The WWT was the name given by Alex Szalay and Jim Gray to describe a new genre of astronomical research that would recognize and utilize the vast resources that were becoming available over the World Wide Web. As that grid of resources becomes a unified reality with the infrastructure provided by the Virtual Observatory (VO) efforts, the Space-Time Machine Consortium and Microsoft Research will be developing a visualization portal that unifies these resources on the astronomer’s desktop.

**Meeting Professional Astronomer Needs**

- Import their data into the WWT Pro for visualization against multiple composite all sky views
- Perform on the fly image registration via services provided by Astrometry.net or WCSFixer
- Enable the visualization and analysis of multi-dimensional data sets that evolve beyond astronomy’s century old “blinking” of image frames
  - WWT Pro will include the ability to stack and visualize the multi-epoch data from DASCH or stored in the TSC database
  - Users, professional or amateur, will want to “blink” multi-epoch time series data to look for transient objects with the assistance of image analysis tools within WWT Pro
- Investigate multi-dimensional images that contain spatial and energy information; examples include Integral Field Units and Chandra ACIS images, which also contain temporal data
- Allow data to stream between the WWT Pro and existing powerful dataset analysis tools
  - Adopt VO client side communication protocols (e.g., PLASTIC (http://plastic.sourceforge.net/))
  - Allow the WWT Pro to interface with existing VO tools such as TopCat (http://www.star.bris.ac.uk/~mbt/topcat/), which can import/export numerous data types, provide multi-dimensional cross-match capabilities, 3D plotting and source selection/filtering

**Providing Interfaces to the Virtual Observatory**

- Querying of the VO Registries and Services
  - Enable on-the-fly spatial queries for localized regions of the sky
  - Including VO services from SkyNodes to Image and Spectra queries and unprocessed data in telescope archives
- Perform Real time Astronomy
  - From worldwide all-sky monitoring efforts to amateur astronomers scanning the skies for new comets to supernovae and gamma ray bursts, real time astronomy has become a huge research topic
  - Monitor VOEvent and Central Bureau for Astronomical Telegrams (CBAT) announcements
- VO Data Models and protocols
  - WWT Pro will return data characterized and validated following IVOA standards
  - Will implement the Data Model libraries developed by the Harvard-Smithsonian Center for Astrophysics, including complex coordinate transformation following the IVOA Space-Time-Coordinate standards
Creating User Case Studies for the WWT

A basic goal of the WWT is to provide an interactive layer that enables “rich exploration across multiple sky surveys and telescope studies coupled with rich media narrative contextual stories about topics in astronomy which are illustrated and linked into a virtual sky.”

Similarly, an astronomer benefits from the use of project workflows that are VO compliant, that allow seamless visualization of their study or provide time series images automatically registered within the virtual sky. Such workflows enable analysis, collaboration, rich media annotation and sharing with research partners and can be adapted to a particular science goal. IIC Scientists are developing specific science workflows for the WWT Pro that correspond to easily understood examples of astronomy data analysis and provide flexibility for subsequent reuse.