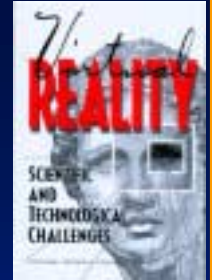


# **National Research Council Report: “Virtual Reality: Scientific and Technological Challenges”**

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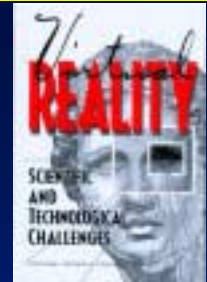


# Chapters

## *Part I: Overview*

## *Part II: Research and Technology*

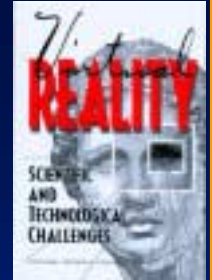
- Some Psychological Considerations
- The Visual Channel
- The Auditory Channel
- Haptic Interfaces
- Position Tracking and Mapping



# Chapters

## ***Part II: Research and Technology***

- Whole-Body Motion, Motion Sickness & Locomotion Interfaces.
- Speech, Physiology & Other Interface Components.
- Computer Hardware & Software for the Generation of Virtual Environments.
- Telerobotics
- Networking & Communications



# Chapters

## ***Part II: Research and Technology***

- Evaluation of Synthetic Environment Systems
- Specific Applications of Synthetic Environment Systems

# Purpose of the Report Committee



## *The NRC Committee on Virtual Reality Research & Development*

- The purpose of the committee was to “recommend a national research and development agenda in the area of virtual reality”.
- Committee consisted of 17 university, corporate and governmental experts in the field of virtual reality & telerobotics.

# Criteria Used to Construct the Research Agenda



## ***Science and technology criteria.***

- Research areas that could advance the state-of-the-art.

## ***Practical applications criteria.***

- Research areas likely to have practical application in the not-too-distant future.

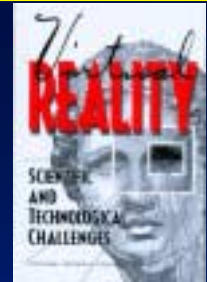
## ***Leverage criteria.***

- Leverage, cost-effectiveness & ratio of payoff to effort.

# Categories of Proposed Research Agenda



- ***Application domains.***
- ***Some psychological considerations.***
- ***Development of improved synthetic environment technology.***
- ***Evaluation of synthetic environment systems.***



# Application Domains of Synthetic Environment Systems

***Recommendations***

# Application Domains Recommendation



***Four application domains show the most promise for SE:***

- Design, manufacturing and marketing.
- Medicine & health care.
- Hazardous operations.
- Training.

# Application Domains Recommendation



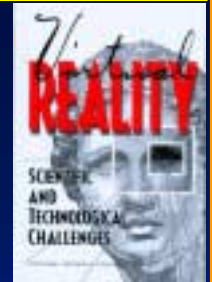
***Research needs in these domains should be used as one of the principal means to focus SE technology development & testing.***

# Application Domains - Special Project Recommendation



***Two projects should receive special attention:***

- Modeling the human body for purposes of medical education, surgical planning and providing explanations of procedures and outcomes to patients.
- Studying the transfer of knowledge and skill gained in training in a VE to performance in a real-world task environment.



# Psychological Considerations

***Recommendations***



# Psychological Considerations - Recommendations

***Support for psychological studies organized around the following objectives:***

- Development of a comprehensive, coherently organized review of theory and data on human performance characteristics from the viewpoint of SE systems.
  - Including basic sensorimotor resolution, perceptual illusions, info. transfer rate & manual tracking.

# Psychological Considerations

## - Recommendations



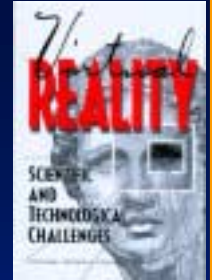
- Development of a theory that facilitates quantitative predictions of human responses to alterations in sensorimotor loops for all channels, with special emphasis on:
  - Degradations in performance resulting from deficiencies in SE technology (e.g. in the form of distortions, time delays and system noise).

# Psychological Considerations

## - Recommendations



- Supernormal performance achievable through introduction of purposeful enhancing distortions.
- Radical sensorimotor transformations that arise, for example, in connection with the use of sensory substitution or strongly non-anthropomorphic telerobots.
- Methods of accelerating both adaptation to various types of alterations and readaptation to normal conditions.



# Psychological Considerations

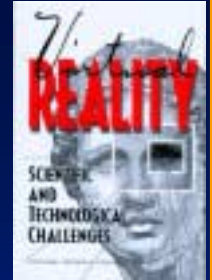
## - Recommendations

- Channel interaction effects that occur with multimodal interfaces.
- Factors governing the occurrence, kind and magnitude of cybersickness from SE exposure.
- Factors governing the strength of subjective telepresence and its relationship to objective performance.

# Psychological Considerations - Recommendations

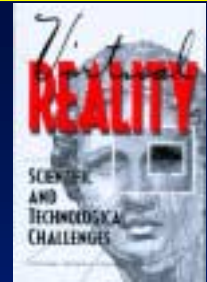


***Development of cognitive models that will facilitate effective design of VE systems for purposes of education, training and information visualization.***



# Psychological Considerations - Recommendations

***Development of improved understanding of the possible deleterious effects of spending substantial portions of time in SE systems.***



# Development of Improved Synthetic Environment Technology

***Recommendations***

# Human-Machine Recommendations



***Support of research on visual displays, haptic interfaces and locomotion interfaces.***

- HMDs.
- Tool-handle interfaces.
- Locomotion interfaces.

# Position Tracking & Mapping Recommendations



## *A multiphase research & development approach:*

- Conduct research & development on mechanical & inertial trackers.
- Explore the possibility of obtaining improved cost-effectiveness in tracking by using hybrid systems.

# Position Tracking & Mapping Recommendations



- Carefully monitor commercial developments in magnetic, acoustical and optical trackers, in eye trackers, and in trackers directed toward registration problems in augmented reality.
  - △ If market forces do not drive the development of these trackers, federal research support is urged.

# Testing & Evaluation Recommendation



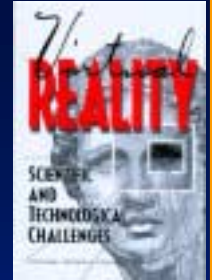
***The establishment of a set of standards or an independent laboratory to evaluate SE interface devices.***

# Computer Hardware Recommendation



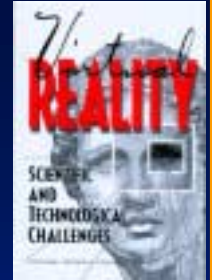
***No aggressive federal involvement in computer hardware development in the SE area at this time.***

- Hardware development remain largely a private-sector activity.
- Should serious lags in development occur, the gov't might then consider strategies for leveraging private-sector development efforts.



# Software Recommendation

***A major unified research program be created that focuses on those areas of development directly related to the generation, implementation, and application of VEs.***



# Topics to be considered

- ***Multimodal human-computer interactions.***
- ***Rapid specification & rendering of visual, auditory and haptic images.***



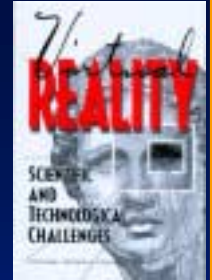
## Topics to be considered

- ***Models & tools for representing & interacting with physical objects under multimodal conditions (including automated model acquisition from the real world).***



# Topics to be considered

- ***Simulation frameworks.***
- ***A new time-critical, real-time operating system suitable for VEs.***
- ***Registration of real and virtual images in augmented-reality applications.***



# Topics to be considered

---

- ***Navigational cues in virtual space.***
- ***Behavior of autonomous agents.***
- ***Computer generation of auditory and haptic images.***



# Telerobotics Recommendations

***Support be given to improving control algorithms, improving methods for constructing and using predictive displays, and improving methods for realizing effective supervisory control strategies.***

# Telerobotics Recommendations



## ***Four areas of hardware development:***

- Multiaxis, high-resolution tactile sensors.
- Robot proximity sensors for local guidance prior to grasping.
- Multiaxis force sensors.
- Improved actuator & transmission designs.



# Telerobotics Recommendations

***Research be conducted on issues that arise when microtelerobots are used in teleoperation.***

***Consideration be given to the development & application of distributed telerobotic systems.***

# Telerobotics Recommendations



***The establishment of intercommunication standards for point-to-point connections in coarse-grained parallel computational architectures.***

- However, for apps with demanding I/O operations, the committee does not recommend new real-time, development systems or operating systems.



# Networking Recommendation

*The federal government provide funding for a program (to be conducted with industry & academia in collaboration) aimed at developing network standards that support the requirements for implementing distributed VEs on a large scale.*



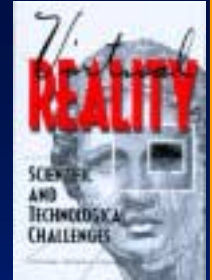
# Networking Recommendation

***Funding of an open VE network that can be used by researchers, at a reasonable cost, to experiment with various VE network software developments and applications.***



# Evaluation of Synthetic Environment Systems

***Recommendations***



# Evaluation Recommendations

*The federal government encourage the SE system developers it supports to include a comprehensive evaluation plan in the early design stages of their research projects.*



# Evaluation Recommendations

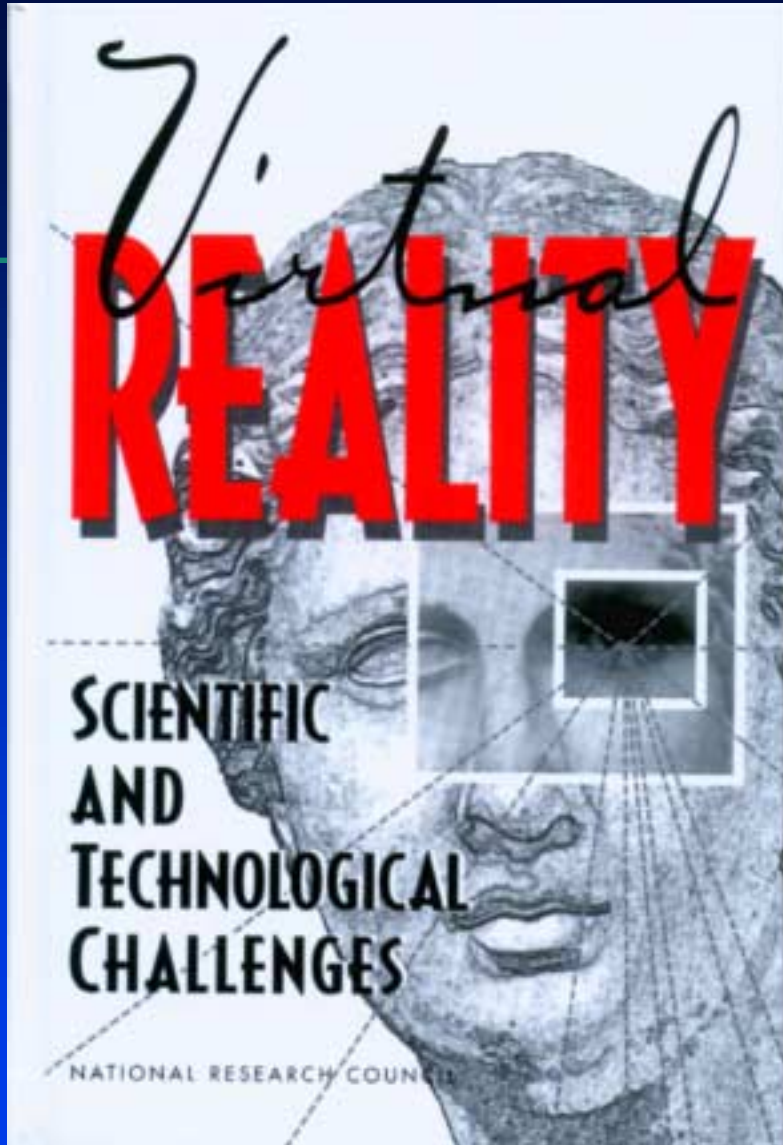
***The federal government help coordinate the development of standardized testing procedures for use across studies, systems and laboratories, particularly in those areas in which the private sector has not acted.***



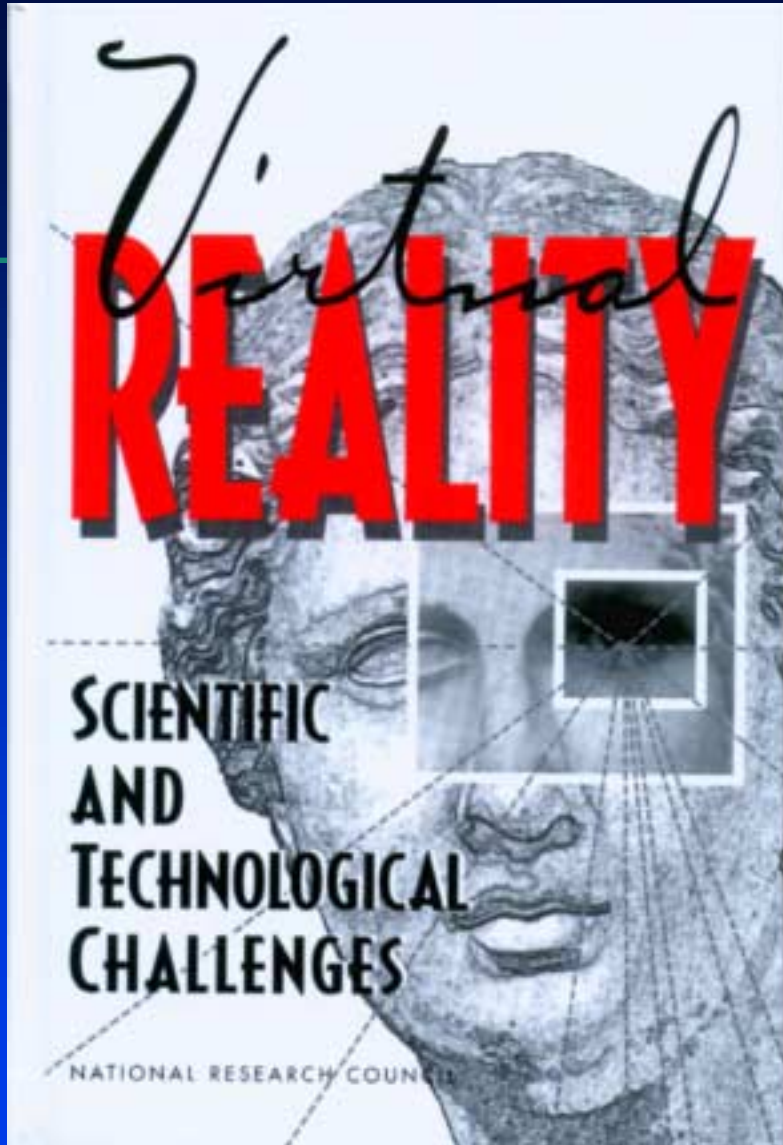
## Recommendations ...

***Now, these are all the recommendations to the government by the NRC Committee...***

- The purpose of the report is to advise the government how to spend its research dollars.
- It is up to the responsible program managers to actually implement the recommendations...



- Where to get the NRC report “Virtual Reality: Scientific & Technological Challenges”
- ISBN 0-309-05135-5
- National Academy Press
  - 202-334-3313 or
  - 800-624-6242



- Where to get the NRC report “Virtual Reality: Scientific & Technological Challenges”
- ISBN 0-309-05135-5
- Maruzen Co. Ltd., 3-10, Nihonbashi 2-Chome, Chuo-ku, Tokyo, Japan.