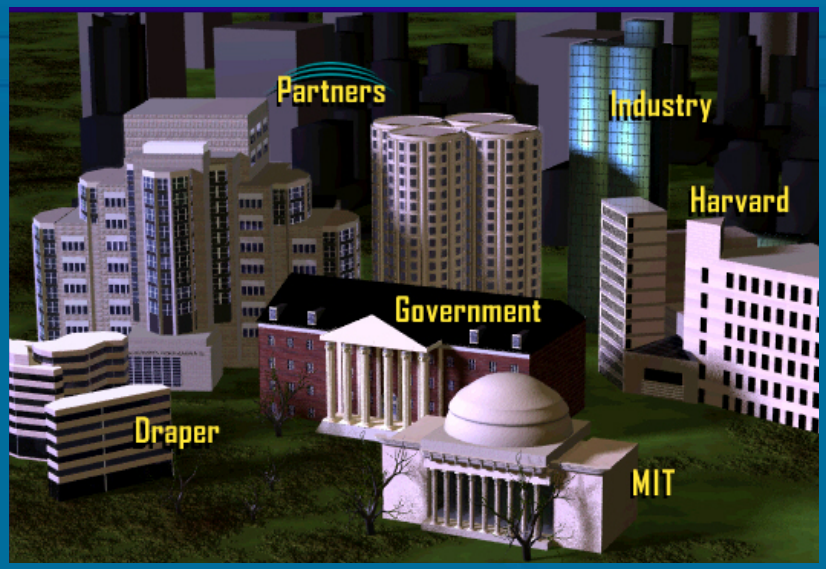
- Exsanguinating Hemorrhage (Tourniquet Trainer)
- Haptics-Optional Surgical Training System (HOSTS)
- Predicting Cognitive Performance of Deploying Health Teams
- Fractured Femur Simulator
- SimGame – Medical Response to Chem-Bio, Radiological, Nuclear Event (CBRNE)
- Simulation-based Open Surgical Training System (SOSTS)
- Compartment Syndrome
- Intracranial Hematoma / Burr Hole Simulator

# Total Immersion Virtual Reality (TIVR)

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| •Med Sim Trainer Iniative | | | | | | | | |
| •Tissue Measurement & Property Sampling Tool (TeMPeST) | | | | | | | | |
| •OpenMedSim | | | | | | | | |
| •Virtual Medical Training System (SBIR Phase I) | | | | | | | | |
| •Virtual Medical Training System (SBIR Phase II) | | | | | | | | |
| •3-D Volumetric Floating Image w/Haptics (SBIR Phase I) | | | | | | | | |
| •Improved Anatomic Modeling Through the Use of Rule Based Systems | | | | | | | | |

# Total Immersion Virtual Reality (TIVR)

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Medical Simulation Trainer Initiative (MSTI – CIMIT) | | | | | | | | |




Principal Investigator:
Steve Dawson, M.D.

- TATRC's bridge to future
- CIMIT Simulation Group
- Strategy - develop fundamental science and enabling technologies that permit learning on a simulator to be translated to actual patient care

# Total Immersion Virtual Reality (TIVR)

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Medical Simulation Trainer Initiative (MSTI) – CIMIT | | | | | | | | |

## Enabling Technology Challenges

- *In vivo* tissue property measurement
- Tissue-tool interactions
- Graphics & visualization
- Learning systems
- Metrics development
- Learning transfer assessment
- Open simulation

# Parachutes, revisited - ATACCC 2003


"ATLAS"
2004-05

"EVE"
2003-04

SITU
April 26, 2003

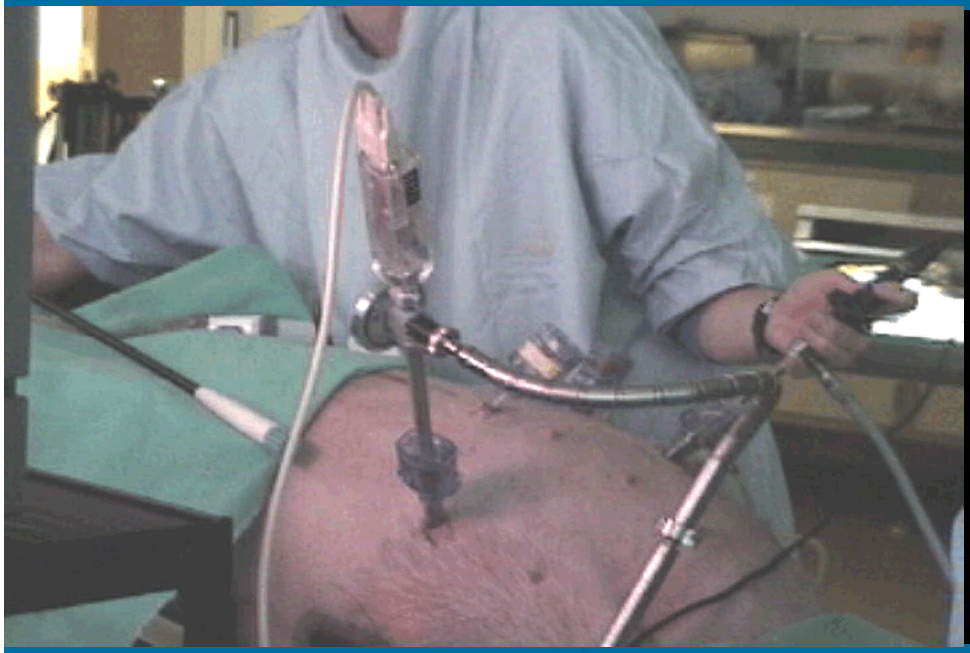
CELTS
March 2003

"Mini-V"
Nov 2002

VIRGIL
Sept 10, 2001

# Total Immersion Virtual Reality (TIVR)

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Tissue Measurement & Property Sampling Tool (TeMPeST) | | | | | | | | |

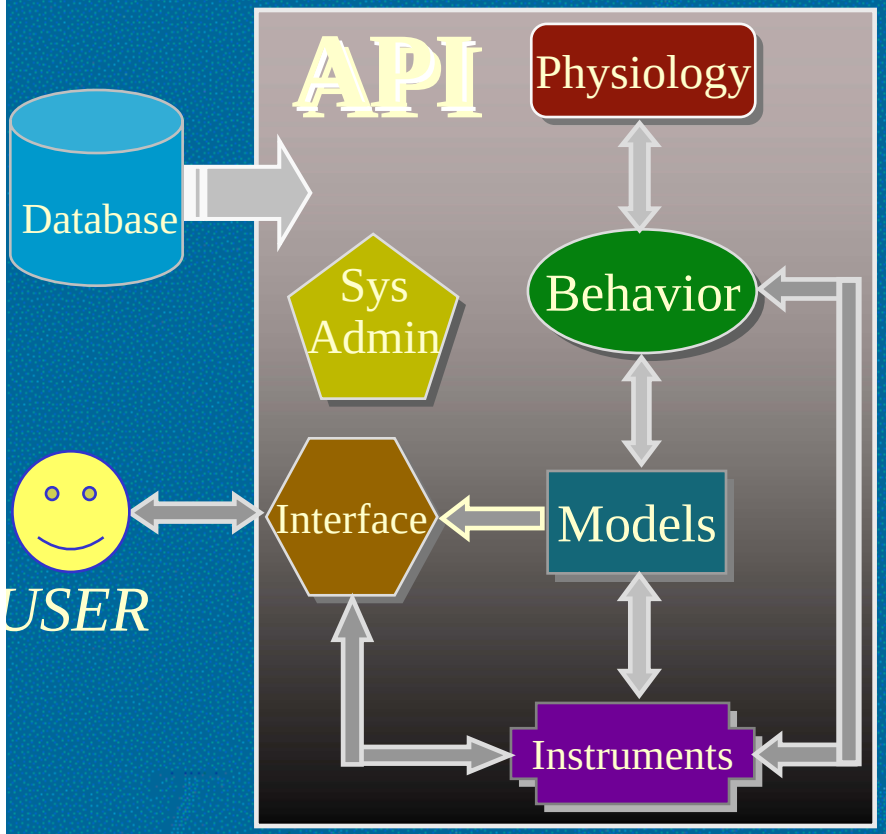


***In vivo*** **measurement of porcine liver tissue properties using TeMPeST. Images from proof of concept testing performed at Dartmouth Medical School. Mark Ottensmeyer, Ph.D. , 2000**

# Total Immersion Virtual Reality (TIVR)

TATRC

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Open Medical Simulation (OpenMedSim) – CIMIT Sim Grp | | | | | | | | |




- Goal: Develop open source standard architecture.
- Harvard, Stanford, five European centers to develop SOW to develop powerful, enabling tool for open source, freely available common simulation framework
- Paul Neumann, Ph.D. *et al*

# Total Immersion Virtual Reality (TIVR)

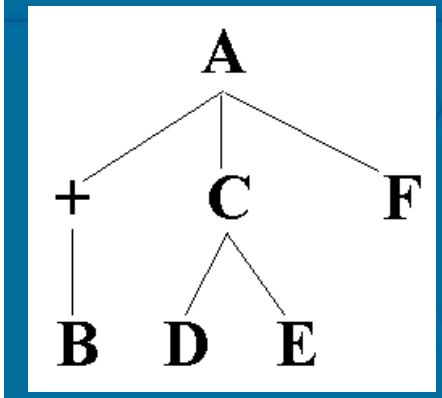
| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Virtual Medical Training System (SBIR Phase I) – Physical Optics | | | | | | | | |
| Virtual Medical Training System (SBIR Phase II) – Physical Optics | | | | | | | | |

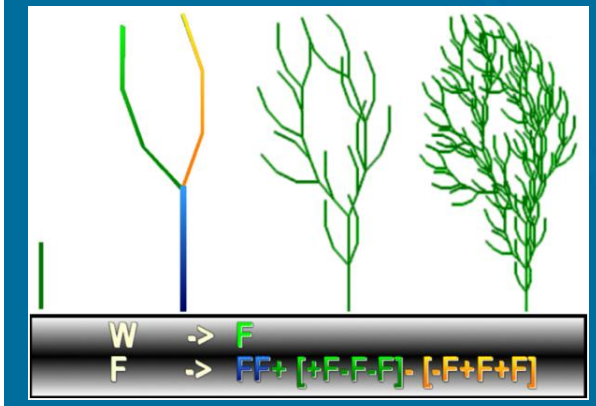

**OBJECTIVE - Develop and demonstrate PC-based, general purpose surgical simulation workstation that combines a 3-D volumetric floating image & co-aligned force feedback**

**Principal Investigator:**
**Stephen A. Kupiec, Ph.D.**

# Total Immersion Virtual Reality (TIVR)

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| Improved Anatomic Modeling Through Rule Based Systems – Crowley-Davis Research | | | | | | | | |

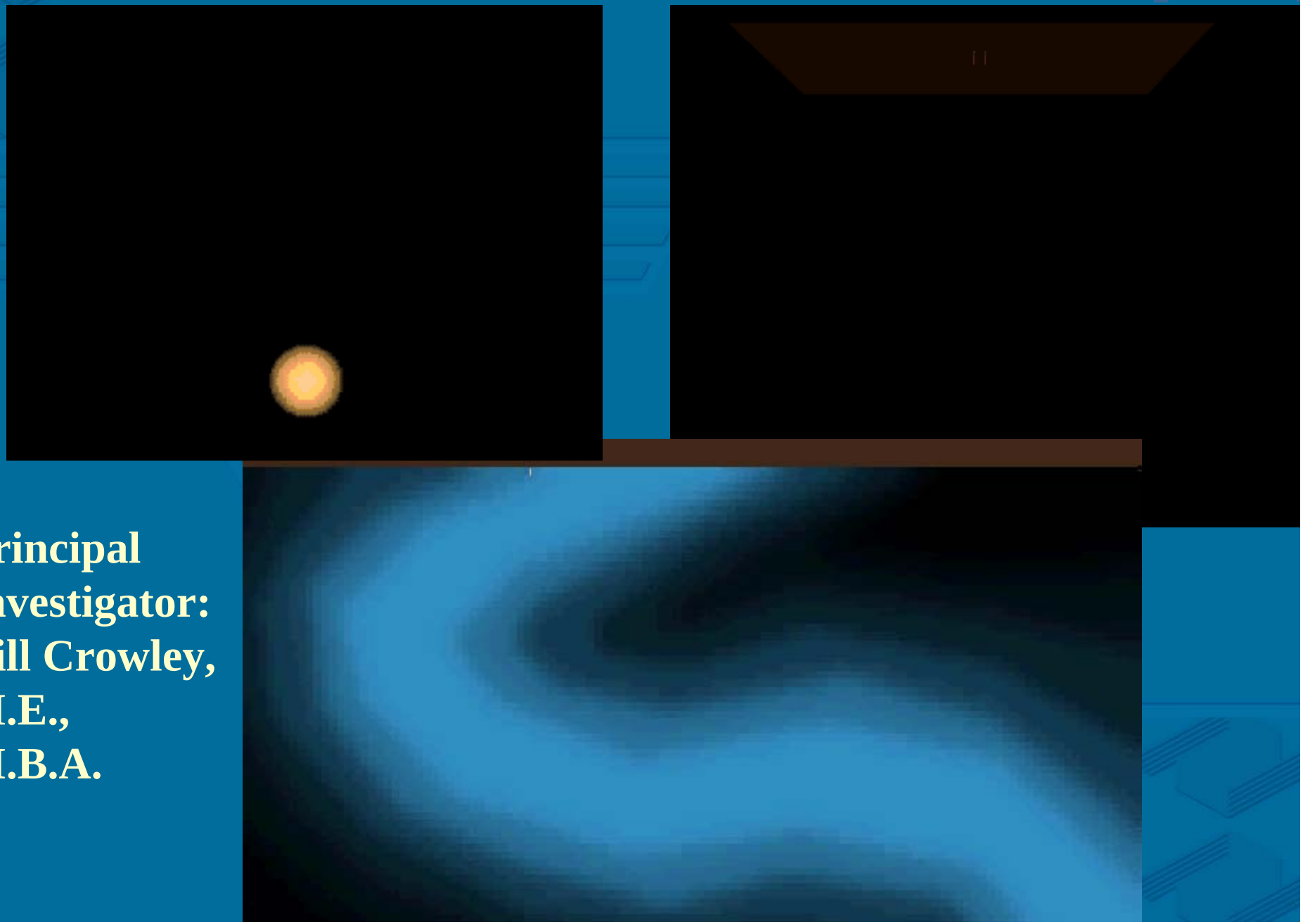



- Rule-based data structure to present complete & accurate virtual image
- Contains all info for haptic & interactive, tactile & other control input/output (IO) functions to achieve realistic and accurate simulation
- Significantly (3-10x) smaller than aggregate size of combined raw data;
- Works on low cost PCs, standard ports

**Principal Investigator: Bill Crowley, M.E., M.B.A.**

# Rule-Based Systems Demonstrations



**Principal Investigator: Bill Crowley, M.E., M.B.A.**

# *THE* Challenge to Medical Simulation: Validation, Validation, Validation!

- **Research Challenge: After a** decade of research, many simulation devices and systems show potential to improve training, but much is based on anecdotal feedback.
- **Response**: TATRC began in 2001 to validate "transfer-of-training" from simulators to actual medical practice.

# Validation Projects

TATRC

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| •Simulation Working Group | | | | | | | | |
| •Formal Assessment of CTPS | | | | | | | | |
| •Formal STATCare validation | | | | | | | | |
| •New Assessm Tools to Support Med Readiness Training | | | | | | | | |
| •Assessment Tools to Support Med Readiness Training | | | | | | | | |
| •National Center for Collaborat | | | | | | | | |
| •Computer Based Sim Tech for Tng Tech Skills in Medicine | | | | | | | | |
| •VIRGIL™ Validation | | | | | | | | |
| •VMAS Committee | | | | | | | | |
| •Ureteroscopic Endoscopic | | | | | | | | |

# Validation – VIRGIL™

| Period | 97 | 98 | 99 | 00 | 01 | 02 | 03 | -> |
|---|---|---|---|---|---|---|---|---|
| VIRGIL™ Validation (USUHS) | | | | | | | | |


Richard Karmona, M.D., United States Surgeon General, performs a chest tube insertion on VIRGIL™ with the assistance of Steve Dawson, M.D. Principal Investigator

- Initial validation study conducted Mar 02 with 24 Medics
- Validation study at National Capital Area Medical Simulation Center Sep 02 – “as good as pig training”

# Validation to Implementation

- **What better test bed surgi simulators than the Nationa Capital Area Medical Simulation Center (NCAMSC)?**
- **NCAMSC has capability to…**
  - **Validate simulation**
  - **Implement simulation into medical education curricula**
  - **Explore and develop virtual reality tools**


**... DOD's medical school!**

# Validation to Implementation

- What better test bed for point-of-injury & field care than the Directorate of Combat Medical Training (DCMT), Ft. Sam Houston, TX…as long as we help them & don't kill them with kindness ?

- DCMT has capability to…
  - Validate effectiveness of simulation
  - Implement simulation into medical education curricula
  - Suggest new ideas to R&D community

# Major Strategic Directions

- Validate effectiveness of simulation training ("Transfer-of-Training" Studies)
- Facilitate development of open architecture standards to pave the way to interoperability among medical simulators
- Advanced Initiatives in Medical Simulation (AIMS) to build national momentum
  - "Rising tide lifts all boats"
- Identify other domains of likely convergence, e.g., surgical robotics, entertainment industry (video games, film), behavioral therapy

# Predicted Benefits

- Improved and accelerated training
- Increased patient safety
  - Aviation safety record, medical safety record
- Increased motivation for learning
- Patient-specific “Just-in-Time” Training
- Reduction or elimination of animal use for teaching
- “Same case” presentation to students
- Improved quality of trauma training for both the military and private sector medicine
- Improved quality of health care nationwide

# Closing Thoughts

- Collaboration paves the way to competition
- Collision detection at the engineering level...collision detection at the human level
- Enabling technologies...enabling relationships
- So why RRR&E (Roles, Relationships, Responsibilites & Expectations)?
  - The building and nurturing of trust is a basis for risk-taking
  - Risk-taking (+ some smarts) can produce win-wins
- One can usually get “Good, Quick, Cheap”
  - But...Pick 2 !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