Virtual Worlds and Virtual Exploration

Working Group Report

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Virtual World and Virtual Exploration Working Group

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Declaration

Virtual worlds will forever alter the landscape of exploration, revolutionizing every aspect of research, design, implementation, and resolution—shattering the barriers to collaboration and participation.

By providing worldwide access to comprehensive modeling tools, contextual databasing, and interactive collaboration forums, virtual worlds will tap currently underutilized resources and ideas, resulting in an inclusive community of explorers, consisting of everyone from kindergarten classrooms to career researchers contributing to a common goal.

1.0 Introduction

Scientists and engineers are continually developing innovative methods to capitalize on recent developments in computational power. Virtual worlds and virtual exploration present a new toolset for project design, implementation, and resolution. Replication of the physical world in the virtual domain provides stimulating displays to augment current data analysis techniques and to encourage public participation. In addition, the virtual domain provides stakeholders with a low cost, low risk design and test environment.

The following document defines a virtual world and virtual exploration, categorizes the chief motivations for virtual exploration, elaborates upon specific objectives, identifies roadblocks and enablers for realizing the benefits, and highlights the more immediate areas of implementation (i.e. the action items). While the document attempts a comprehensive evaluation of virtual worlds and virtual exploration, the innovative nature of the opportunities presented precludes completeness. The authors strongly encourage readers to derive additional means of utilizing the virtual exploration toolset.

1.1 Definition of a Virtual World

A virtual world is a computer-simulated environment in which one explores or interacts via computers. These worlds may be intended for collaboration, entertainment, or education. While online games are a mainstream example of a virtual world, other examples include detailed virtual representations of part of the lunar surface or virtual conference calls where participants can interact with models to help communicate ideas.

1.2 Definition of Virtual Exploration

Virtual exploration is the interaction of humans with data and models representing reality; it is exploration without being physically present. It was practiced by the first robotic space exploration mission and has been refined ever since. Today, computers can serve as intuitive and efficient interfaces to visualize the results from exploration and scientific experiments.

1.3 Current Applications of Virtual Worlds and Virtual Exploration to Support Space Exploration Initiatives

Engineers frequently use Computer Aided Design (CAD) programs to model components, for system integration, and for testing, thereby reducing development time and cost. However, these software toolsets can be specialized for space exploration missions and expanded upon, thus further reducing time and cost. Similarly, scientists model various physical phenomena—even detailed environments—to explain observations. Once again, improvements in the toolset for modeling will enrich data analysis and interpretation.

In addition, the potential of certain, commonly-used virtual world tools to support space exploration has yet to be fully realized. In particular, the Internet is widely used for business and personal interactions and serves as a resource for entertainment, education, and communication. While information about space exploration activities is already shared over the Internet, it can be done more effectively. The 2-D maps of Google Mars are prime examples of how virtual exploration via the Internet currently aids the dissemination of information about space to the public. These tools can (and should) be improved upon. For example, a 3-D virtual environment of well-mapped regions, which allows users to explore by driving a virtual rover, is more engaging.

2.0 Themes

Four primary themes exist to motivate utilization of virtual exploration and virtual worlds.

2.1 Support Public Outreach

Virtual exploration engages, inspires, and educates the public through interactive, graphically stimulating, virtual replicas of explored regions. The emerging technological tools of virtual presentation, specifically the creation of a virtual environment, enable the public to be contributing members to exploration and discovery. Derivative benefits include, but are not limited to, encouraging students to pursue careers in high technology and scientific fields and ensuring that individuals enter the workforce with the requisite skills and enthusiasm necessary to sustain exploration.

2.2 Generate Environmental Simulations and Effective Data Presentation

Virtual exploration augments understanding through interaction with environmental simulations and data presentation. Simulations in the virtual domain reveal the nature of complex interactions that are not easily observable in the physical world. Example simulations and their purposes include (1) modeling a stellar environment to explain the spectral observations, or (2) testing technologies, systems, and operations in a virtual environment to streamline mission planning and operations. Effective data presentation techniques improve the understanding of phenomenon and of the correlations between data sets.

2.3 Facilitate Communication

The interfaces in virtual environments streamline communication between groups essential to the processes of design, implementation, and resolution of a project. Such technologies and processes are useful for projects in exploration, science, and education.

2.4 Increase Productivity

Virtual exploration increases productivity and has the potential to reduce costs throughout all stages of a mission including planning, execution, and post-analysis. The unique characteristics inherent to virtual environments, such as operations at low cost and low risk environments and as highly visual, multidimensional displays, present new tools for mission stakeholders. By capitalizing on these tools, the stakeholders increase value extraction and realize new values.

3.0 Objectives:

While specific applications of virtual worlds and virtual environments are too numerous to identify, below are eleven categories encompassing most objectives for utilizing virtual worlds and virtual exploration. Since virtual worlds and virtual exploration support all stages of a mission, the objectives are listed in chronological order, starting with mission planning. However, the utility of a virtual world does not cease when a mission terminates; with a little creativity, researchers can develop highly-stimulating and engaging software to present mission results to the public. Facilitating public interest and education supports new space exploration missions, eventually leading into planning for the next mission.

3.1 Collaborative 3-D Computer Design Program

Objective: Develop software that allows individuals from across the world to develop 3-D conceptual designs. This tool would have a user-friendly interface and would allow multiple users to contribute simultaneously to a design.

Value: In current practice, individuals brainstorm concepts and designs within groups using simple tools such as whiteboards. Using objects such as virtual whiteboards in this collaborative design program, groups can develop their ideas more effectively and efficiently because the individual contributors are able to modify 3-D conceptual designs in real time, even if they are dispersed across the globe.

3.2 Total Virtual Analysis and Design Tool

Objective: Develop an all-inclusive, fully-integrated tool for design, simulation, and analysis of space-structures. Similar to ModelCenter or to CATIA system, this tool enables virtual assembly, allowing engineers to examine interfaces before costly physical prototypes are manufactured. Moreover, the virtual environment models the conditions a structure will experience in all stages of deployment, including (but not limited to) launch, microgravity flight, and landing, thereby enabling engineers to perform performance estimates.

Value: This tool is a single platform to perform component design, system integration, performance prediction, risk analysis, and mission planning for space-bound vehicles. The comprehensiveness of the software not only identifies the need for redesign, but also eases component modification and subsequent testing. It directly reduces design development times and costs; and it enables a broader design space, increasing the potential for higher reliability and lower risks.

3.3 Virtual Meeting Space: Collaborative Planning and Decision-Making

Objective: Provide a virtual analog of a conference room with audio/visual presentation capabilities similar to a physical room and with additional tools such as 3-D holographic projections, thus removing location barriers and promoting collaboration among geographically dispersed project members. This allows all parties involved to view and to critique material presented by interacting with the virtual environment.

Value: A virtual meeting space can eliminate substantial cost, time, and logistics associated with travel and lodging, which enables more geographically diverse participation. It can also improve communication and allow participants to better visualize ideas presented as a result of 3-D technology.

3.4 Virtual Simulation of Unmanned and Manned Missions

Objective: Use data collected from previous missions to create virtual simulations of equipment and physical environments in which designers model missions before they occur and accumulate experience in an environment that closely simulates reality. Such simulations allow both testing of autonomous robots and assist in planning for human missions.

Value: Virtual tools can supplement physical analogs used for training of humans and autonomous vehicles. They are preferable to physical analogs because they allow groups to debug and test concepts in a virtual environment without the risk of damage to the equipment and because they reduce training costs.

3.5 Enhance Tele-operation Capabilities

Objective: Use data collected from previous missions and the current mission to create virtual simulations of equipment and physical environments in which operators manipulate and control remote systems. As new mission data and device feedback are incorporated into the virtual environment, researchers increase their awareness of the position and the capabilities of the equipment. In addition, these virtual worlds can assist in debugging and repairing mission glitches, if necessary.

Value: For certain exploration applications, human presence is not required and tele-operations are sufficient, thus reducing the mission cost and risks. Virtual exploration enhances the execution of tele-operations, thereby increasing the level of complexity suitable for tele-operations.

3.6 Enhance Data Processing and Analysis via Virtual World Visualization

Objective: Employ the diverse arrangements for data presentation in virtual worlds, and use virtual environments and interfaces to format, process, and analyze data more effectively for mission operations, science, and outreach.

Value: The way that data is presented influences which results are evident. Often charts and graphs are used to demonstrate trends when a table is unclear; in virtual worlds, data presentation can be fully 3-D and is not confined to 2-D analogues or perspectives. Moreover, virtual worlds can also play with variables such as time or decision points and provide various scenarios and potential futures. Various stakeholder communities can adapt the presentation of the data in a virtual world to suit their needs.

3.7 Augment Data Interpretation via Virtual Environment Simulations

Objective: Model environments and simulate their evolution to recreate conditions that agree with observations.

Value: Often researchers must infer conclusions from the gathered data; however, a clear correlation between the data and its meaning does not always exist. Inferring planet or solar system evolution are two immediate examples of when this correlation is absent. By allowing virtual models to evolve under various circumstances and by examining the equivalent observational data in the evolved world, researchers can infer additional meaning from the data.

3.8 Facilitate Communication between the Public and Experts

Objective: Provide interested individuals with additional means to interact with experts through live sessions and correspondence in virtual environments. For example, augment traditional chats and forums with graphical sketch tools or with models in a 3-D virtual environment.

Value: Virtual environments can enhance direct information exchange from the professionals to enthusiasts and members of the general public with a casual interest.

3.9 Virtual Environment Entertainment

Objective: Produce Omnimax, simulator, and virtual reality rides to demonstrate mission accomplishments and to educate the public. A more extreme example of virtual environment entertainment, one which follows the current trends in television programming and employs the philosophy of the traditional SIM computer games, would be to develop a Virtual Martian Awareness Reality Show (V-MARS) in which contestants would learn to survive in the harsh environment.

Value: Virtual reality rides and reality shows can increase public interest in and awareness of space exploration.

3.10 Fully Interactive Promotional and Tutorial Software

Objective: Utilizing the graphically-stimulating and multi-dimensional benefits of virtual worlds, produce an interactive virtual mission. The mission destination in the virtual world will use real mission data to replicate the physical destination (such as the Moon or Mars) and will use engineering principles to replicate the exploration process. Users control various mission elements, such as launching spacecraft, driving a rover, or docking. Moreover, users make simulated discoveries with the virtual instrumentation.

Value: The software would engage the public and increase interest in specific missions and space exploration in general. It would also educate and place the mission purpose and findings in context for the public to better understand the motivations for supporting exploration missions.

3.11 Online Depository for Conceptual Designs Submitted by the Public

Objective: Create an online warehouse or library where the public can submit and review ideas, in particular conceptual designs. Both solicited and unsolicited projects can be posted to this location for organizations to review and to adopt for further consideration.

Value: By allowing an avenue for the public to design space missions, space agencies foster an environment that stimulates creative ideas and that entices public participation and support. Moreover, agencies open the door to a range of innovative concepts.

4.0 Issues and Enablers

As virtual worlds open the door to new levels of collaboration and interaction for a diverse range of interest groups, it inherently presents an assortment of roadblocks before reaping the benefits of its implementation. In addition, virtual exploration also faces some more traditional obstacles. The following list, though not comprehensive, identifies major barriers to a variety of virtual world and virtual exploration applications:

- Software can be unfamiliar to new users, leading to disuse.
- Software needs to be widely distributed to be effective.
- False data can be integrated easily into a virtual world without being noticed.
- Free flow of information between individuals and groups is limited by barriers of language and knowledge export controls.
- Abuse of intellectual property can happen in a public domain.
- It can be difficult to extract credible ideas or useful information from large databases.

- Collaborative virtual environments can also be used by organizations that threaten national security.
- Large programming projects can become redundant, wasteful, and ineffective.
- There is currently not a strong enough financial incentive to develop some of these technologies.
- It is difficult to code the complexities of the physical world, including physical laws and human psychology, into a simulated, virtual domain.
- Projects will require massive amounts of processing and storage facilities. Who operates these facilities? Who owns the data contained at these facilities?

One should recall that, while the above roadblocks are associated with virtual world development or virtual exploration, they do not apply to all forms of and all uses for virtual worlds and virtual environments.

Similarly, certain trends in society are conducive to developing the potential of virtual worlds and virtual exploration in support of space exploration. These include:

- The popularity of websites to convey near-real-time information to the public on demand, such as with the NASA Mars Pathfinder mission and the first Space Shuttle mission after the Columbia accident.
- Existing software for communication and collaboration between geographically dispersed users.
- Extensive use of the Internet for entertainment, education, and communication, both business and personal.
- A strong public interest in gaming technologies, especially those which more accurately mimic reality.
- The common engineering practice of using software for component design, integration, and testing.
- The need within space agencies to more effectively communicates to their stakeholders that allow an element of participation.

5.0 Action Items:

The potential of virtual world and virtual exploration technologies has yet to be realized.
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With comparatively little effort, engineers, scientists, managers, and the public can begin to reap the benefits of space exploration in the virtual domain using existing technologies. As time progresses, interest increases, and as more advanced software tools are developed, more complex interactions in virtual worlds will allow for greater benefit extraction.

5.1 Tools for Dissemination and Representation of Information

A wealth of data, obtained from missions as far back as the 1960's and from Earth-based observations, provides descriptions of various regions of the solar system. While these descriptions fall short of completeness, they are enough to develop a basic model of the environments. With the necessary resource investment, data can be used to create virtual worlds in which users may immerse themselves. Such environments could then be employed to inspire and instruct the public or to design and test future missions for the regions.

Guidelines for achieving basic information dissemination and representation in the virtual domain with existing technologies are listed below. While the near-term goal is to provide more uniform and optimal access to existing datasets, as the software for virtual worlds and virtual exploration advances, the techniques for data presentation permit more complexity.

- Gather and organize existing data.
- Identify legal issues regarding sharing the data (e.g.. protecting intellectual property or national security).
- Survey existing technologies to identify practices best supporting efficient data distribution.
- Devise a presentation format for the data which is most suitable for the intended audience and objectives. For example:
    - o Maintain a data warehouse for professionals and public;
    - o Develop interactive games for educational purposes; or
    - o Produce a virtual environment that continually incorporates new data to assist tele-operators.
- Modify existing tools and continually develop new tools that most effectively convey the desired information

5.2 Tools for Collaboration and Mission Planning

Once again, technologies exist to facilitate communication via the virtual domain. These technologies are not being used to their full potential. First, agencies engaging in space exploration should use virtual world communication devices, such as the Internet, to collaborate with stakeholders in order to clarify a mission's value and to collaborate with engineers in order to facilitate component design and integration. Guidelines for realizing near-term benefit are:

- Identify the needs for effective collaboration and the requirements for a virtual meeting place.
- Survey existing technologies to identify practices best supporting collaboration.
- Execute trial runs of existing virtual meeting areas, such as Second Life.
- Modify existing tools and continually develop new tools that most effectively allow collaboration among stakeholders, engineers, managers, etc.

Effective collaboration strongly correlates with mission success and productivity, and likewise for effective mission design and planning. Agencies engaging in space exploration should more readily employ the newer, currently-marketed software tools for design, system integration and testing; while these software programs are not the all-inclusive, fully-integrated design tool discussed in Objective 3.2, they are an important component. To begin development on more complex tools, agencies should:

- Survey existing technologies to identify practices best supporting design and testing of both components and systems.
- Gather experts from various fields to identify the needs of a comprehensive simulation machine.
- Adopt a single, standardized design software toolset for a given mission or project, thus facilitating communication among engineers contributing to different design aspects.

Virtual Worlds Working Group

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Emerging global space leaders designing the future of space exploration.

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NASA Ames Research Center • Building 3

What would you do…

- **To make space more relevant to you?**
- **If you couldn't get there yourself?**
- **If you had the universe at your fingertips**
- **If your friends could join you anywhere and anytime!**

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Virtual Worlds are Here Today

- **> 10 million people pay $15/month or more to play online games**
- **Property right exist in virtual worlds, providing incentive for innovation**
- **Companies including Wal-Mart, American Express and Intel are experimenting with training and collaboration inside virtual worlds**
- **Players spent an estimated $1 billion in real money in 2005 on virtual goods and services within virtual worlds/online games**
  - in Project Entropia one player paid $100,000 in real money for a virtual space station; hopes to earn money charging other players rent and taxes
- **Examples today**

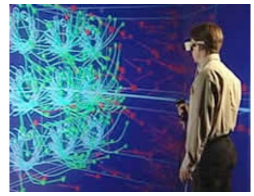
Google MARS   SECOND LIFE   WIKIPEDIA The Free Encyclopedia   WORLD OF WARCRAFT BURNING CRUSADE

Themes

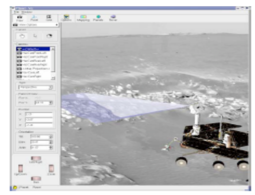
- **Public Outreach**
  - Virtual exploration engages, inspires and educates the public through interactive, graphically stimulating, virtual replicas of explored regions.
- **Environmental Simulations & Presentation**
  - Effective data presentation techniques improve the understanding of phenomenon and of the correlations between data sets.
- **Communication**
  - The interfaces in virtual environments streamline communication between groups essential to the processes of design, implementation, and resolution of a project.
- **Increasing Productivity**
  - Virtual exploration increases productivity during all stages of mission planning, execution, and resolution.

Objectives

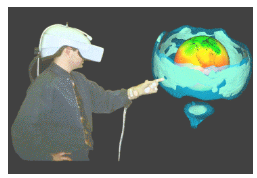
- **Before a mission**
  - Total Virtual Analysis and Design Tool
  - Fully Interactive Promotional Materials



- **During a mission**
  - Live event coverage
  - Tele-operation
  - Collaborative planning and scheduling



- **After a mission**
  - Post mission analysis
  - NASA Google / Virtual visitor centers
  - Condensed mission highlights (podcasts, YouTube, etc…)



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Action Items

Virtual worlds are already here but we must connect the space community

- **Survey existing technologies (commercial & NASA) to identify useful ones for efficient data management.**
- **Use trial runs of already existing virtual meeting areas (example: Second Life)**
- **Evaluate national security concerns and IP rights**
- **Collect, organize, and analyze existing data for meaningful interpretation as well as future references so data is not lost.**
- **Use virtual world technology to make public outreach more effective through interactive experiences.**

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Declaration

- **Virtual worlds will forever alter the landscape of exploration, revolutionizing every aspect of research, design, implementation and resolution, shattering the barriers to collaboration and participation.**

- **By providing worldwide access to comprehensive modeling tools, contextual databasing, and interactive collaboration forums, virtual worlds will tap currently underutilized resources and ideas, resulting in an inclusive community of explorers, consisting of everyone from kindergarten classrooms to career researchers contributing to a common goal.**

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