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Introduction

MicroImages in its 19th year in business is pleased to distribute **RV7.0** of the **TNT** products. This is the 55th release of **TNTmips** and adds approximately 280 new features submitted by clients and MicroImages. Because of the length of this MEMO, the color plates are stapled separately to make reading the MEMO and viewing the color plates more manageable. Registered and successfully completed downloads of **TNTlite** are 26% higher in 2004 relative to 2003 and double the number in 2002. MicroImages appreciates your support and assistance in promoting more awareness of the **TNT** products around the world. In exchange we continue to concentrate our focus and resources on product development and support.

What follows is a brief summary of many of the significant new capabilities in **RV7.0**.

- **TNTsdk:** The software development kit used to build every **TNT** product has been 20 years in the making and represents about 100 man years of effort. Changing from Motif graphical libraries to royalty free LessTif graphical libraries has permitted the optional charge for **TNTsdk** to be dropped. Now your **RV7.0** CD and weekly patches permit you to install and maintain **TNTsdk** and use it to build programs to add to your **TNT** products' menus including to **TNTlite**.

- **TNTatlas:** A DVD entitled Property Viewer Lincoln, NE is included with **RV7.0** of your **TNT** products. This sample atlas demonstrates how a large collection of geospatial data (~50 gigabytes) can be assembled into a form for easy general public use. Navigation by an owner or address query is implemented in a **TNT** Tool Script. Complex information about each property is presented in the form of an enhanced DataTip. A CD entitled TNTatlas of Afghanistan is also included to demonstrate several completely new concepts that can be added to your atlases. It demonstrates the dynamic pop-in of spatially aware graphical information using the new GraphTip and Display Control Script features.

- **TNTsim3D:** Large JPEG2000 texture layers can be used without any performance degradation. For example, a 50 GB image could be compressed 12 to 1 and distributed on DVD as part of a landscape. Cloudy skies and other panoramic dome backgrounds are provided and add realism to all simulated views. **TNT** scripts (**SML**) can be used to add dynamic custom features. New **SML** functions let you exit these scripts by using the flight controls (which means keyboard, mouse, or joystick), rather than having to de-select the script from a menu. Startup scripts now permit simulations to automatically start up in specified positions, following programmed paths, and so on. A Custom View can be started with an observer position related to and locked to the simulated changes in the Main View. The contents of this Custom View can be the same, selected, or entirely different components of the landscape.

- **TNTserver/clients: TNTserver** can now serve up results as JP2 (JPEG2000 compressed) and PNG (compressed) in addition to JPEG rasters. Graphical layers can be served up as Scalable Vector Graphics with a database table and embedded/linked rasters. The latest **TNTclients** have been modified to use these new data structures.

- **TNTview:** The price of **TNTview** has been lowered from US$1000 (NAFTA) or US$1200 (international) to a uniform US$500 fixed license and US$600 for each floating seat for all supported platforms. See the sections below entitled 2D Dis-

play, 3D Display, and others for all the **RV7.0** features automatically inherited by **TNTview**.

- **2D Display:** Labels created as part of a CAD sketch layer can now have frames and leader lines. DataTips can be enhanced in appearance by using all the **TNT** text codes in their formation including picking the background color inside their frames. GraphTips and Display Control Scripts are now available.
- **Shapefile Layers:** Shapefiles can now be quickly auto linked and displayed as layers in a composite 2D and 3D view with styles and symbolism. Styled entries for shapefile elements now show in the LegendView. **TNT** special visualization features can be used, such as DataTips, selection procedures, and so on.
- **JPEG Layers:** An auto link to JPEG compressed rasters permits them to be selected for use as layers in 2D and 3D views. Companion world files (*.jgw) provide their georeference.
- **PNG Layers:** An auto link to PNG compressed or uncompressed rasters permit them to be selected for use as layers in 2D and 3D views. Display processes will use companion world files (*.pgw) for georeference if found. An opacity mask layer, ICM color profile, and other features are stored in the link file and used.
- **3D Display:** All older rendering modes have been removed and only the three current methods are provided. Relief shading can be optionally computed from the DEM and viewed. A layer can use the transparency setting for the layer or for each individual polygon for all rendering methods. Complex pedestals can be created downward or upward for a fence effect. Pedestals can be curved and have smoothed shaped color effects. Manifolds can be viewed with or without 3D surface views.
- **Manifold Surfaces:** Raster, vector, CAD, and linked objects can now be georeferenced in 3D to orient and shape them into planar, curved, or folded manifold surfaces representing cross sections, profiles, objects, and related shapes. These 3D control points are used to compute a TIN surface in a 3D view onto which the object is projected as a texture. The TIN can be interactively edited as well as the texture.
- **Stereo Display:** A 3D view (texture plus DEM) can be switched into a stereo mode that matches the available viewing device, such as a mirror stereoscope or 3D monitor. Modes include side-by-side, line interlaced, column interlaced, and anaglyph.
- **Display Control Script:** This is a **TNT** script that is stored with a group or layout and will auto run when either is opened in the Display process. When the cursor pauses in the view, just as with a DataTip, they can access its geocoordinates, the nearest element (point, line, or polygon), and/or a raster cell's content. The rest of the script can use this result for anything that can be done in a script.
- **GraphTips:** Simple DataTips no longer need to pop-in as spatially aware information just in the form of styled text. Now data read for the cursor position using a Display Control Script from attributes or computed from them can be presented in graphic forms—hence, GraphTips. For example, GraphTips can draw working clocks or combine attributes into a pop-in pie diagram or histogram.
- **Dynamic Spatial Analysis:** The geoposition/element(s) at the paused position of a cursor can be used in a Display Control Script for a complex geospatial analysis for every position of the cursor. The inputs to the analysis can be any layers in the view or in objects of any **TNT** geodata type. The script can then project these re-

sults into their corresponding locations in the current view (for example, as multiple GraphTips) or open and present them in a new view. Move the cursor, and it changes the analysis and results.

- **Editing Spatial Data:** Features in a geometric object (vector, CAD, shape, and TIN) selected by any **TNT** selection method (region, attributes, cursor, …) can be copied and pasted into any other type of geometric object or simply cut. Manifold surfaces can be edited.
- **Validation.** Validation of polygonal or full vector topology is faster and more robust.
- **Coordinate Reference System:** The industry standard ISO 19111 Coordinate Reference System (CRS) definitions and the corresponding EPSG geodetic parameters, equations, and datum transformations are now supported using a new Spatial Reference (SR) service, which supplies them to all **TNT** products. Thousands of new CRS are available. Datum to datum transformations are used for more accuracy. Defined units of measure are used to avoid conversion to/from meters to increase accuracy and speed.
- **Mosaicking:** Mosaics can now use linked MrSID, JPEG, JP2, or PNG files or JPEG2000 compressed raster objects as input. The resulting mosaic can be a lossy or lossless JPEG2000 raster object. A null mask subobject is created to specify cells of null, or no, data.
- **Geometric Object Conversions:** A mixture of several geometric objects (vector, CAD, shape, region, and TIN) can be selected as input in the Extract or Merge processes. The specific output type is determined by your menu selection.
- **Render to SVG:** Rendering into a Scalable Vector Graphics layout is now faster. It uses a new improved control window with tabbed panels. New features include a JavaScript to reproduce any DataTips that were defined in the source object(s), zoom up labels 2x when they are under the cursor, and others.
- **Geospatial Scripting Language:** 20 **SML** scripts designed to demonstrate new visualization and analysis capabilities are illustrated and dissected in the accompanying color plates. These include Display Control Scripts used for Enhanced DataTips and GraphTips, **TNTsim3D** startup scripts, a sample Dynamic Spatial Analysis script, and a **TNTatlas** startup script to create a user input form for a complex query.
- **Tutorials:** Two new tutorials are provided on the topics of managing massive geodata layers and setting up the **TNTsdk**. 14 new Quick Guides are included and all Quick Guides can now be installed and are indexed and accessible directly from within your **TNT** products. 62 new color plates accompany this MEMO to illustrate the use of the new features in **RV7.0**. Four other tutorials have been expanded in scope to cover new features and updated and 2 more have been updated.

Editorial and Associated News *[by Dr. Lee D. Miller, President]*

Official Releases.

Introduction.

For 20 years your requirements and our interest in addressing new opportunities for geospatial analysis have continued to make **TNTmips** and the other **TNT** products advanced and flexible. In responding to this continual demand and opportunity for new and more efficient features, the **TNT** products are by necessity continually evolving. As

a result, you have to make the choice between reliability and your need for new features, ease of use, speed, and so on. MicroImages has an effective weekly patching system in place that provides upgrades for several official versions of our **TNT** products to support the evolutionary nature of our product development. Patching is easy and can be done each week.

Cycling Releases.

As we approach the end of a development cycle of the next version of the **TNT** products (for example, **DV7.0**), we formally announce its new features. This came to you in synopsis form in a MicroImages MEMO entitled <u>V7.0 New Features</u>. From our viewpoint, this is about the time that the initial coding of most of the new features for the next version is complete and their improvement is underway. This New Features MEMO is issued to you as early in our development cycle as possible to permit you to decide if you want to order that version and/or begin to experiment with it.

Soon after the New Features MEMO reaches you, we begin to get inquiries about when we will officially release that version. The official release of a new version of the **TNT** products is made on a specific date via microimages.com. On that day the official release version of your **TNT** product is posted for downloading (for example, **TNTmips RV7.0** on 17 November 2004). During the weeks prior to this official electronic release, MicroImages' staff is searching for and correcting errors and making minor adjustments to tune the features in the release. This effort is guided by your and our observations from using each successive weekly prerelease as **DV7.0**. During this last period before the official release, our activities are not focused upon adding new major features, but some may appear that were not documented in the early New Features MEMO.

Electronic Release of Versions.

On the day of the official release we are merely changing the name and status from a development version (**DV7.0**) to the official release version (**RV7.0**). As a result, the official release differs from the last or weekly posting of the development version by one week. The first patch file posted the next week (**PV7.0**) will differ from the official release version by 1 week, then 2 weeks, and so on as will the full release version posted for download. One significant thing that happens on this official release date is that development of new features ceases. Correspondingly, on that date a new development version is created internally at MicroImages (for example, **DV7.1** on 17 November 2004). Within a few weeks, when some new features are working in this new development version, it is made available for downloading and new descriptive material about it begins to appear at microimages.com.

Making Your Update Decision.

You can enter this weekly cycle at any time you choose that is permitted by your subscription status by downloading an RV, PV, and/or DV that each may differ from their previous release in weekly increments. If you are maintaining dual versions (for example, the latest **PV7.0** and **DV7.1**), you may be updating them frequently. You probably became aware of some interesting new feature via a new color plate(s), our daily news, or eventually via the new feature summary MEMO. You may decide to set up and start using **DV7.1** because you need access to, or at least want to experiment with, some new feature available in the DV. You then often lobby us with suggestions for improvements in these new features while such changes are easy to make. You also report er-

rors so that you can get these new features into working shape for your immediate application via the DV. In the weeks just before the official release, adding significant changes and features decreases significantly and tuning and error correction are the focus of our activity in that version. As of the date of the official release, no new features are added to that version, a new development version is created for that purpose, and the patches to the official release are focused only upon correcting the inevitable additional errors you locate when running your specific production projects.

From all of the above you can conclude that the concept of an "Official Release" of the **TNT** products is somewhat arbitrary and subjective as our product evolution simply progresses from week to week. The point at which you as a client, institution, or reseller install the newest versions of the **TNT** products is, thus, arbitrary. The earlier in a development cycle that you install and work with the development version, the faster you will gain access to its new features and the more likely you will be motivated to, and become interested in, participating in the perfection of that version as well and in influencing its final features and form.

Physical Release of Materials.

When the effort of bringing a DV to the point of officially releasing it as an RV is complete, the physical materials for it can be completed, such as writing this MEMO, printing hundreds of thousands of color plates, reproducing color booklets and Quick Guides, duplicating many thousands of CDs and DVDs, and packing and shipping. This takes time. Many popular commercial product upgrades first become available as a download with rather useless help file updates and later via a single CD providing the same lack of information but packaged in a big, fancy, and otherwise empty box. This may work for your products that are feature stable, such as a word processor or spreadsheet, if you have good Internet access (not a modem), access to commercial retail outlets, and are willing to buy expensive books months later to consult regarding the possible new operations provided in the upgrade. It is not workable approach for a complex, rapidly evolving, and more expensive professional product, such as **TNTmips**.

Independent User's Flexibility.

As a typical professional **TNTmips** user, you are probably using a Windows- or Mac-based computer with dual displays, 1 GB of memory, hundreds of gigabytes of drive space, and DSL or cable Internet access. While **TNTmips** is a very large set of programs on a relative basis, each copy of it now has a relatively small footprint on your large hard drives. Your high speed network access enables you to effortlessly grab our large weekly releases while at lunch and maintain several of them on your hard drive. MicroImages also insures that, if you have multiple versions of your **TNT** product installed on the same computer, they can be operated totally independently.

Dependent User's Production Approach.

The **TNT** product upgrades are widely distributed internationally and must reach users with a wide variety of highly varied distribution channels and Internet bandwidth. Those of you with fast Internet connectivity can have your RV within days of its postings. You do not need the CD containing it. In fact, it is likely that something on that CD has already been patched by the weekly patches before the CD reaches you, and you have already downloaded your release and patches to it. Those who are in remote locations who can not at least borrow a fast Internet connection have to wait for the CD to arrive

and probably stay with using that version and its potential problems. Those of you using floating licenses with software installation, maintenance, and version testing controlled by system managers have to live with their decisions with regard to when they upgrade you. You are again experiencing the same circumstances that originally led to the personal computer rebellion and now to the monopoly of various software products. In this case, try to persuade them to let you have access to 2 **TNT** versions: "the tried and true and something new." MicroImages' various official release and patching procedures are designed to support this widely diverse clientele (for example, fast versus slow web access) and international customs (for example, locations with an absolute aversion to prepaying for or even maintaining software).

How Do TNT Innovations Occur?

Innovations in application software are not born out of nothing. Software evolves based on multiple factors, some controllable (for example, existing features and the introduction of new libraries) and some uncontrolled (for example, new operating systems versions and hardware and increased computational power). Innovations in the **TNT** products come about within these circumstances in a process that might be thought of as guided chaos. Thus, when we release new features with long range objectives, their utility may not be clear to you and may not even be totally clear to us.

Examples of earlier **TNT** innovations of this type might be the transparent use of geodata objects without regard to their projection or coordinate reference systems, keeping all information for a geodata layer together in a single object, managing geodata of differing structures in a single file, adding the concept of scale to objects and views, **TNT** scripting, and so on. The utility of these features introduced over time may not have been immediately apparent, but they now provide the building blocks of your current **TNT** products' advanced capabilities.

Enhanced DataTips, GraphTips, Display Control Scripts, and Dynamic Geospatial Analysis introduced in **RV7.0** provide an interesting example of how slowly perfected software building blocks can be assembled and reassembled into innovative new **TNT** features. The history of how these features evolved from the simple DataTip idea may be of interest and provide insight into how these new features work and can be applied. As you read this account, you might wish to jump ahead and examine accompanying color plates in the category entitled <u>Sample GraphTip Scripts</u> to help you visualize the kinds of results they can provide. These color plates are also referenced and discussed in specific detail in the corresponding technical sections of this MEMO.

<u>Can we spatially interact with a view?</u> *DataTips are born.*

Years ago in the 20-year evolution of the **TNT** products, we happened to see the idea of a pop-in feature identification label in some other small software product. At the time, this was the basis for the addition of the DataTips concept into the **TNT** products. Our implementation took this example idea further by permitting you to designate which attribute to present as the DataTip for the element at or nearest to the cursor. As soon as this feature appeared, you asked for more in the form of longer strings for the prefix and suffix for better identification of the information shown in the DataTip. This led to requests for multi-line DataTips and then to DataTips presenting information from more than one field.

Can we compute their contents? DataTips are computed, not simply read.

Next came the desire to manipulate the "raw" values in an attribute field before they pop in as a DataTip. An early example of this was the need to change the units of the value in the field before showing it in the DataTip or to combine real fields together to compute and present a new and more meaningful value. In a parallel development elsewhere in the **TNT** products, the idea of defining and using virtual fields was evolving. This capability made it possible to make new fields available that were not really there in the tables and records (in other words, they are virtual). They are defined using an equation or **TNT** script from other real or virtual attribute fields in the table(s) and reevaluated every time they are used for anything. These virtual fields appear and behave the same as real fields in the designated table and to other **TNT** processes. In general, this approach is analogous to the use of computed fields in what is called a "view" in a database session and terminology.

At that conjuncture, it was easy to adapt the virtual field concept for use in the DataTip application. So now the evolution of the DataTip had led to the ability to set up DataTips that presented in real time the results of a model computed from the values of the attributes at the current position of the cursor. This procedure can be said to be "spatially aware" since when the cursor position is changed, this model is instantly computed from the current field values and the result then automatically pops in as a DataTip. This was considered innovative at that time because, if some other program or database activity changed the field(s) in the attribute table(s), this changes the computed value of the virtual field and the corresponding DataTip.

Can we get modeled contents? *DataTips evaluate models.*

You can use this feature to compute modeled results from complex equations to define the virtual field from geodata layers that may be hidden from view. One example would be the use of the simple Universal Soil Loss Equation (USLE) to compute and display as a DataTip the potential soil erosion for any point in the image being viewed. The equation defining the value of this virtual field would be derived from hidden vector layer(s) of soil properties and raster layer(s) of terrain properties. These hidden layers do not even have to match the image layer being viewed in projection, cell size, area extent, and so on.

Why can't we style the content? *Complex DataTips get styled.*

Innovation, or the application of others' innovations to our products' objectives, can not stop. Computer power enables it, you demand it, competition requires it. Through all this you and we continued to communicate and work together. Thus, about a year ago at a weekly informal lunch meeting of the MicroImages software engineers, we were discussing how we could respond to your requests to improve the appearance of Data-Tips.

The initial focus of the discussion was that the information presented in a DataTip would be easier to understand if they used font styles and tabs. The immediate requirement causing this review at the meeting was the use of font styles to differentiate prefixes from values and units and to align the values vertically for easier reading.

In a few minutes of discussion, it was concluded that this feature and many other related to formatting could be easily implemented for use in DataTips in a couple of days' work. Simply permit the DataTip text to contain the many format codes used in the text editor

by modifying the DataTip display code to use them. Within a few days this was applied and used in the attractive DataTip that pops into the Lincoln Property Viewer sample **TNTatlas** DVD accompanying this MEMO. It is also illustrated in the accompanying color plate entitled <u>Property Viewer Atlas for Lincoln, NE</u>. Easy, yes, but it requires to-day's computing power and years of other earlier **TNT** developments to be interactive and to build and display many lines of formatted data from multiple layers in a fraction of a second.

<u>Can the changing data change the style?</u> *Enhanced DataTips arrive.*

Next, at this same meeting, the idea followed that it would be useful if the text color and background color of the frame of the DataTip could be determined at the time of its display and changed based upon its current value. These visual stimuli could be used to alert you or your user of some particular aspect of the content or the changing content of the DataTip. For example, "red" background could indicate that the temperature, pressure, and other values for the flow in the nearest pipeline are critical and out-of-range, "yellow" that they are approaching critical, and "green" means that they are in safe range. Of course, this is merely an example as you might want the pipeline and DataTip to automatically pop in to the view if its condition is "red" and approaching critical.

A practical use of color to draw the attention of the user to specific conditions is illustrated in the color plate noted above by changing the background color of the DataTip and the corresponding value to alert you of the floodplain category of the property. This zoning might be of particular interest since a lending bank may require the potential buyer to purchase expensive floodplain insurance, pay higher mortgage interest rates, or even have a no-loan policy for flood prone areas. In this example on your sample DVD, all you have to do is move the cursor to the house of interest. Alerting you to this special condition in this complex spatial reconnaissance **TNTatlas** would not be very interactive by other means. For example, this zoning could be reviewed by turning on the flood zone vector layer for the view with polygons filled with transparent colors. However, showing this and any of the other interrelated layers used in this DataTip would soon obscure the view and make it difficult to understand, particularly for your clients in other professions and with other backgrounds.

Another example of how to use enhanced DataTips would be to present the results of a Multi-Criteria Decision Analysis equation (MCDA) that applies linear weights to the attributes of several hidden vector objects (for example, land use, soil properties, elevation, slope, temperature, rainfall, …). This MCDA equation would combine the attributes of these layers to populate a virtual table with virtual fields whose values are the suitability index for each potential crop. The virtual field for each crop could even incorporate local production costs, conservation impact (for example, erosion potential), and market value for each crop and present these factors with or incorporated into these crop suitability indices. All these virtual fields could be dynamically evaluated at any cursor position, combined, and popped into the view as a single attractive enhanced DataTip for all major crops with a layout similar to the enhanced DataTip in the Lincoln Property Viewer atlas.

How could this MCDA-derived DataTip be used in a rural scenario? Assume you or your client need to work with local land owners and land stewards who are not particularly computer aware and do not even want to know anything about geospatial analysis. One objective is to show any one of them at any unscheduled time what is likely to be

the most suitable crop(s) for their land using "appropriate technology." Unscheduled is the key word here; it's when they walk into your office unannounced or you stop at their village with a portable computer. If you start out by showing them some complex paper map prepared in advance or screen view of the suitability of the general area for each potential crop you are using "inappropriate technology" and will only confuse them.

As an alternative, suppose you have prepared in advance a nice color image of the area, with an overlay of some general road, village, label, and property boundaries. You then view this in a free **TNTatlas**, the new low-cost **TNTview**, or any other **TNT** product including a **TNTserver**. You use this view to help them get their bearings in a 2D view of their general area. You first and then they move the cursor around on the 2D view, and wherever they hesitate, an enhanced DataTip pops in showing clearly labeled values for the suitability of each potential crop for an area they can recognize from the image and its simple feature overlays in the view.

Maybe they need a 3D view or even a **TNTsim3D** opened to help them get oriented in the 2D view. However, from this DataTip when moving the cursor around, they will easily get the idea of the comparative crop suitability. They may be concerned at this point about how these values are derived, but could care less about how the underlying technology manages it. Next they will want to see the general variability of the suitability of a crop in their area rather than these point results. Now you or they can make a simple step further and turn on a single vector overlay showing in transparent color the suitability of a single crop for the entire area of possible interest, and so on.

But text is not the best way to present interrelated values! *GraphTips arrive.*

The design for implementing a GraphTip approach for an interactive graphical presentation similar to DataTips was defined at the same lunch meeting. We recognized that DataTips were getting complex and being used to present multiple lines of interrelated values. It was then a small but innovative jump to discussing how this information might be presented in a graphical form as a GraphTip that pops in instead of a DataTip.

GraphTips are an interactive form of pin mapping. The simplest example of this is to pop in a pie diagram or a bar graph to visually show the percentage relationship between several database fields, for example the relative population of men and women in a county. Yes, a pinmap layer or map could present this same graphical information by showing all the pins. This is the way pin mapping is used in a physical printed map. However, in an interactive setting all these pins, unless carefully controlled by scale, can obliterate the basic theme layers in the view and each other. So now you can use GraphTips to present these same symbolic results as an interactive presentation that automatically shows these details for every position of the cursor.

Why are we limited to only one graph? *Display Control Scripts are added.*

After these simpler GraphTip concepts were developed, even more complex applications of the GraphTip concept were discussed at a later informal lunch meeting. These ideas were sufficiently complex and varied that they could not be achieved by further extension of the DataTip/GraphTip coding structure. So the idea of using our codeveloped **TNT** geospatial analysis scripting language (**SML**) to provide for more real time, complex spatial decisions to determine what to draw and where to draw it. Thus, the concept of a Display Control Script (DCS) was added to the **TNT** products.

In some ways GraphTips created by a DCS are closely allied to the already familiar idea of using a **TNT** script to add new special tools to the icon bar or menu in the view. However, you "pull information to you" with a Tool (Tool Script) since it only evaluates information about the position when you click on it. A DCS "pushes information at you" in the form of instructions, graphs, images, or whatever you preprogram it to do if the cursor simply pauses on or near a feature in the layer.

Examples of a Tool and a Display Control Script that have been deliberately designed to have very similar objectives (a moving spyglass view of another layer) are discussed in the technical sections below. While Tool Scripts and DCSs have different internal structures, in application they may only differ in operation in a simple fashion. A Tool is selected and turned on by your deliberate choice and action. You then may get a dialog to define how the tool should operate. The simplest dialog at the start of using a Tool might let you select the object in the layer list or any other overlapping object for use with the Tool. You must then click the Tool in the view to initiate its activity.

In contrast, a Display Control Script (DCS) is automatically evaluated every time the cursor moves a designated minimum distance in screen pixels and pauses a specified period of time, usually set to 0.5 seconds. When these cursor movement/pause conditions are met, the DCS, which has been concurrently running, automatically operates on layers typically hidden in the view, or on objects in fixed directory locations. These objects can be of changing size, content, different Coordinate Reference Systems, and so on but must be named and found in the preprogrammed directory positions or kept track of by some means, such as top or bottom layer. The DCS draws in a GraphTip and then closes it when the cursor is moved. However, since it is a **TNT** script, it can take a wide variety of other geospatial actions leading to the next kind of dynamic application.

Can we graphically present spatially interrelated results? *Dynamic Geospatial Analysis arrives.*

Via the Display Control Script (DCS) we have ended up this **RV7.0** development cycle with the idea that multiple GraphTips can pop into your view that are at positions that are spatially related to, but not at the pause position of the cursor. These GraphTips can visually represent the data about features at remote locations in or off the edge of the view. This is illustrated in the accompanying color plate entitled Exploring District Services.

This is a dynamic analysis. If you pause the cursor at any location on the color image of Lincoln, 3 GraphTips symbolically representing school buildings pop in at the location of the 3 different schools (elementary, middle, and high school) that serve the geographic location of the cursor. Move the cursor and the school symbols move around appropriately. This is a DCS so no mouse click is necessary and its use is completely "discoverable," simply pause the mouse over the view!

In this example DCS, the cursor position is used to detect the property parcel from a hidden vector layer when the cursor is paused. This parcel is overlapped by the three school attendance area polygons in the hidden school attendance vector layer. This permits the point at which the school is located to be found in this layer and the GraphTip school symbol to pop in at that position. The accompanying color plate entitled Using Overlapping Polygons graphically illustrates how the DCS uses these unseen vector elements. This DCS script is listed and dissected on the backs of these 2 color plates.

<u>Now it is up to you, at least for this development cycle.</u> *Show us what you can do!*

In many applications of **TNTmips** as a geospatial specialist, you are setting up materials for other professionals to use and exploit. We might define their goal as "interactive spatial data mining" and we have decided to call this activity in the **TNT** products Dynamic Geospatial Analysis. DataTips are now commonly used in your applications but took some time and improvements to become ubiquitous.

While perhaps complex to set up, this school example is the latest crest of the wave of our innovations in this direction. Each time we provide a new crest, you exploit it in innovative ways in your area of interest and extend our initial applications well beyond our ideas. For example, you might set up geodata and GraphTips for an expert geologist to explore for spatial relationships in digital layers of geological geodata. Yes, you or your client might find these conditions by successive "batch-like" applications of other geospatial analysis tools, in other words, you jointly think up a scenario and then run out the map for visual or hardcopy review. However, this greatly reduces the chance that the expertise of the several professionals involved will be used to interact and "think spatially" rather than simply periodically "evaluate spatially." Can you think up ways to use these new interactive capabilities to search for spatial relationships that can be interactively discovered?

<u>And we have not truly invented anything new!</u> *"Innovation favors the well prepared!"*

It is easy for us to think that we discovered or invented these new kinds of tools and ideas. What in fact is happening is that "we are actually discovering" how to adapt and apply what we have observed elsewhere for use in the particular focus of our **TNT** products. Most of these concepts discussed above are used in other types of application products, but not necessarily in competitive geospatial analysis products. For example, many analogs of these ideas are encountered in web browsing if you are using a broadband connection and dynamic HTML, flash, SVG, and so on. They are discovered and added to your **TNT** products using our building blocks as part of our efforts to maintain the most innovative, professional-level, desktop geospatial visualization and analysis software available.

<u>Bigger, Bigger, and Bigger Projects.</u>

<u>Introduction.</u>

The innovation in the **TNT** products discussed above is interesting and potentially useful in some of your applications. But it is certain that the size and scope of your geospatial analysis tasks for the **TNT** products will grow and grow and continually require our development efforts to keep up. You can handle these large geodata tasks in a lot of little orthoimage pieces or map units using a batch-like strategy, but this may impose limitations, such as edge effects. You can also approach these tasks for your nation, state, or the world using large, single objects and Project Files.

It should be clear to you that just as the outer boundaries of your projects expand toward some physical, geographical, or political boundary, the inner detail required will also continue to increase. Available image resolution and extent will increase, GPS precision for line oriented materials will increase, datum and local coordinate reference systems will be refined, and so on.

This is why the Coordinate Reference System (CRS) standardization and related modifications have been released in **RV7.0**. These standardized coordinate systems are the base needed to build these obvious future "really big jobs" and meet their accuracy requirements. For example, the new High Accuracy Reference Network (HARN) datums and transformations in and out of older datums are being introduced into geodata sets in Japan, Europe, and the US to support new accuracy requirements.

Future geospatial applications require standardized, industry wide, exchangeable, and accurate CRSs. It may be as simple as resolving the current arguments between image providers about how to standardize the access to the CRS of JPEG2000 compressed images (*.jp2 files) moved around the Internet. Or, it may be as complicated as some future application in automatically driving a vehicle.

As you need them, these new demands are met by our **TNT** upgrades released to respond to these new requirements in size and accuracy. Often, it is you clients who are professional geospatial analysts (in other words, those using **TNTmips** as part of earning their living) who identify to us these new requirements by asking for these kinds of "bigger and better features." These improvements can then be applied by all clients whether you are developing geodata for a nation, state, or river basin or simply requiring very high precision for preserving the spatial relationship of features in managing a municipal infrastructure or recording and analyzing a small archaeological site.

Big Project Strategy.

Throughout its existence, MicroImages has focused on getting the really large project completed as efficiently as possible on your desktop. Our working premise is that if the **TNT** products can do the really large geodata storage, access, and analysis in acceptable times, the small activities of these types will appear to be nearly instantaneous.

Your concept of what is a "really large project" for your **TNT** products has continuously ratcheted up over their 20-year evolution. What is a "really large project" has primarily been, and continues to be defined by the availability to you of larger and larger inexpensive hard drives; CDs, then DVDs, and soon HDVDs as a publication media; the limits of your operating system; and other limits these hardware factors place on **TNT** objects and Project File sizes.

Our original conceptual design of the Project File, its objects, and their subsequent adjustments has enabled us to adjust the Project FIle to keep well ahead of these improvements in your storage, operating system, and processing power and the ever larger objects they permit you to use in your projects. Today you do not hesitate to commit to undertake massive city, county, province, and country sized projects in **TNTmips** using single objects for each data layer.

Your personal time is often most efficiently used if your project can be approached in this fashion, even if you need to run a complex **TNT** analysis task in the background while completing other work in a word processor or even when it continues running unattended overnight. Then often, upon completion of the project, you tile out the objects for export into other formats in smaller units so they can be used in less robust products.

Certainly your desktop hardware speed (processor, bus and drive access, memory, and so on) and the efficiency of a required **TNT** process control your efficiency in completing the task. However, usually it is the storage media that enables you to consider undertaking it as a "really big project" rather than inefficiently in pieces or not at all. Yes, you

most certainly let us know when a particular process runs for hours or days. We then go to work to determine if that process can be made more efficient and faster. Sometimes it is a matter of the basic limitations of the current hardware. However, in either case, you often move ahead with your "really big project" running slow tasks overnight or over the weekend.

Sample Past Improvements.

The Global Data Set DVD released as part of **V6.9** and the Lincoln Property Viewer **TNTatlas** released with **RV7.0** demonstrate that your large object approach to large projects can be viable and cost effective and differentiate the **TNT** products from others. Keeping pace with your expectations in this area does require that new or completely revised building blocks and strategies are needed and must be gradually introduced and perfected. Some of these "really large project" software strategies introduced over the past years in the **TNT** products are:

- image pyramiding for very fast display of images at any scale,
- periodic implementation of new and better means of raster compression,
- optimizing the internal structure of a polygonal vector object,
- providing simpler topologies when polygonal topology is not needed,
- using geodata in objects closer to their original CAD and shape designs,
- indexing large database tables, and
- continuing effort to speed up topology validation.

How well have these past features you have had for years met these "really big project" goals as we have evolved forward? Inserted here is a web comment addressing the last feature listed above. It was picked up from a discussion on a forum for an inexpensive GIS product by a user of **TNTmips 6.4** (circa 2000) and the latest version of the other product. The **TNTmips 6.4** version mentioned is now more than 4 years old, a long time in this rapidly evolving business. The inclusion of this quote is not intended to be critical of the other low-cost products mentioned (they have their own design objectives), but to present a totally objective comment on how users of products react to how our products or their other products use their time. This posting is obviously a comment from a user who remains satisfied with the capabilities of **V6.4** or has a lot of time and little money for upgrades.

From a posting to manifold-l@lists.directionsmag.com on 18 November 2004

"Another interesting thing I've just been looking at (and I know this has featured in a few discussions, and [a name] *mentioned that they're working on it) is the display time for a large drawing (75mb e00 file) of watershed basins (i.e. areas). I double clicked the drawing and it opened up and is still working away at displaying the basins (quite a while now) - in the meantime I've opened up TNTmips 6.4 and displayed it in there. The initial time was about 1 minute, thereafter redrawing took less than ten seconds (while Manifold is still not showing anything but the red dot in the right hand corner). I then overlayed the flowpaths (couple of tens of thousands of lines) on the basins in TNTmips, and again the initial display time was about a minute, and thereafter redisplaying, zooming in/out, etc/ takes less than 10 seconds. Selecting basins or flowpaths is almost instantaneous (recolouring the line/area as well as showing the attribute data in the table). How do they do it? I know this has been one of TNTmips' features for many years - very fast drawing/displaying of vectors and rasters. I've seen ArcView battling with less, and so do all the open source*

products (especially the Java products like Jump and OpenMap) that I've worked with. It takes ages for larger vector objects to display. I'm interested in how it's done - curious. I know there's a checkbox in TNTmips, when you import vector data: Optimize vector for display. Also, a process for optimizing old (pre 6.4, I think) vector layers. Any theories? What voodoo art do they use to get MSWindows to display these things so very quickly?

Mmmh, no drawing yet - Manifold's still oozing along... :-)

V7.0 Results.

A major portion of the effort expended in getting you **RV7.0** is to alter and improve **TNT** features to accommodate your bigger, bigger, and bigger project materials. These activities are summarized here in this context of largeness and robustness improvements in **RV7.0** and are covered in much more detail later in this MEMO's corresponding technical sections.

Mosaicking: making big raster objects bigger.

Assembling mosaics of large areas from good quality orthoimages and collarless, good quality, scanned maps is becoming common. Often the source material is large in number (for example, thousands) and/or large in uncompressed size, but provided in a compressed form such as JPEG, MrSID, or PNG. By necessity, the target is also compressed, such as in a JPEG2000 object or a JP2 file. Mosaic can now accept as direct input any linked raster files, does not import them, and outputs the mosaicked object in any supported raster type including a compressed JPEG2000, JPEG, or standard lossless object. To accomplish this kind of task, even if it is so big that it takes hours, has required a lot of attention to be given to the **RV7.0** version of Mosaic.

Compression; making big raster objects small again.

JPEG2000 compression is now completely integrated for use in raster objects in **RV7.0** of the **TNT** products. For example, you can now mosaic directly into JPEG2000 compressed raster objects. These objects can then be used as texture layers in your **TNTsim3D**, greatly increasing the texture raster dimensions of the Landscape File that can be distributed on a DVD. JPEG2000 compressed images (as well as linked MrSID, and ECW) can be used to put much larger images into your **TNTatlas** on DVD and correspondingly for use by your **TNTserver**. JPEG2000 files can even be served up by **TNTserver** to reduce transmission time to a **TNTclient**.

Shape Object: making shapefile layers faster.

Large, single shapefiles are beginning to appear of over a gigabyte, usually due to attachments to large database structures. The use of the new shape object concept has been advanced in **RV7.0** to greatly accelerate the ability of the **TNT** products to directly link to large shapefiles and use them just like any other layer in a **TNT** view. Accompanying this has been the addition of procedures into this automatic link to show the shapefile's legend entries and styles in the **TNT** LegendView for the linked object.

Coordinate Reference Systems (CRSs): supporting the precision needed.

You can not do many types of large projects without accurate, standard CRSs and conversions between them and their possible datums. **RV7.0** introduces a completely revised CRS based on ISO standard 19111:2003. For example, your large project might

have a small geographic extent, such as a city, but require very high accuracies. These could be difficult specifications to accommodate without using the new High Accuracy Reference Network (HARN) datums and datum transformations enabled by this new CRS management introduced first in **RV7.0**.

Merging and Combining: assembling bigger, more complex geometric objects.

Copy/Paste, extracting, merging, and combining large vector, CAD, shape, and TIN objects can now be set up to run with fewer intermediate steps using the new Geometric Conversion Engine introduced in **RV7.0**. However, the larger and more complex the objects combined directly into a polygonal vector object or converted later, the greater the possibility that conflation errors (in other words, microscopic topology errors) might occur. This improved capability and your tendency toward creating larger geometric objects, particularly vector objects, have required substantial improvements in the validation of topology to detect and resolve these errors and in speed to accommodate all the additional computation and checking this necessitates.

Scale Control: preventing meaningless, slow displays of large geometric objects.

Even a trivial thing like displaying a large vector at meaningless map/view scales has been addressed. Now you are given a warning in the form of a Dense Layer Verification window and options if the geometric object you are selecting to display at the current view scale is so dense that it will simply fill in the view in a meaningless mass of criss-crossing lines.

This Dense Layer Verification window is illustrated in the accompanying color plate entitled <u>Managing Display of Large Vectors</u>. It will appear when you select a vector object for the current view that exceeds an element density threshold. When this warning window appears, you are being informed that at the current scale of the view the vector will be slow to render and will solidly or densely fill in the area it covers. You can choose to dispose of this window using several toggles.

Do not add layer.
Select this toggle if you simply want to skip this layer for the moment. You can then use some other layer(s) to zoom into your view to the local area of interest, and then come back and add in this vector when it will display with a lower element density.

Add with full visibility.
This toggle overrides this warning window and displays the vector object.

Add with scale range of.
This is the toggle that is initially on by default for each new large vector object you display. Along with this toggle you are provided with data entry boxes to set the scale range of the view window over which this layer will be drawn in the view. Each box will have a default scale value in it that you can edit. The larger value will determine how far you zoom into the view for this layer to begin appearing. It is determined to be a reasonable scale from the element density. The lower value is initially zero. If it is set to some other value, it will determine when the layer will cease to appear as you zoom in further and further. If you set this toggle, the current values in this window will be saved with this vector object and appear as defaults in the Dense Layer Verification window the next time the vector is added as a layer in any view. If you want to change the scale range previously set for any layer, reset it the next time it is added or choose Show

Scale Ranges from the Options menu in the Group or Layout Controls window, and change it there.

Add initially hidden.
This toggle adds the vector to the layer list as a hidden layer. You can then toggle the layer on when you have zoomed into the view to a scale at which it is needed and will not be so dense that it obscures all other previously added layers.

DV7.1. Making it even better.

In **DV7.1** we plan to experiment to see how other kinds of modifications can improve, or at least keep pace with, your ever increasing project sizes. At least two areas of investigation are related directly to how fast you can work in your **TNT** products.

Buffering Individual Layers.
As you know, big geometric objects can take time to add to a composite view each time any layer is turned off and back on. Using a new memory buffering approach, it may be possible to add individual new layers to a view or toggle those already showing off and then back on without regenerating all the other layers in that view.

Selecting File Opens a View.
Another feature of possible wide interest, which has already been implemented in **DV7.1** in its initial form, is the ability to double click on a file with a supported extension (for example, *.jpg, *.jp2, *.shp, *.sid, and so on) and automatically open the **TNT** product registered in Windows for this file, the X server and the display process, link to the object, and display it. You can also click and open to run an **SML** script (*.tkp, *.sml), or a Landscape File (*.sim) for **TNTsim3D**, or a Project File (*.rvc). Selecting a Project File in this fashion will open it in the registered **TNT** product using the first layout, the first group, or the first object it finds in that Project File. Methods for determining and controlling which of these objects to open when more than one is present are currently being explored. This new capability is currently limited to Windows but will soon be made available for Mac OS X and other **TNT** supported operating systems.

Yes, this click and go even works for a single layer if the free **TNTatlas/X** is installed and is registered in Windows as the software used to open any of these extensions. **TNTatlas/X** is downloaded and installed as part of every **TNTlite** and does not have the object size limitations of the other **TNT** products included in **TNTlite**. Thus, any supported file type or **TNT** object can be opened in this fashion by a lite user and use all the features and tools in **TNTatlas/X**, but only one object at a time.   If you want to view more than one layer or layout then install and register these extensions for use with the new, lower cost **TNTview** product. Using the mouse to select a *.jp2 or *.sid file of many gigabytes before or after compression can automatically open **TNTatlas** (or your other **TNT** product) to view the raster in seconds! Shapefiles may take a few more seconds but work just the same. Will this new feature make the **RV7.1 TNTatlas** the most powerful and useful FREE geodata viewer available?

New Feature Priorities.

Will the feature be there when you need it?

The **TNT** products probably cover the widest range of geospatial application areas and uses of any single product without expensive extensions or options. However, in a specific project, you often concentrate your use and requests for new features in a specific

area. For example, your interest is primarily in using **TNTatlas** as a geodata publishing tool. You may go along in this fashion for years with this activity and may not feel you need to keep your **TNTmips** current. Suddenly you encounter a situation, say a new operating system, new hardware lacking an earlier feature (for example, a portable with no parallel port), a data source such as MrSID, large mosaics, a detailed project area with a special local coordinate reference system, and so on. Any one of these may require you to take advantage of the newest features in the latest version of **TNTmips** to make your **TNTatlas**. Depending upon the potential generic nature of your request, you will find it has been addressed in a recent version of the **TNT** products. If you do not find that feature in the current version, you begin to lobby for it or even for a completely new direction in product development (for example, the introduction of manifolds in this release). Every request we receive is documented and assigned a priority.

It's a case of setting priorities.

At the present time we have 2750 new feature requests of varying priorities, which have accumulated over the last 20 years. The majority of these were not logged by you, but internally by MicroImages' staff as part of our internal design decisions. **RV7.0** completed 281 new feature requests from this list while 404 were added since **RV6.9**. To manage our resources and product development we have to establish priorities for which new features we add and which we do not add for each new release. Once you have received back the code number assigned to any new feature you have submitted, you can check the priority we give to it at www.microimages.com/support/features/. The initial priority we assign to a new feature request is based upon our perception of whether or not that feature represents a commonly needed feature for our clients. However, assigning a high priority to any new feature does not mean that it will be in the next release. Often this is because it requires some lower level, underlying, and not obvious developments in the **TNT** code and must await these developments; it can already be accomplished by other **TNT** procedures; it is large and complex to implement; or it simply becomes less important due to other internal software or operating system changes.

Increasing a priority.

Finding that a less than high priority has been assigned to your new feature request does not mean you should give up on getting it. Sometimes you have to be persistent and convince us that it is in our interest and that of other clients to raise its priority. Or, you may want to discuss the possibility of contracting with MicroImages to add that feature to the **TNT** products. Often we will cost share the expenses of such developments. But, even if it is added in this contract fashion, the feature will not be proprietary and will become available to everyone in the next **TNT** release.

Opportunity costs.

Many commercial product companies will not respond to custom feature requests. Why? Because the true cost, not your perceived cost of commercial software development, is not obvious. These are called "lost opportunity costs." This is the cost(s) of not completing the most important features of common and wide interest at the earliest date with a limited resource, in this case the time of the software engineering manpower available. Software engineers experienced and capable of doing **TNT** programming are

a limited resource that can not be replaced simply because extra money is made available.

Also keep in mind that any new feature added to our commercial product whether by our initiative, your lobbying, or by a contract must be maintained indefinitely on all platforms, may restrict other future developments, must be supported for all, requires documentation (for example, at least color plates), may delay widely usable generic developments, can delay a release and thus, subscription fulfillment, and so on. Consider these hidden costs of software development to the extreme by reflecting on how large the Microsoft employee base has grown. Yet clearly this gradual increase in their size was not accompanied by a proportional increase in the number of software engineers actually coding their products. As they grew larger and larger, the proportion of their staff members writing product code is quite small in comparison.

Design costs.

However, the biggest single hidden cost to us in adding more complex new features via contract can be even less obvious. It's the time required to figure out what you want by our management and our software engineers, especially when we speak different languages both literally and professionally and reside in different nations necessitating written communications. We are a software development, production, and marketing company and are not staffed as you are by geospatial analysts or professionals in the various application disciplines. Yes, we have some professionals from the application areas, but they are responsible for preparing written materials for all users and associated general software feature design and testing. Whether you are lobbying for a new feature, or possibly contracting for its addition, considerable momentum and waste of time can be overcome if you simply arrange a visit with us. And, of course, you always have the opportunity to satisfy a special or unique need in the **TNT** products using **TNT** scripts (**SML**) or our **TNTsdk**.

Hardware News

Geologic Mapping Station.

Periodically this section brings to your attention hardware configurations of particular interest to you as a geospatial analyst, such as good portables, good US$3000 workstations, and so on. This time it discusses a high-end Apple system designed for a specific purpose that is being used with available geodata and the latest **RV7.0** 32-bit and 64-bit builds of **TNTmips**. This specific purpose is only one example of the many large project uses for such a workstation.

Apple Based High Resolution Workstation.

Apple has available large, high resolution flat panel monitors in 20" (1680 by 1050 pixels), 23" (1920 by 1200 pixels), and 30" (2560 by 1600 pixels) sizes. A MicroImages client site has recently explained their configuration and use of **TNTmips** systems on Mac OS X based workstations using these Apple monitors. Their stations are based on Apple Power Macs with dual 2.5 GHz G5 processors (US$3000), a 30" monitor (US$3000), and a 23" monitor (US$1800). The 30" monitor requires an additional NVIDIA GeForce 6800 GT or Ultra DDL display card (US$600) to support its extra high frequency refresh rates. Total cost of this Apple workstation is US$8300 plus some additional US$ for more memory. The top of the line Power Mac has 8 memory slots for 8 GB and Apple

promises very soon (V10.4 = Tiger?) to let a single **TNTmips** process use more than 4 GB. The **TNTmips** Mac OS X system for this workstation would cost $5000 to $7500 depending on its location and the need for the large format printing option.

Application.

The application of these workstations is to compile geologic maps and other forms of geologic information to guide the search for coal, oil, gas, and minerals in a nation. The total cost of each system is equal to a single day of field work for a professional geologist in costly, remote, and/or potentially dangerous locales. To reduce or eliminate field work time in hazardous areas, they are using these workstations for their office preparation or the entire compilation task. The results will be compiled and distributed at 1:100,000 scale in printed and electronic form and then recompiled from this scale to a 1:250,000 series.

Geodata Available.

Maps.

An existing reconnaissance level geologic map of the nation was originally compiled on 1:250,000 base maps and is available in a single vector object with attributes.

More than 1000 1:50,000-scale topographic maps are available in ~150 dpi scanned form for the entire nation in JPEG format (*.jpg) and georeferenced with a world file (*.jgw). The collars, or marginalia, for these maps have been trimmed away. **RV7.0** can link to and display these JPEG maps directly from this format. They can also be mosaicked directly from this JPEG format and the result saved as a single JPEG2000 compressed raster in one step for the whole nation under Mac OS X.

Elevation Models

SRTM 30-meter elevation data is available for the nation. RADAR-shadow holes in the SRTM data have been patched using elevation data from other sources and some proprietary software.

Imagery.

Landsat.

Landsat ortho imagery is available for the entire nation at 30 meters. It has been extensively processed to bring up the geologic detail, such as to remove as much vegetation as possible. A proprietary process has been used to remove terrain induced radiance effects using the DEM. For high resolution viewing, the natural color and special image color enhancements, such as ratioing, have been pan sharpened to about 15-meter resolution.

The complete 15-meter natural color imagery for this site is in MrSID format (*.sid) in 1 by 1 degree units. This same kind of 30-meter Landsat image coverage of most of the world can be downloaded from NASA in MrSID format (for details see the section below entitled Reference Geodata). In either case, **RV7.0** can link to and display multiple MrSID images directly from this format. These images can also be mosaicked directly from the MrSID format and the result saved as a single JPEG2000 compressed raster in one step for the whole nation under Mac OS X.

High Resolution.

Higher resolution, 1-meter, pan sharpened imagery from IKONOS and QuickBird is available for spot locations.

<u>Other.</u>

Gravimetric and magnetic surveys are also available for some areas, as well as other miscellaneous geodata of more detail for spot areas.

<u>Working at Map Scale on the 30" Monitor.</u>

A 30" monitor is used for the 2D composite view of the georeferenced 1:50,000 color map quadrangle (white areas transparent) superimposed on the 15-meter images of various types in the **TNT** Spatial Data Editor. This is the base upon which the detailed map units are interpreted and drawn.

<u>Map Views "To Scale."</u>

The single 1:50,000 topographic map scanned at >150 dots per inch in color yielded 5134 columns and 3707 lines and can be viewed at 1:50,000 on the 30" monitor.   The horizontal maximum fit of this on the 30" monitor is 5134 map cells / 2560 pixels or ~2.0 map cells or dots per pixel. The vertical maximum fit of this on the 30" monitor is 3707 cells / 1600 pixels or ~2.3 map cells or dots per inch. Thus, fitting the entire map on the screen would sample 2.5 map cells into a screen pixel allowing for the vertical dimension and the marginalia of the **TNT** view. This translates to viewing the map at a resolution of about >150 dpi / 2.5 dots per cell or the equivalent of viewing the map at about a 75 to 100 dot per inch scan resolution. When resampled from the 2X pyramid layer formed in the link file for these JPEG files, it produces a readable overlay of map features including the contours.

Alternatively, this base map could be viewed on this 30" monitor at about 1:100,000 at the full 150 dpi scan resolution. Then the 1X zoom icon would bring up a composite view of ¼ of the area of the map in seconds to about 1:50,000 design scale noted above.

<u>Image View "To Scale."</u>

Several layers of Landsat images are added to this view before the transparent topographic map is added (best enhancement for materials A, best enhancement for materials B,… natural color, …). This permits toggling them on and off and using the View-in-View types of tools. These ~15 meter Landsat images require about 3300 pixels horizontally to display at 1:50,000. So for the 30-inch monitor and a map scale of 1:50,000, you are viewing nearly the full resolution of these Landsat images overlaid by a readable ~75 dpi map. For a 2X zoom the imagery is zoomed ~2x and the map is displayed at nearly its 150 dpi design scan resolution.

<u>Any Area "To Scale."</u>

The 30" monitor nicely fits the familiar map scales and boundaries as outlined. However, you are not restricted to working map by map. Working in this same range of scales you can just as easily get a 2D **TNT** view of the images and map at the same scales where their 4 corners mosaic together, but without first mosaicking them. However a more direct approach would be to use the sketch tool in the GeoToolbox to draw features across object boundaries in a 2D view and save them as a CAD object. Later this CAD object can be merged, refined with attributes, styles, and so on in **TNTedit**.

This "sketch it first" is the classic approach to all visual image interpretation (geology, forestry, …). First concentrate on how the big picture fits together and capture the important linear features in the easiest way possible by sketching them on mylar overlays, which translates into sketching in a **TNT** view in display. Then, as your understanding of the site and its 3D structure matures, you edit and refine that initial line work in the **TNT**

Spatial Data Editor as a CAD object or as converted to a vector object. In this step you unify and encode the structure and finally identify it (for example, add attributes and styles) within a schema and presentation standards used by others in a printed and/or electronic form.

Referencing 3D and Control via the 23" monitor.

The 23" monitor is used for **TNT** process control together with 3D views of the same or other combinations of these image and map materials to act as a substitute for being on-the-ground. This view is open, altered to various viewpoints, and used concurrently with the mapping activities on the 2D map base in the Display, Spatial Data Editor, or other **TNT** processes. Various interrelationships between 2D and 3D views can be established, such as concurrent layer control and a gadget that shows a trapezoidal outline in the 2D view of the edges of the area in the perspective 3D to help understand its orientation when the 3D viewpoint is changed.

The 3D view can also use other combinations of layers such as a Landsat natural color image for realism or the enhanced false color images; color coded elevation, shaded relief, contours, and topographic maps; a vector overlay of the reconnaissance geologic map, lineaments, or the new interpretations; and so on. As these 3D views are rotated around, they help in visualizing how the surface structural features and their manifestations indicate subsurface structures and trends. These 3D views can then be used to 2D sketch in the detail between the surface features seen only as edges in the 2D view. DigitalGlobe and IKONOS images of higher resolution available for some small areas are used to help identify the edge features that can be seen and traced out for the total area being mapped. They act as a substitute for some of the ground truth and also reduce the cost of time in the field or improve its value.

Stereo.

The new and improved stereo capabilities in **RV7.0** and related hardware are discussed and illustrated in a later section. These have not yet been factored into this geologic mapping project. However, the use of mirror stereoscopes or the Sharp and SeeReal direct view 3D monitors may be of use to improve the 3D understanding of the area being mapped. Similarly, the value of manifolds for constructing and visualizing geologic profiles in these 3D views is just becoming available to this project in this **RV7.0** release.

Rendering Speeds.

2D Views.

TNTmips is the fastest system available on the Mac OS X or a Windows-based platform for handling composite views of multiple layers to scale. Pyramiding rasters, fast JPEG2000 decompression, vector optimization, and scale control are just some of the examples of how multiple objects of any size are rapidly read to form a composite view. However, if you want to delete or add a layer to the composite view, it is all redrawn from these various sources. At this time for **DV7.1** MicroImages is experimenting with using separate real memory buffers of 32 bits each (RGB and alpha) for each layer. This would not change the time to create the original composite view, but might significantly reduce the time needed to toggle layers on and off or add a new layer. In this example application, multiple Landsat layers are loaded at the outset as noted above. If they could be rapidly toggled on to become the image exposed under the transparent

map layer, this would improve their geologic interpretation. This might be possible using this new buffer per layer by simply rotating their position in the display order.

3D Views.

As discussed below, making composite 3D views is now not only of high quality, but in **RV7.0** also has new features and all previous features restored, for example, layer transparency. Even reorientation of the viewpoint is faster in **RV7.0**, for example 10 to 20 seconds. This redisplay speed is important in this type of geological application and in other plans for the **TNT** products. Redisplaying a 3D view is already 2 to 4 times faster in **DV7.1** and work in this area is being actively continued.

Windows High End Workstation.

The following dual display subsystems can be put in the Windows PC of your choice to use for a similar application to that outlined above. These high end Windows workstations are also currently being used by other **TNTmips** clients for applications where the highest quality image display is important.

Highest Resolution Color Monitor.

ViewSonic 22" VP2290b (3840 by 2400 pixels called QUXGA-Wide) (US$6000) www.viewsonic.com/support/desktopdisplays/lcddisplays/proseries/vp2290b/.

The same monitor is also available from Ilyama and IBM. It is used in place of the 30" Apple monitor noted above for the 2D image/map display. This monitor uses 4 VDI video inputs to create the refresh rates needed for this resolution. Therefore, it must be coupled with the Matrox Parhelia HR256 (US$2500) quad out display board (see www.matrox.com/mga/products/p_hr256/home.cfm).

Best 3D Companion Monitor.

These monitors are very similar in screen design and capability to the Apple 23" monitor used for this purpose above.

HP 23" monitor HP f2304 (1920 by 1200 pixels) High-Definition LCD. (~US$2000).

Sony 23" monitor SDM-P234/B (1920 by 1200 pixels) (from Dell at US$1900).

The Matrox Parhelia HR256 board used for the ViewSonic VP2290b uses a PCI bus slot. Thus, one of these 23" monitors can be added via the display board in the standard AGP slot of the PC, assuming it supports their higher resolution.

Other Considerations.

If you set out to assemble a Windows/PC based equivalent of the Apple station noted above, please keep in mind the following features automatically available in the Apple system. You will need a high powered PC with a big power supply and plenty of cooling. SATA serial drives are faster and best. Your memory for each application is limited by Windows XP and a 32-bit processor to 2 GB until a formal release of XP-64 is available for use with an AMD F64 based processor or the future Intel equivalent. DDR2 memory is used in the best PCs whereas only DDR memory is usable in the Power Macs.

Starting TNT products from a Portable Drive.

If you are using Mac OS X 10.x (presumably the latest release) you can use a USB2.0, Firewire400, Firewire800, or cartridge hard drive or flash card as an installation drive for your **TNT** products making them physically portable across G4 and G5 based Macs. This will permit you to move both **TNTmips** software and your preferences along with

the USB **TNT** Software Authorization Key between your Apple portable, base system, classroom units, and so on.

External tri-interface drives supporting USB2.0, Firewire400, and Firewire800 are now available and give the most portable drive flexibility. If the portable Firewire drive is an 800 instead of a 400 (800 connectors are only on the PowerMacs at this time), it will be just as fast as an internal drive. On a USB2.0, Firewire400, or flash card, the startup and the loading of processes may be about ½ as fast or faster compared to the speed of an installation on an internal drive. A faster result than ½ will depend upon the type of flash memory, USB2.0 support, and so on.

A 1 GB USB2.0 thumb drive or memory stick could also be used to carry a **TNT** product and geodata around in your pocket between Apple systems that are not networked or can access a **TNT** floating license but do not have the **TNT** product locally installed. The first thumb sized Firewire flash memory drives have now also appeared but are Firewire400 and, thus, perform at about the same speed as the much more widely available and cheaper USB2.0 drives.

The above portability idea does not work quite as well for Windows-based systems. Without a direct install to the internal hard drive of each computer, it is unlikely that all the Windows libraries and many other factors will permit this portability.

Serial ATA drives.

Serial interface SATA hard drives are now only 10% more expensive than IDE interface drives and are approaching cost parity with them. You should make sure any new PC you buy uses these SATA drives, which are faster, more flexible in use, and will soon be cheaper than IDE drives.

Software News

Further Confusion over Wavelet Compression.

LizardTech vs. ER Mapper.

After an earlier apparent resolution by a Federal Judge of a LizardTech appeal, five years of litigation has just been resumed between LizardTech and ER Mapper with regard to their patent dispute over their proprietary wavelet compression products. The dispute has focused upon how limited memory is managed when compressing large rasters.   When insufficient memory is available to hold the wavelet coefficients for the entire input raster because it is very large, the source image can be broken down and compressed in tiles. If a large, lossy compression ratio is targeted and each tile is compressed separately, the slight differences in the lossy result can occur at the edges between these tiles and may be visible.

An approach to the application of consistent wavelet compression to match the edges of a series of tiles is particularly significant when mosaicking many large pieces into an even larger mosaic. For example, you might wish to mosaic hundreds of uncompressed or compressed orthoimages into a compressed province or national level image. The management of these edge effects determines whether or not a large, uncompressed mosaic must be temporarily created on a hard drive before it can then be lossy compressed to 10 to 1 or 20 to 1 or more and if the large, temporary uncompressed intermediate image can indeed be compressed.

How to unify or mitigate this edge effect in the compression procedure is the subject of this legal dispute. More information on this topic and the current position taken by www.lizardtech.com/press/news.php?item=11-01-2004a, and www.ermapper.com/company/news_view.aspx?PRESS_RELEASE_ID=359. Please note that LizardTech is now wholly owned by Celartem Technology USA, Inc., which is part of Celartem Technology, Inc. in Japan.

File formats can not be patented but the software used to create them may use patented or copyrighted techniques. This is the basis for legal disputes when the software used to create the wavelet compressed file is deemed to be proprietary and using it is under control of a license. LizardTech and ER Mapper create their own compression and decompression files in this manner that have no relationship to JP2 files and require a license from their patent holder to use the software they provide to perform the compression. Thus, in these legal disputes, it becomes a matter of deciding if a patented technology has been used without a license to create their proprietary compressed formats in a competitor's product.

An internal **TNT** raster object is compressed into and out of JPEG2000 using the Kakadu library and not by proprietary wavelet code or methods created by MicroImages. You can use these raster objects without a license in the **TNTserver**, the FREE **TNTsim3D**, and FREE **TNTatlas** or as external JP2 files in any manner you choose. However, you do need a **TNTmips**, **TNTedit**, or **TNTserver** to create JPEG2000 compressed raster objects or JP2 files.

Proprietary Approaches Versus JPEG2000.

Since the release of **RV6.9** of the **TNT** products in early 2004, both LizardTech and ER Mapper have announced the addition to their products of support for the creation and reading of JPEG2000 compressed Part 1 compliant JP2 files. Their support of these JP2 files is being added in parallel to their disputed proprietary wavelet compressed file formats. The question of how their support of this standard JPEG2000 JP2 file fits in with their proprietary file's performance, legal claims, and marketability is best addressed to them.

LizardTech is using the Kakadu library for this purpose. This is the same library MicroImages selected for the first JPEG2000 features introduced in **V6.7** 2.5 years ago and continues to use. ER Mapper's approach to supporting JPEG2000 compression is unknown. The latest version of the Kakadu libraries supports a form of tiling during compression for memory management for very large images. **RV7.0** of the **TNT** products does not utilize this potentially contested procedure. Using the amount of real memory common on your desktop computers (0.5 up to 2 gigabytes), large images up to 250 gigabytes can be JPEG2000 compressed without this tiling in the **TNT** products. The MEMO entitled Release of the RV6.9 Products and dated 31 December 2003 discusses this JPEG2000 compression of large raster objects in detail in the section entitled JPEG2000 Compression. This earlier MEMO can be reviewed in HTML or Microsoft Word formats at www.microimages.com/relnotes/v69/rel69.doc, and www.microimages.com/relnotes/v69/rel69.htm respectively. How MicroImages will handle JPEG2000 compression of even larger images is being investigated. An example of the need for this would be the assembly and compression of the 15-meter NASA Landsat imagery of entire continents for public distribution as a single compressed image.

LuraTech located in Germany was heavily involved in the development of the JPEG2000 standard and has a licensed proprietary wavelet-based compression product called Lurawave Smart Compress, which creates files in the LuraTech Wavelet Format (*.lwf). This proprietary format and compression library has been popular in Europe and also now licenses a toolkit for JPEG2000 software development. In the following published paper Carsten Heiermann, President of LuraTech in Germany concludes the following regarding the future of LuraTech's proprietary compression.

"To close, I asked Heiermann to look ahead five years. Would the company still be offering its proprietary solution? He suggests that by then, there will be no new business in that area. Even now, he notes, the company is not actively selling its proprietary solution. Existing customers are moving to JPEG solutions, sometimes running both concurrently as they make the transition. New customers invariably purchase the open standards-based solution over the proprietary one."

Quoted from <u>Image Compression Embraces Open Standards: A Conversation with Carsten Heiermann of LuraTech</u>, by Andena Schutzberg, EOM magazine, November 2004, pp 24-26.

Generic Requirements of JPEG2000.

The JPEG2000 specifications dictate how a JP2 file must be structured, but not how this is most efficiently accomplished. The Kakadu library is one procedure for wavelet compression of rasters into a standard JP2 file. There are other libraries and possibly other patented approaches used for this same purpose. Since a file format is not patentable, patent disputes over wavelet compression primarily focus upon the procedures and efficiencies employed in assembling and compressing JP2 files.

MicroImages and now LizardTech use the Kakadu library to create and read JPEG2000 compressed rasters. Part 1 of the JPEG2000 specifications defines the features that can be incorporated into a stand alone JP2 file. The Kakadu library insures that the JP2 file created in or exported from these and the **TNT** products meets the Part 1 compliance standard. It is important to understand that a product can not claim to support the creation and/or reading of a Part 1 standard JP2 file unless it can be decompressed and used by other JPEG2000 Part 1 compliant products. Variations are permitted by Part 1 depending upon the type and size of raster material used. Even with this variability the JP2 file created using this permitted variability must still be useable in other products. However, this does not guarantee how efficiently a Part 1 compliant program can read a specific JP2 file. For example, the pyramid structure inherent in a Part 1 JP2 file may be ignored by the reading program making zoomed-out viewing quite slow because it is sampling.

Size Limitations of JP2 Files in Other Products.

For faster operation many low-cost commercial products that do not use pyramiding are designed to work with full sized, uncompressed images stored directly in real memory and go really slow if virtual memory has to be substituted when the file size is large. As a result, if these programs support using a JP2 image, they automatically decompress the full resolution image into real memory and then into virtual memory as needed. The pyramid structure automatically built into JP2 rasters is simply ignored. If the raster is small, this is not a problem. However, this places limitations on how big a JP2 raster used in these products can be or how long it will take to decompress and load it. Some simply will not load a JP2 image over a few megabytes uncompressed or automatically

revert to virtual memory which, from a performance viewpoint, is extremely slow and more or less equivalent to not working. Examples of products with these size limitations on using JP2 images would be Photoshop, QuickTime, and all known browser plug-ins.

LizardTech MrSID Compression to Be Supported in DV7.1.

As you will learn elsewhere in this MEMO, **RV7.0** of the **TNT** products can now import or link to and directly use MrSID formatted files on all platforms including Mac OS X. Recently LizardTech and MicroImages have come to an agreement whereby the **RV7.1** of **TNT** products will be able to export raster geodata into the MrSID format for use in the **TNT** products such as your FREE **TNTatlases** or in other software that can use MrSID files. These MrSID files will be created with the accompanying georeference information in a companion world file (*.sdw) and/or embedded in the MrSID metadata.

The integration of the LizardTech compression engine will be available in the early **DV7.1** releases of **TNTmips** and **TNTedit**. There will be no extra charge by MicroImages for providing you access to this proprietary compression procedure beyond the charge to upgrade to **RV7.1**. It is planned that it will be available for all **TNT** supported operating systems including Windows, Mac OS X, Linux, and Sun. It may be likely that this may be the first product to create MrSID compressed files using the Mac OS X operating system.

Charges for MrSID Compression.

As you may already know, LizardTech's stand alone GeoExpress mosaicking and compressor product and any other product, such as **TNTmips**, that provides compression into a MrSID format, requires that you pay a per byte charge to LizardTech. Since LizardTech does not charge anyone for decompressing and using compressed MrSID files, this is their mechanism for charging end users for using their proprietary compression engine. This use fee is metered by a software data cartridge that you buy from LizardTech or one of its dealers. You purchase it with an amount of compression encoded into it. You then install it and every compression into a MrSID file by your **TNT** product reduces the capacity of the meter in your MrSID data cartridge until it reaches zero or until you purchase and add additional capacity.

GeoExpress permits a MrSID file to be read and recompressed into a new MrSID file without charging their data cartridge. For example, you can convert a lossless MrSID file into a more compressed lossy MrSID file without any charge. In contrast, as part of MicroImages' agreement with LizardTech, if you choose MrSID files for input to a **TNT** process, such as mosaic, and designate MrSID as the output format, the data cartridge will be charged for its compression according to the decompressed size of the input objects you have selected.

Data cartridge metering is based on the uncompressed input bytes you send into the compression engine from the uncompressed equivalent of the **TNT** source raster object and not on the size of the compressed raster object or MrSID file. Please keep in mind that a data cartridge is metering bytes and not raster cells, thus a 24-bit color composite image will use 3 times as many bytes as its pixel count. Additional information about the operation of their data cartridge can be found at www.lizardtech.com/products/geo/faq.php or can be addressed directly to LizardTech. LizardTech does not directly publish the prices of GeoExpress or data cartridges, however you can get an idea of

their prices from those charged to U.S. Government agencies from the General Services Agency (GSA) price schedule at www.saic-gsa.com/products/lizard1.html.

> **Note:** You will need to buy and install a LizardTech data cartridge to export **TNT** raster objects into MrSID compressed files.

Charges for ECW Compression.

ER Mapper's approach to compression into their wavelet based proprietary compression engine has exactly the opposite cost strategy. A license for using this compression engine can be obtained free-of-charge for the use of this engine in other products. This free license limits the compression to the input of single uncompressed rasters of 500 MB or less. It is under this license that **TNTmips** and **TNTedit** can export and compress raster objects into the ECW format (*.ecw) within this size limitation.

To compress rasters of greater than 500 MB uncompressed, a software developer must pay a large, upfront, one-time charge and large annual charge. Both of these licensing charges can be found at www.ermapper.com/pricing.aspx. Once their compression engine has been added to another software developer's product, its end user can create ECW compressed files from uncompressed rasters greater than 500 MB without paying any per byte fee.

> **Note:** You can export **TNT** raster objects that when uncompressed are less than 500 MB to ECW compressed files without an additional charge. You can not export a raster object that is greater than 500 MB when uncompressed.

Reference Geodata

Orthorectifying OrbView-3 Images.

OrbView-3 1-meter panchromatic and 4-meter multispectral imagery can now be ordered with Rational Polynomial Coefficients and orthorectified when a DEM is available using **TNTmips**. More information about obtaining their imagery in this form can be found on their web site at www.orbimage.com. There is no indication as yet that SPOT images can be ordered with Rational Polynomial Coefficients.

Landsat Global 15-Meter Color.

NASA's Goddard Space Flight Center sponsored the Earth Satellite Corporation to assemble and mosaic global Landsat coverage of the earth in enhanced natural color for circa 1972, 1990, and 2000. This NASA project was managed at NASA/GSFC by Dr. Compton J. Tucker* and its assembly and content are reported on in considerable detail in the article entitled NASA's Global Orthorectified Landsat Data Set, by Compton J. Tucker, Denelle M. Grant, and Jon D. Dukstra, March 2004, Vol. 70, No. 3, Photogrammetric Engineering & Remote Sensing, pp. 313-322. [*footnote, Dr. Compton J. Tucker completed his Masters in Forestry (1973) and Ph.D. in Forestry (1975) specializing in remote sensing under the guidance of Dr. Lee D. MIller, President of MicroImages while both were at Colorado State University. The long time and continuing goals of MicroImages products in handling massive geodata sets on a personal computer are set forth

in other sections of this MEMO. One might assume from these historically related activities of these individuals that what was a common academic concept has become a lifetime scientific challenge.]

Now most of these image segments are available in latitude/longitude bounded blocks for download in compressed MrSID files (*.sid) with companion world files (*.sdw) from https://zulu.ssc.nasa.gov/mrsid/. The circa 1990 imagery assembled from 7600 Landsat scenes is 28.5 meters in resolution and covers most of the area of the continents except the Arctic and Antarctic. The circa 2000 imagery assembled from 8500 Landsat scenes is 14.25 meters in resolution and also does not cover the Arctic and Antarctic continents.

These Landsat blocks for the 2000 epoch can be downloaded without charge. In **RV7.0** these blocks can be mosaicked directly from the MrSID format into JPEG2000 compressed raster objects or JP2 files. This imagery and procedure was used to prepare the single Landsat image of all of Afghanistan included on the enclosed TNTatlas of Afghanistan CD and compressed from 1.62 GB to 164 MB in a single raster object (10:1).

These larger mosaicked units trimmed to your area of interest and using JPEG2000 compression provide an unparalleled image map base for direct interpretation in regional projects, such as described above in the section on Hardware. They also provide an excellent base for your **TNTatlas** and for reference in detailed projects when overlaid by the worldwide map vector layers provided on the Global Reference Geodata DVD with your **RV6.9** shipment.

SRTM 90-Meter.

The most practical earth-oriented result of the Shuttle program was the Shuttle Radar Topography Mission (SRTM) in 2000. Most of this source material has now been processed into 30- and 90-meter elevation data sets. All the 90 meter resolution for North America and South America is available free from the USGS site at http://seamless.usgs.gov/website/seamless/products/srtm3arc.asp. Access to the 30-meter resolution is limited to the United States and potentially to government agencies in other nations. This SRTM data has its holes patched using a surface fitting method. The files can easily be mosaicked into larger elevation rasters, clipped to the rectangular area of interest, and compressed lossy or lossless with JPEG2000 into a raster object. This is how the single JPEG2000 lossless elevation raster object of all of Afghanistan was prepared for use on the enclosed CD entitled TNTatlas of Afghanistan. These elevation maps can be used with the circa 2000 Landsat images noted above to create 3D views and **TNTsim3D** simulations of almost any area of the world.

The raw elevation data for all the areas covered by the mission is now available from ftp://e0dps01u.ecs.nasa.gov/srtm but still has holes in it. MicroImages is now receiving questions on how to patch the various holes or null areas in these SRTM elevation rasters. These null areas are due to a number of factors ranging from signal noise (1 or 2 cells), water bodies with no RADAR return (usually a few more cells), topography induced RADAR shadows (usually mountains and, therefore, many cells), and ground coverage gaps. Since this hole filling would be done once, or infrequently as new substitute data was developed for these holes, it is an appropriate task for an **SML** script. Such a script would be used to improve the hole filling in the JPL processed results if better substitute elevation data for these holes is available locally or developed with **TNTmips**.

Properly patching holes in these SRTM derived elevation rasters requires that you supply locally derived elevation data that can be smoothly inserted into these holes. This missing elevation data might be derived by resampling the GTOPO30 global elevation raster on the Global Reference Geodata DVD for a coarse elevation patch. For better results a substitute elevation raster could be created for the larger hole areas using **TNTmips**. For example, you could digitize the contours from scans of 1:50,000 topographic maps and then convert them to the needed elevation rasters. Since this is a common problem, MicroImages has decided that it will create an **SML** script to patch substitute elevation data into these null areas. Any good ideas you read about or have on this topic should be brought to MicroImages' attention now.

Nebraska 1-Meter.

This data set is not global and is of more interest locally. However, it is introduced here because it is illustrative of what can now be accomplished for your nation, province, or region at reasonable project cost using the new all digital cameras and orthophoto map production systems available for purchase or lease.

Nebraska was the first state (and the only state in 2003) covered by 1-meter color orthophotos acquired by an airborne digital camera system for the purpose of agricultural management and land conservation under the auspices of the USDA's Farm Service Agency. Using other analog film based systems, 1- or 2-meter DOQQs were prepared for 1/10 of the United States land area in 2003. In 2004 approximately 1/3 of the United States land area was covered by 1- or 2-meter DOQQs acquired by a mix of digital and analog cameras (670 counties). Additional details about this USDA image acquisition program, its sample cost per DOQQ, and the availability of all of these DOQQs to the public via the Internet can be reviewed in the article Imagery to Support USDA Agricultural Programs: The National Agricultural Imagery, by Kent Williams, Earth Observation Magazine (EOM), December 2004, Volume 13, Issue 18, pages 10 to 12. The text of this article without the reference maps can be read at www.eomonline.com/Common/ Archives/2004Dec/04dec_AgriculturalImagery.html. According to this article these national coverage DOQQs will be available in early 2005 from http://datagateway.nrcs. usda.gov/ or www.apfo.usda.gov.

The digital imagery used for the 2003 Nebraska DOQQs was collected in a few summer days and processed into excellent, almost completely cloud free, orthoimages in a couple of months. The source images were collected in wide north/south swaths across the state and processed into Digital Ortho Quarter Quadrangle units of 3.75 by 3.75 arc minute areas for distribution and use. The DOQQs match all across the state in color and mosaic accurately at the edges since the were clipped originally from larger orthophoto mosaics. These DOQQs can be downloaded free in JPEG format from the State of Nebraska's Department of Natural Resources' website at www.dnr.state.ne.us/ databank/fsa03.html.

These Nebraska DOQQs are posted for downloading in 2 different projections each of just over 6000 files in JPEG (*.jpg) format with 6000 companion world (*.jgw) files. One set has the JPEG DOQQs in the correct UTM zone projection (3 different zones cover Nebraska) and the other duplicate DOQQ set is in the single Nebraska State Plane Coordinate projection.

You can download an index map and several of these Nebraska DOQQ files to review and to demonstrate the quality of the color orthophotos, which can now be acquired by

digital means for your province, nation, or project area.   Start out by mosaicking several DOQQs directly from their downloaded JPEG file format into a JPEG2000 compressed internal object in **TNTmips 7.0**. Note that these good quality color DOQQs do not require any color balancing for general viewing or any contrast matching when mosaicked. Next use this sample JPEG2000 compressed mosaic for directly interpreting detailed surface cover, local infrastructure, or other geometric features of interest using your **TNT** Spatial Data Editor or the sketch tool in the **TNT** GeoToolbox. Since the original DOQQs were georeferenced with the companion world file, your mosaic and its interpretation into a topological vector, shape, CAD, and/or geodatabase object will be also georeferenced in the target Coordinate Reference System (projection and datum you choose in the mosaic or interpretation steps).

Preparing a small sample geodata set in this fashion with these Nebraska DOQQs, perhaps with geometric interpretations in vector, shape, and CAD object types, will provide you the demonstration material you need to show what you can do with **TNTmips**. It also demonstrates what could be accomplished if an airborne data collection effort of this type was cost shared between agencies or institutions for your area.

Nebraska is covered with 10-meter elevation rasters prepared in cooperation with the USGS. These DEMs can be downloaded from the Nebraska Department of Natural Resources at www.dnr.state.ne.us/databank/dem.html. Combining these DEMs with the 1-meter color DOQQs or your mosaic and your geometric interpretations will create quality, high resolution **TNT** 3D views and simulations of the farms and ranches and other features that make up almost all the land area and land use of Nebraska. These companion 3D views can also be used with the 2D views in the Spatial Data Editor and sketch tool to illustrate how they assist in the direct interpretation step to locate and identify the desired geometric features. You can then extrapolate from these Nebraska results to how these geodata acquisition and analysis procedures can be applied to mapping and monitoring the smaller agricultural, timber, and natural areas and village infrastructure in your nation.

Floating TNT Licenses

Using a Floating License as a Fixed License.

The Software License Key that supports floating licenses can also be used for a single-user fixed license on one computer. This single-user support is provided as a convenience for situations, such as when a Software License Key is needed for a notebook computer in a remote, non-networked location. The key does not support simultaneous single-user and floating licenses. So, if you want to use a **TNT** product on the computer that is serving as the floating license manager, you must check out one of the floating licenses.

> *IMPORTANT:* If the Software License Key is used for a single-user fixed license on the computer that is serving as a license manager or removed, the license manager immediately shuts down all floating instances of the license.

Updated Tutorial.

The tutorial containing the instructions for setting up a **TNT** floating license is expanded to 20 pages and is current with the installation and operation and use of **RV7.0**. This tutorial is installed as one of your many **TNT** product tutorials, can be accessed directly

from your **TNT** product CD, or downloaded from www.microimages.com/getstart/ pdf_new/enterpri.pdf

Windows 95

RV7.0 of the **TNT** products no longer supports W95. Maintaining backward compatibility of the **TNT** products with this 10 year old operating system places restrictions on the capability of the **TNT** products when they are being used with modern versions of Windows. Please anticipate that **RV7.1** or perhaps **RV7.2** of the **TNT** products may no longer support W98, WME, and NT for similar reasons. However, this will not occur before Microsoft ceases support for these Windows operating systems.

Mac OS X

Version Tracker.

Version Tracker at www.versiontracker.com is a very popular means of staying current with the development and release activities for Mac OS X software products. For example, you can get automatic email notification that a specified product has been updated. It also provides access to similar information about Windows product releases, but is not as popular with this community since there are many competing sites. Since May 2004, information about the availability of the current release and the development version of the **TNTlite** and **TNTmips** products for Mac OS X and Windows has been maintained on Version Tracker. This information has also been updated weekly to announce and provide access to the new features added via the weekly patches to the development version. As a result, there have been 7000 individual downloads of **TNTlite** and **TNTmips** for Mac OS X, or about 1000 downloads per month started from this site. A multipart download is counted only once, but incomplete downloads are not counted.

Mac OS X 10.2.x Dropped.

MicroImages has discontinued support of the **TNT** products for all versions of Mac OS X 10.2 and earlier versions of the Apple operating system.

Upgrading any Mac computer using the G3, G4, or G5 processor to Mac OS 10.3.x is not expensive and provides the reliable Apple-supported X11 environment required by the **TNT** products. These processors are also required to provide sufficient power to operate the **TNT** products effectively.

Mac OS X 10.3.X (Panther).

The **TNT** products now operate as either 32-bit or 64-bit applications under Mac OS X 10.3.7.   If you are using an earlier version of Panther, please install your free upgrade to V10.3.7 before using your **TNT** product.

Mac OS X with Windows Remote Desktop.

MicroImages' writing and testing staff use the 64-bit version of Mac OS X 10.3.7 and now use G5-based Macs for their primary daily routine operation, testing, and documentation of the **TNT** products. They report that connection to their secondary Windows XP machines from their Macs using Windows Remote Desktop works for controlling various

activities on the Windows machine. This approach ties the 2 or more workstations together (Mac to Windows or Windows to Windows) but requires only a mouse, keyboard, and 2 good monitors at the primary workstation. This is an effective means of moving your primary activity to a Mac (or new computer) without losing access to the software functionality and special peripherals you have built up on your existing computer. Furthermore, since the **TNT** products are cross-platform transparent, they do not care if you mix your Project Files between these operating systems and their drives and other peripherals.

Mac OS X 10.4 (Tiger).

PV6.9 of the **TNT** products <u>will not operate</u> with Mac OS X 10.4 and <u>will not be patched</u> for this purpose. If Apple officially releases Mac OS X 10.4 before the official release of **RV7.1** of the **TNT** products, then an **RV7.0** of the **TNT** products will be released for Mac OS X 10.4. If the reverse is true and MicroImages releases **RV7.1** of the **TNT** products before Apple officially releases Mac OS X 10.4, then you will have to have **RV7.1** of the **TNT** products to operate with Mac OS X 10.4.

Ensuring the Correct TNT Versions.

Mac OS X 10.3.7 and 10.4 require a G5 processor to operate in 64-bit mode and to use the 64-bit version of the **TNT** products. Occasionally support questions have been received that are traced back to attempts to run the 64-bit version of **TNTlite** on a G3- or G4-based Mac using V10.3.x. Both **PV6.9** and **RV7.0** of the **TNT** products now produce appropriate diagnostic messages if the version downloaded does not match the capabilities of the processor and Mac OS X.

TNTsdk™

Motif Required a Royalty.

Since its first creation years ago, MicroImages' **TNT** products for Windows and the Mac have used the Motif graphical user interface libraries. Even though MicroImages purchased a license to use Motif in our **TNT** products, a royalty fee had to be paid to the Open Group for every copy of their Motif libraries compiled and distributed with our **TNTsdk** for Windows and Mac OS X. Furthermore this group charges totally unrealistic fees for each upgrade of their libraries. On the other hand, when you use a Unix, or a Linux operating system, you can simply use the Motif libraries automatically provided with their X server since they pay the royalty.

MicroImages has always wished to provide you free access to **TNTsdk** for Windows to develop and add new compiled processes as this is in our interest as well as yours. MicroImages has had the option to pay this per copy royalty and absorb it as part of the price of your **TNT** product. However, this was contrary to the approach used in the **TNTlite** versions of the **TNT** products since The Open Group, among the other problems with their license agreement, made no provision for the free distribution of their libraries. This left no option but to control the distribution of the **TNTsdk**.

Using LessTif is Free.

RV7.0 of the **TNT** products for Windows has been modified to use a free open source equivalent of Motif called LessTif. To quote from www.lesstif.org

> "LessTif is the Hungry Programmers' version of OSF/Motif®. It aims to be source compatible meaning that the same source code should compile with both and work exactly the same!   LessTif is 'free software': it is licensed under the GNU Library General Public License (LGPL)."

This change is totally transparent to you since LessTif is equivalent, function by function, to Motif.   However, this change means that the large **TNT** software development kit (**TNTsdk**) library used to build all the **TNT** products is now available for use, free of charge, by any MicroImages clients, including those using the free **TNTlite** versions of these products.   However, please remember that programs developed with the **TNTsdk** will check the **TNT** product's Software Authorization Key unless the geodata objects and their analysis are found to conform to the size limitations imposed on the FREE **TNTlite** versions.

Reference Booklet.

A reference booklet entitled Using the TNTsdk is enclosed in printed form with your **TNTmips 7.0** kit.   It is also installed in PDF format as part of your online tutorials.   It explains how to set up and get started using your **TNTsdk**.   It is not a programmer's reference manual!   Consult any current C++ reference manual for help in this area.   Unless you are an experienced programmer, you will find it easier to solve your unique geospatial problems using MicroImages' geospatial scripting language (**SML**).

Compiler.

Effective with this release of **RV7.0** of the **TNT** products you will need to set up and use Microsoft's C++ compiler in Visual Studio .NET 2003 - Professional Version for building programs using the FREE **TNTsdk** for Windows.

Sample Programs.

Sample programs coded using the **TNTsdk** libraries can be downloaded from www.microimages.com/product/tntsdksamples/.   These samples provide models on the folowing topics:
- cadtovec.c   convert a CAD object to a vector object
- mklayer.c   sample for Mdisp layer creation from a "fixed" file and object
- objview.c   demonstrate use of object display functions.   This program allows the user to view one or more spatial data layers.
- rastinfo.c   very simple application allowing user to select a raster and display basic information about it
- smlapp.c   an older method for extending **SML** functions with SDK
- smlplug.c   a better method for extending **SML** functions by creating plugin modules to be called from **SML** scripts
- stdattr.c   computes "standard attributes" for CAD/TIN/Vector objects

Weekly Upgrades.

MicroImages is modifying daily the libraries that are used to build the **TNT** products and, thus, the **TNTsdk**.   Functions and classes are constantly being added, adjusted, and corrected.   To help you keep up with these changes, just as with those in the **TNT** products, a new **TNTsdk** is posted weekly for your access at www.microimages.com/product/tntsdk.htm.

Documentation.

The documentation of all components of the **TNTsdk** is maintained and updated as HTML text on MicroImages' Internet website. A Google search of MicroImages' website such as TNTsdk site:microimages.com will produce over 24,000 entries since all this documentation for all functions, classes, and methods are indexed by Google. However, a more specific Google search of TNTsdk RVC nullmask class site: microimages.com yields 154 specific references on this subject in this documentation. Using Google for this access will, of course, be a couple of weeks delayed or out of phase with the most recent weekly posting of these **TNTsdk** libraries as part of the latest download kit. This is the time it takes Google to periodically "crawl" microimages.com and index the changes. However, this Internet access can be useful since it is available anytime and anyplace via Google's powerful search engine. For the documentation that is concurrent with each weekly upgrade, use the search feature installed with the latest **TNTsdk** libraries.

Support.

MicroImages software engineers will provide limited support by email to assist you in perfecting your **TNTsdk** based programs. However, you should be knowledgeable and experienced with building C++ programs before contacting us. If you are planning a large project with the **TNTsdk**, MicroImages encourages you to spend 1 or 2 weeks designing and implementing a skeletal approach to your project or product at our offices. This has proved quite useful to others using the **TNTsdk** to develop other products. For a reasonable fee, you will be provided an office and computer equipment and direct consulting access to those who create and maintain the **TNTsdk** and the **TNT** products we derived from it.

TNTsim3D™ for Windows

Building Massive Geospatial Simulations.

Previous versions of the Landscape Builder in **TNTmips** permitted you to apply JPEG2000 compression for textures that were stored as external linked *.JP2 files. Now the Landscape Builder process permits you to create textures with JPEG2000 compression as internal raster objects within the Landscape File. This is illustrated in the accompanying color plate entitled JPEG2000 Compression in TNTsim3D.

Landscape simulations are usually designed to move around in real time and, thus, a very minor degradation in texture (image/raster) quality is never noticed by the user. JPEG2000 compression, as contrasted to JPEG compression, is very effective at masking or hiding image degradation at a 10 to 1 or 20 to 1 lossy compression ratio. Even higher JPEG2000 compression ratios may be acceptable because only intricate spatial details are lost and these losses may not be important in a moving simulation. Using lossy JPEG2000 compression for the texture and standard lossless compression for the terrain means that **TNTsim3D** and very large landscape areas can be distributed on a single DVD.

The color plate noted above contains a table to illustrate how large a **TNT** landscape model can be when distributed on a single DVD. The table presents the area covered by a landscape model that uses color image mosaics of varying ground resolution from various sources. Each image is a texture in a single raster object compressed 15 to 1

using JPEG2000. For example, using a 1-meter, 24-bit color image for a texture permits a maximum **TNT** landscape area of 17,000 square kilometers to be distributed on a DVD, even more if 16-bit color were used. This is the size of a small province or state (Massachusetts = 21,386 square kilometers) or a very large county (Cherry County, NE = 15,438 square kilometers). Combining JPEG2000 compression with other larger mobile media such as a cartridge hard drive, USB2 or Firewire hard drive, or the ~8 times larger DVD replacements (Blu-ray or HD-DVD of 25+ GB) will permit much larger landscape simulations to be distributed.

If high spatial detail is needed for any specific selected ground area in the FREE **TNTsim3D** you can package the Landscape File with (or as) an atlas and from **TNTsim3D** automatically open a 2D view of the same area in the FREE **TNTatlas** product. Another alternative would be to use a **TNT** geospatial script (**SML**) in **TNTsim3D** to automatically launch your browser with a **TNTclient** plugin or a stand-alone **TNTclient** with the selected point's coordinates. This could retrieve a lossless, high-resolution, multilayered view from a **TNTserver** for that geographic position via the Internet or a private network. The atlas used by the **TNTserver** could contain all the geodata coverage for an entire province or nation. This strategy would also be useful where the full resolution lossless image and map geodata are restricted or proprietary. **TNTserver** would provide several ways to control this access such as:
- restrict area viewable at full resolution (to the current view's area/resolution),
- control access (by passwords and/or payment),
- add additional layers (confidential or proprietary),
- dynamically change layers (track moving features), and
- prevent copying of the base geodata (restricted to capturing only current view).

TNTsim3D can function in effect as a FREE 3D extension of your **TNTserver** and client. It provides rapid 3D simulation of the area covered by the server's detailed atlas and provides a natural access to the locations it covers (autostart from DVD, fly if mouse is moved, point to an area, click, and get 2D details).

Panoramic Backgrounds.

Skies Add Increased Realism.

Adding cloudy skies, sunsets, atmospheric conditions, and other backgrounds can markedly increase the realism of your simulation. **TNTsim3D 7.0** can now project these kinds of texture backgrounds onto the inside of a sphere or dome encompassing your simulated landscape. This provides a realistic, seamless, hemispherical sky dome or other background for your simulation.   Some of these sky effects are illustrated in the snapshots of the **TNTsim3D** views in the accompanying color plate entitled Sky Domes in TNTsim3D.

The skies provided with **TNTsim3D** are texture rasters projected inside a hemisphere encompassing your 3D surface. Each of these images was derived from a single real hemispherical sky photo or graphically modified equivalent. This image was then unwrapped using an equirectangular projection into a panoramic raster object whose columns represent the horizontal angle (0 to 360 degrees) and whose lines represent a vertical angle of 90 degrees. **TNTsim3D** projects the selected panoramic raster object in real time onto the inside of the dome using the inverse of the equirectangular projection. This procedure creates the appropriate sky background segment for every view you

have open in every direction including the new Custom View (with the exception of the Map View).

Standard Skies.

A library of 16 prepared cloudy and sunset sky textures are now available with **TNTmips 7.0** as JPEG2000-compressed raster objects in a reference file. All of these sky textures are automatically available for use in **TNTsim3D** and can be selected for viewing at any time with any of your Landscape Files. These sky images are all illustrated in the accompanying color plate entitled Sky Domes Provided With TNTsim3D. Seven of these skies are real images photographed with a hemispherical camera and were taken and placed in the public domain by Philippe Hurbain via www.philohome.com. The remaining 9 virtual skies were artificially created by Johannes Schlörb and purchased, downloaded, and modified for distribution from www.schloerb.com/Dreamscape2. You can purchase and add your own skies to your Landscape files from this source.

Custom Skies.

You can create and add your own skies to your Landscape Files using your digital camera. This might be considered if you want your sky dome to contain local distant features on the horizon and other special effects. This general approach starts with a series of overlapping standard photos or graphics covering the sky hemisphere, which can then be mosaicked and reprojected into a panoramic raster in the equirectangular projection as described above. A source of information for collecting these photos with your digital camera and low-cost software for assembling them into a panoramic view is www.panoguide.com.

You might also copy one or more of the standard skies from the reference file and edit it to have your local horizon features around the bottom edge. For example, you could use raster editing to add distant representations of your mountains and tree masses that match the colors and nature of the content of the surface textures in your simulation. As discussed below in more detail, you can then set a large radius for the sky dome so that the center is below the average terrain (try 90%) to pull the dome and these features down around the edge of your simulation. This can create a distant skyline inside your dome and mitigate the "looking over the edge-of-the-world" effect as you near the edge of your landscape in the simulation. Using the fog setting in the control panel can further improve the appearance of your simulation by obscuring this edge.

Embedding Skies.

The Landscape Builder permits you to embed any number of your own sky domes into any Landscape File. This procedure is illustrated and discussed on the accompanying color plate entitled Adding Sky Domes to Landscapes.

Positioning Skies.

Any time during the operation of **TNTsim3D**, you can select a new sky from among the standard sky rasters in the reference file or from your own panoramic rasters embedded in the current Landscape File. Sky selection and the controls for positioning the dome relative to your terrain are located on the new Options / Sky tabbed panel illustrated in the accompanying color plate entitled Sky Domes in TNTsim3D.

Fixed Sky Center.

The sky dome can optionally be centered relative to the approximate center of the terrain surface. Choosing this option means that its clouds and other background features will approach in your views as you move forward. This means that you can fly through and out of the sky dome depending upon how large you make it. Setting it small, even clipping out the corners of the landscape means that you will not be as likely to see gross edge drop-off effects between the end of the surface and the dome when the viewer is at high altitudes and/or near the its edge.

Moving Sky Center.

The sky dome can optionally be set to move along with the observer position of the Main View. In this case, its center will always be somewhere on a vertical line passing through the observer position. This vertical position is determined by the other options you set for the dome position. When the dome travels with the observer in this fashion the features on it, such as clouds, never get any closer in the views. This is realistic but can expose the bottom edge of the dome as the edge of the surface is approached and/or for higher view angles.

Setting Sky Diameter.

The sky dome's diameter can be set to be larger or smaller relative to the extent of the surface being rendered using the Scale value you enter. The default Scale value of 100% sets the dome diameter to the greater of the north/south or east/west dimension of the surface it encompasses. This means that the dome encompasses nearly all of the landscape extent, but the remote corners may be outside the dome and obscured by the sky image. Increasing this value above 100% can be used to enlarge the sky dome to good effect. Decreasing it below 100% can clip the edge of your surface so you can not look over when the dome center position option is set to lock it to the center of the landscape. This can be useful if you have very large terrain and texture inputs. Even setting this to clip off just some to the 90 degree corners for a rectangular surface can be effective.

Setting Sky Center.

The vertical position of the dome is set using the Height value you enter as a percent of the current dome diameter. The default of 0% places the center of the dome approximately on the terrain surface. A negative setting places the center of the dome proportionally below the surface. This pulls the dome down around the edges of the landscape and can prevent your view, especially at higher angles, from looking out under the edge of the dome. A positive Height setting greater than 0% will lift up the hemisphere and expose its lower edge.

Suggestions.

A good place to start positioning your dome is to set it to move with the observer and use a diameter larger than the terrain (try 200%). This will permit you to pull down the dome by setting its Height/center well below the surface, as you seldom look up. You can then turn on fog as a function of distance to obscure the distant edges of your landscape in your views and to make the skyline of your clouds hazy and obscured as it is in the real world.

The orientation of the dome relative to the surface can also be set using the Yaw, Pitch, and Roll settings. These settings rotate the sky dome contents relative to the plane of the landscape. For example, if the sky dome has a sun in it, you can rotate it so that the

horizontal angle to the sun in the sky is 180 degrees opposite to the shadows' direction in your texture and any shaded relief effects. You can also "recycle" the standard images of skies in the reference file by rotating them to various new starting positions relative to your landscapes.

Geospatial Scripting (SML).

V6.9 of the **TNT** products introduced the use of the **TNT** geospatial scripting language (**SML**) to customize your **TNTsim3D** simulation. **RV7.0** makes several simple, but significant additions for use in the scripts you add to your simulations. These include a procedure to permit you to automatically start a script when **TNTsim3D** is started. You can also now detect the use of any input control and use this event to trigger actions in the script, and interactively use the position selected on the surface with the mouse in your script without halting the simulation.

Overrideable SML Functions for Mouse and Input Device Actions.

V6.9 permitted your script to capture the 3D coordinates of the viewer's current position in the simulation, as well as the coordinates of the view center, the location on the terrain surface at the center of the Main View. A script could use these coordinates to start an atlas, a browser, or your own Visual Basic program, or to start up position-aware custom tools and views.

RV7.0 scripts can now be created that can detect a mouse button-press event and capture the corresponding surface geocoordinates of the cursor projected along the line-of-sight of the Main View to its intersection with the terrain. In other words, a script running concurrently with the simulation can change the standard action of the mouse while the simulation continues to run and accept input from other devices, such as a joystick. A simple example of the application of this feature would be to program a mouse button to record the position of the cursor and then redirect the viewer to move toward that point. Or feature coordinate positions and data might be reported and recorded for each mouse click while the joystick is used to move through the simulation in the normal fashion.

In addition, an **RV7.0** script can be set up to detect the activation of any control on your joystick or other input device and then take some programmed script action. The detection of these kinds of input device events in a script permits the script to be automatically stopped or interrupted during the simulation simply by using any control on the joystick. For example, a script flying a programmed flight path can be interrupted at any time simply by moving the joystick, so that you can seamlessly regain direct control of the simulation.

Startup Scripts.

Color plates distributed with the release of **V6.9** of the **TNT** products illustrated the use of geospatial scripts (**SML**) to record a simulation flight path and to orbit a fixed point. You can now add to your Landscape File an **RV7.0** geospatial script (**SML**) that will automatically start when the simulation starts and continue running as desired. This startup script can be used to set the initial position and orientation of the first view in the simulation. It can startup the simulation to orbit or fly a predetermined path until interrupted by your actions. It can be used to provide messages and collect input for the script before the simulation starts and to provide many other control actions for your simulation. Three simple examples of the use of a startup script are illustrated in the

accompanying color plate entitled <u>Startup Scripts in TNTsim3D</u>. Landscape files that contain these sample startup scripts can be downloaded for trial use from www.microimages.com/products/tntsimLandscapeFiles.htm.

<u>Start from a Default View.</u>

The most obvious use of a startup script in **TNTsim3D** is to position its Main View at startup in a predetermined position and orientation relative to the landscape. It is no longer necessary to start every simulation at the center of your landscape. A simple 13-line sample startup script to do this as well as add your own custom sky background is illustrated and dissected in the accompanying color plate entitled <u>Startup Scripts in TNTsim3D</u>. This script starts the Main View and all associated views at the predetermined position. It also selects one of the prepared sky backgrounds and turns it on. After this script has set up the default startup view, all your flight control devices are automatically active waiting for you to touch them to begin flying out from this startup position. Add this simple script section to the beginning of your more complex startup scripts to preposition their starting view.

<u>Starting in an Orbit.</u>

The color plate distributed with **V6.9** and entitled <u>Customizing TNTsim3D with SML</u> provided a sample script that orbited a specified point. That script, when selected from the Script menu in **TNTsim3D 6.9**, would detect the current viewer position and view point and begin orbiting the viewer about that view point with a fixed orbit radius. The orbit continued, and movement commands from the joystick or other input device were suspended, until the script was stopped using this same menu. This script has been modified to use the new **RV7.0** startup procedure to automatically begin an orbit motion when the Landscape File is opened. The script initiates the orbit using preset viewer position, center location, and radius, but provides the option of using the new mouse event detection to stop the orbit motion.

Pressing the right mouse button during the orbit exits the script, stops the orbit, and restores motion control to your input devices. The right mouse button press in this case serves the same function as using the Script menu to stop the script. This transition from scripted flight path to user control is seamlessly accomplished between frames. This script is also illustrated and dissected in the accompanying color plate entitled <u>Startup Scripts in TNTsim3D</u>. Note in the illustration of this script that it also sets an appropriate fog level. Since this sample script is set to orbit a feature central to the landscape, this fog acts like ground haze to obscure the distant edges of the landscape.

This script could be easily modified to stop on activation of any joystick control (in addition to or instead of a right mouse button press). This modification would allow a seamless transition from the preset orbit to normal flight controlled directly by you.

<u>Starting with a Path.</u>

The color plate distributed with **V6.9** and entitled <u>Create Flight Paths in TNTsim3D via SML</u> illustrates and dissects a sample script that records a flight path and orientation during simulation in a simple tabular form. The same script could then be used to playback the simulation for that path. The startup script feature added in **RV7.0** also permits **TNTsim3D** to be started to automatically fly this prerecorded path. It also selects one of the prepared sky backgrounds and turns it on. It then restarts and loops through this path until the script is stopped using the Script menu. This script is described and discussed in the accompanying color plate entitled <u>Startup Scripts in TNTsim3D</u>. If a path

is recorded so as to return to the starting view, then this use of a startup script will appear to be a continuous loop over the terrain. This script to follow a predetermined and possibly looping path can be easily modified so that activation of any input device will cause this automated looping simulation to halt and user controlled flying to begin in the direction and orientation of the current axis of the Main, or pilot, View of the simulation.

Custom View Window.

TNTsim3D 6.9 provided options to open several different auxiliary views in addition to the pilot, or main, view. Thus preprogrammed Left, Right, Down, Rear, Point-of-Interest, and Map Views can be selected and opened. You can also open a view(s) fixed on a specific ground Point(s)-of-Interest (POIs). **RV7.0** adds the capability to use the View menu to open a Custom View. The content of the Custom View, just as with the preprogrammed and POI views, is simulated and updated in real time relative to the movement of the observer in the Main View. When initially opened, the Custom View by default has the same content, XYZ observer position, field-of-view, and orientation as the Main View. The size of the Custom View window can be changed in the normal interactive fashion. The content, orientation, and observer position of the Custom View can be independently altered relative to the axis of the Main View using icons and a control panel.

Just as with the preprogrammed views, the terrain and texture in the Custom View can be different from those in the Main View and chosen using an icon from any provided in the Landscape File. The position change for a Custom View is set as an offset to slide its viewpoint ahead of, or behind, that of the Main View while keeping the view axis of the Custom View the same as that of the Main View. Using icons, a Custom View can also be zoomed in and then out. If it is set up to use a different texture for the zoomed area, this view might be used in 3D to read map features for the physical surface being manipulated in the Main View. The orientation of a Custom View can also be altered in its control panel using roll, pitch, and yaw settings to view in any direction relative to the current axis of the Main View. All these options are discussed in more detail in the sections below and illustrated in the accompanying color plate entitled TNTsim3D Custom View.

Selecting Textures.

The Custom View initially shows the default texture layer (the first texture created) for each available terrain in the Landscape File. However, just as in all other preprogrammed views, an icon is available in the Custom View to permit you to set it up to use any terrain, texture, and overlays available in your Landscape File. Using a Custom View provides considerable flexibility in providing different perspective and/or content reference views for the Main View depending upon the purpose of your simulation.

Observer Offset.

The Custom View control panel provides an Offset value you enter as a distance. This moves the observer position of the Custom View forward (+) or backward (-) that amount from the observer position of the Main View, and along its axis. This offset along the axis is then maintained in real time in the specified units for all "flying" changes in the Main View. By default the size and height and width angles of the Custom View match those of the Main View.

A default offset of "0" means that the observer position of the Custom View is the same as that of the Main View. An offset of +10368 meters means that the XYZ observer po-

sition of the Custom View has moved forward 10368 meters in front of the XYZ of the observer position in the Main View along its orientation axis. This moves the observer position of this view closer to the surface but does not automatically change the Custom View window's angular field-of-view. Thus, the area of the surface viewed is less. If you want to enlarge or reduce the area of the Custom View relative to that of the Main View, use the mouse to drag an edge or corner of the window. Correspondingly, if an offset of -26989 meters is entered, the observer position of the Custom View is moved back 26989 meters from the observer position of the Main View and along its axis. This means that the Custom View is looking at the surface through the position of the Main View, which is centered in the Custom View.

Setting a large negative offset means that a much larger area of the surface is being viewed relative to the Main View and all other preprogrammed views. Thus, if a large terrain is available and loaded, a different synoptic image might be selected for the texture of the surface viewed in the Custom View. For example, the Main View in the simulation could use a 1-meter color image to provide a detailed image, while the pulled-back Custom View is set up to use a 15-meter color image that constantly provides a synoptic or general area reference for the detailed scene in the Main View. Conversely, a Custom View with a positive offset could use a high-resolution scan of a large-scale map as its texture, which would provide readable labels allowing you to identify features at the center of the Main View as it is moved.

The offset value you enter moves the observer position of the Custom View the specified distance away from the position of the observer in the Main View. Thus, a sufficiently large offset can push all or part of the Custom View through or under the surface. It will be immediately obvious that part of the Custom View is absent since it is beyond the terrain. However, this can be used as a feature if the underside of the surface has a different texture and the Custom View has been reoriented to look backward. In future versions of **TNTsim3D**, additional controls will enable you to move the observer position of the Custom View off the axis of the Main View. This will provide the basis for using several Custom Views to provide a better grasp of the structure of terrain and manifold surfaces being manipulated in **TNTsim3D**.

Zooming.

An icon is available to zoom the contents of the Custom View without changing its relative observer position to that of the Main View. Each click on the zoom-in (+) icon narrows the initial field-of-view 5% relative to the initially matching field-of-view of the Main View. The size, position, and orientation of the Custom View window do not change, so each click on this icon appears to zoom the contents of this view. If the Custom View has been zoomed in, the zoom-out (-) icon is activated and can be used to reverse the zoom back to the original scale. As usual, the size of this view's window can be changed in the normal fashion to show more or less of the surface at any zoom level.

An example use of zooming in would be when a map is used as the texture in the Custom View. Several clicks on the zoom-in icon would quickly zoom in this view relative to the image in the Main View. This would permit map features, such as labels and contour values and spacing, to be read for the area near the center of the Main View.

Off Axis Orientation.

The view axis of a Custom View can be set to be in any direction relative to the axis of the Main View. The orientation of this off-axis viewing is specified by changing the roll,

pitch, and yaw to non-zero values in the control panel of the Custom View. Yaw is the horizontal angle measured counter-clockwise from the Main View's axis. Pitch is the vertical angle from the Main View's axis. Roll is the vertical angle from the horizontal in the plane perpendicular to the Main View's axis. Thus, if yaw is set to be 180 degrees while pitch and roll are set at 0 degrees, the axis of the Custom View is coincident with, but backward, along the axis of the Main View. These same orientation settings and an offset of 10000 meters means the Custom View is positioned 10000 meters in front of the Main View on its axis and is looking backward along this axis of the Main View. As noted earlier, this permits a Custom View to be positioned with an offset to be beyond or below a surface and to look at features extending from or below the surface. These settings also permit the Custom View to see the observer position of the Main View.

Miscellaneous.

New Starting Position.

The default viewer position and orientation when a simulation is started have been changed for **RV7.0**. In **V6.9** the viewer was placed above the northwest corner of the landscape and pointed toward the landscape's center. This positioning provided a synoptic view of much of the landscape, but entailed considerable motion to reach interesting features within it. **TNTsim3D 7.0** starts the viewer above the center of the landscape with a view toward the northwest. You can easily use the joystick to turn in any direction, then quickly move toward any features that you find interesting. Of course, a Landscape File can also be provided with a startup script to set a predefined viewer position and orientation to immediately focus the viewer's attention on particular features, as discussed above.

Grabbing Snapshots.

A snapshot of the contents of the Main View, including special effects such as the sky, fog, and so on, can now be captured at any time during a simulation. By default the F1 key grabs the contents of the view. You then use the dialog this presents to specify the file name and location where you wish to record this image as a *.bmp file. F1 is commonly used for this purpose in games, but if you wish to assign this action to some other key or input control, this can be done using the Configure DirectInput button on the **TNTsim3D** Options dialog. These operations are illustrated in an accompanying color plate entitled Snapshots from TNTsim3D.

Tinting Views Below Terrain.

This feature allows you to optionally select a color to tint the view if the observer position of that view is below the terrain. This feature will alert you when a view has penetrated the terrain, which can be disorienting if unexpected and undesired if you have not set a minimum terrain clearance limit. This option for tinting and its color and opacity can be set on the Effects tab panel of the **TNTsim3D** Options dialog. Its effect is illustrated on the accompanying color plate entitled Subterrain Color in TNTsim3D.

DV7.1 – *Some Ideas for Additions.*

Manifold Surfaces.

The relative positions of multiple manifold surfaces can be difficult to visualize in a static 3D view. Adding the ability to **TNTsim3D** to use manifolds would allow them and the associated topographic surfaces to be explored in real time. This would significantly as-

sist you in gaining a better understanding of the 3D relationships in these multiple 3D surfaces. Adding this feature will require that the Landscape Builder be modified to transfer these surfaces into the Landscape File. **TNTsim3D** will then be modified to project them into the various views. The impact of this on your simulation's frame rate is unknown at this time. However, a significantly slower frame rate (for example, 10 to 15 frames per second) could be tolerated if necessary in simulations using multiple manifolds and a topographic surface considering the benefit.

Positioning Custom Views.

Understanding spatial relationships in manifold structures would also be enhanced using Custom Views with additional modifications. In **RV7.0** their observer position is always on the axis of the Main View. For manifold simulations it would be important to create Custom Views whose axes are related to, but not coincident with the axis of the Main View. This may be accomplished by providing additional Custom View controls to position them relative to the Main View, but using these controls could be confusing. Meeting these objectives could be more flexible using **TNT** geospatial scripts if the capabilities were added to open new views with computationally defined orientations relative to the Main View.

A typical example would be to open two Custom Views looking at the some "center" position within the simulated structure. The axis of one new view is offset 120 degrees clockwise from the Main View and the other is 120 degrees counterclockwise. The axis of all these views and their point of intersection are maintained so that as the Main View is moved, all 3 continue to view the structure from the same relative observer positions. For example, if the observer position of the Main View is moved in and up, then the observer positions of the two Custom Views move the same amount in and up and the intersection point of the axes is maintained. If this procedure is implemented in a **TNT** script, then a startup script could set the initial Main View contents and then orbit the 3 views in tandem until user input moved the Main View. Many different kinds of relationships between the Main View and the Custom Views may be needed and creating these scenarios is an appropriate task for **TNT** scripts.

Curved Land Surface.

Creating a curved land surface is needed as the earth surface area that can be covered by a Landscape File is increasing. Suitable free geodata is becoming available for large area simulations such as the free 15-meter color Landsat coverage of the continents. JPEG2000 compression has created the opportunity to make use of these large textures in your simulations. All the 90-meter SRTM elevation data is now available. The sky dome can be easily set to rotate with forward movement around the curved surface to prevent looking under its edge. Provision has also been included in **TNTsim3D** to use complete spheres for the sky dome. However, at this time it is unclear what the content of these spheres will be and where it will come from. Is the sun always up or does it get dark and stars appear when the terminator is crossed, if so what does the surface look like?

TNTatlas 7.0 for X

Atlas Discussion Group.

An active creator of **TNTatlases** has volunteered to maintain and moderate a discussion group by which you can communicate with others with regard to your activities, news, ideas, tips, and uses of the FREE **TNTatlas** product. This discussion is not a MicroImages activity, however, your active participation in it is encouraged. If you wish to join this discussion group, you can sign up at http://groups-beta.google.com/group/atlastalk, send your email address to atlastalk@mchsi.com or use the link at www.microimages.com/product/tntatlas/atlastalk.htm.

Introduction.

There are many applications and also geographic areas of the world, including in the United States, where the general public's Internet access is not fast enough or even available at all to support the interactive use of large collections of geodata materials. **TNTatlas/X** provides you a FREE means to make a controlled public distribution of a large assembly of image, map, and tabular materials for use with all popular operating systems. Automatically accompanying every **TNTatlas** is a wide variety of tools to access, explore, and analyze these materials. These include searching via scripts; interaction via simple or complex DataTips; measurement, sketching, and other GeoToolbox tools; GPS support; feature selection and location by several methods including queries; and a variety of additional interactive tools.

TNTatlas is also a FREE viewer for large geodata files. Simply download the shapefile, JP2, MrSID, JPEG, PNG, … file and browse to it for viewing and using any tool provided by **TNTatlas**. For example, **TNTatlas** is the best FREE viewer with tools for JPEG2000 compressed JP2 files. Most other free JP2 viewers cannot even open large files and are incredibly slow if they do. The direct viewing of these geodata file types is fast since the **TNT** link to each of these file types creates for it an accompanying link file providing many of the **TNT** view-oriented optimization features.

TNTmips 7.0 provides you important new features that are automatically available now for use in your **TNTatlas** publications. The Lincoln Property Viewer sample DVD demonstrates how to construct a detailed, special purpose **TNTatlas** that is easy for the public to use for the designed objective. The Afghanistan atlas uses sample materials obtained freely from the web to illustrate how to assemble several different scale-controlled map and image themes. These sample themes are then used as the geodata to demonstrate how GraphTips can be used to interactively present tabular results as interactive "pinmaps."

These sample atlases deal with specific real estate and map/image distribution applications. However, their design can be a guide to creating your public atlases for other applications in your area of interest. The "public" here can be defined as anyone who is not particularly adept at using geospatial materials but has a reason to use them. This is the person (husband or wife, geologist, … even judge) or group of persons (executive board, investors, regulatory board, … even jury) who make final decisions for purchase, projects, and disposition and need the spatial knowledge conveyed in your atlas to do so wisely.

Lincoln Sample Atlas.

Objective of Sample.

You wish to determine the appropriateness of the price and longer term investment potential of a home located in a newspaper advertisement before getting emotionally involved with it via a visit. You should consider a number of spatial questions in this assessment. Is this house's price similar to those in the neighborhood? What is the general appearance of the neighborhood? How does this house compare with those nearby in price, square footage, condition, general materials, lot size, and placement? Are neighborhood houses owner occupied or rented? Is it in the floodplain or does it have other special zoning?

These are important questions whose answers will determine how the house is priced relative to its neighbors. The answers will indicate if it will increase in value (which means, in a good neighborhood with higher priced homes) or decrease in value (which means, larger home and price in an neighborhood of smaller, older homes). Think about how you would go about evaluating these spatially interrelated questions in some other "X"View software. A large, detailed color image of the entire city would need to be instantly viewable at any resolution. You need at least a dozen vector and other layers containing the spatial details. Topology is particularly important to insure that areas such as land parcels are not duplicated. You need to know how to turn image overlay layers on and off, use queries or at least select them from a list, locate and zoom to the property of interest and to adjacent properties, and so on. Finally, and of great importance, is the need to quickly view and evaluate all the available information for the individual neighboring houses. And, of course, none of this would be of value to you unless it was presented entirely in your language!

Providing easy access to this neighborhood material for any location in the city would not be an easy goal to achieve with some "X"View, free or not! Attempting to relate a number of different spatial layers overlaying an image in an "X"View for a specific house will totally confuse the general public user of the material. The valuable, high resolution information that this user can extract from a detailed image on their own of the house and neighborhood is obscured by this approach. Yes, "X"View can present the detailed image of the neighborhood and have all these layers available to be toggled on and off according the specific interest of the user. It can provide layers that are combined and processed to contain the specific spatial results required about the neighborhood. "X"View can even provide canned queries to retrieve specific details for a house. However, the "X"View approach expects the "public" users to learn how to understand the spatial presentation of graphical layers and use some unfamiliar tools to formulate the questions of interest.

Overview.

RV7.0 of the **TNT** products is accompanied by a FREE DVD that contains a home/parcel ownership **TNTatlas** for Lincoln, Nebraska. The data contents of this atlas are not particularly interesting or reusable by you as they are local and transitory. However, this sample atlas has been designed and reproduced to illustrate to you a variety of new features that have been introduced to **TNTmips 7.0** to add new important capabilities for use in your FREE **TNTatlas** product.

The Lincoln DVD atlas demonstrates some of these and is focused upon showing you and your clients how to distribute a 50 GB image with vector overlays such as how to:
- use scripted forms to go directly to the area of interest or just navigate there,
- use new enhanced DataTips to present complex information for any position in the atlas without cluttering up the image,
- craft an atlas for a public user and objective without using the color fills, labels, pinmaps, layer controls, and many other confusing features.

The accompanying color plate entitled Property Viewer Atlas for Lincoln, NE provides an overview of this **TNTatlas**.

Startup Tool Script.

Using knowledge of the area (for example, a real estate broker or land developer) you can use the zoom tools, map features presented by scale, and speed of the **TNTatlas** to go right to a local area of interest and perhaps a specific house (especially if it's yours). However, this atlas demonstrates how to include a Tool Script in your atlas to find and automatically zoom to a specific parcel among the 100,000 covered in this atlas. Since locating a specific parcel is the purpose of this atlas, this Tool Script is automatically started when the atlas starts. It can also be closed and restarted later using the "binoculars" icon it adds to the icon tool bar. The Tool Script generates a form for you to set up your owner name or address search criteria. This is illustrated on the accompanying 2-sided color plate entitled Property Finder Tool Script and an excerpt from the script is described on its reverse side.

This simple search form is designed using the XML approach provided in the **TNT** geospatial scripting language. The same form could be built using Visual Basic. It provides tabbed panels to set up the search as either address oriented or owner name oriented. When the user has completed this very simple form and pressed the Search button, a fast indexed search will find the parcel, outline it, and zoom in centered on it. If your entries in the form are not specific enough to define a single parcel, a list of candidate properties is presented from which you can then choose the one of interest. This Tool Script reproduced on the reverse of this color plate creates a flexible search form since the **TNT** scripting language is inherently geospatial and versatile by design. The form it presents uses tabbed panels, drop down choices, constraints and user feedback, sample entries, action controls, retrieval of results and selection, and other features.

Address Search Tabbed Panel.

The Address Search tabbed panel provides for the entry of the street number, the selection of its prefix from those available (for example, S, N, …), the street name, and its type (for example, BLVD, RD, …). This is illustrated in the accompanying color plate entitled Property Finder Tool Script. Constraints will confine your choice of road prefix and type to those available in this Lincoln parcel owner dataset. Some or all of this information is all you need to search for a Lincoln property by its address. If your entry is unique, it will zoom your view to that property. If not, a list of properties to choose from is presented for your selection.

Result List Panel.

If your address or owner name search finds a unique match and the zoom to the parcel occurs, the Result List tabbed panel will show the complete address for your reference. If your search retrieved several addresses, they are presented in this panel in a scrolling

list. You can then select the parcel of interest to complete the search and zoom to the parcel.

From this panel you can choose the View Assessor's Website Data button for the unique parcel you zoomed to. You can also select this button for a parcel on the list that you have highlighted but not yet zoomed to. In either case, this automatically opens your browser and takes you to the Lancaster County Assessor's website for the parcel zoomed to and outlined in the view or selected from the list. This will provide this website's detailed ownership record of the selected parcel, which includes a frontal photograph, sale history, a list of liens, access to the deed of ownership, and so on. The URL that the atlas automatically computes and sends to your browser for this purpose will match and retrieve for the same unique parcel since the parcel layer used in this atlas is derived from the same shapefile parcel layer and tables used on this Assessor's website.

Owner Name Search Panel.

Select this panel to search for a parcel by using its owner's name. Enter only a last name and optionally a first and middle name or initial. An unusual last name may produce a unique hit whereas using "Smith" alone may produce a long list. Many properties also have joint ownership names. In this case, as shown on the plate, an owner search will find and retrieve an ownership list even when the owners' names are listed in different orders. Properly indexing the 100,000 records in the parcels layer ownership tables makes this and all retrievals in a few seconds even when used directly from the DVD. Just as above, the unique parcel or multiple owners' name and address list will appear in the same Result List panel.

Settings Panel.

This panel permits you to control the action that will take place if you click the left mouse button outside the form on the image in the view instead of clicking the Search button on the form to complete your search. You can also set the zoom action for search results.

Zoom In to Location.

This toggle is the default and will zoom 2X to the specific parcel at the position where you click—which means, you recognize the parcel from the image/map or from its Data-Tip, so go there. The search mode is still active and the form is still open for your use.

Zoom Out from Location.

This toggle will zoom out the image view by 2X while keeping the search mode active and the form open for use. This permits you to restore more of the image and try again.

View Assessor's Website Data.

This opens your browser for the cursor selected home/parcel and takes you to the Lancaster County Assessor's website and automatically shows you their information for that parcel, such as a frontal photograph, a sale history, a list of liens, access to the deed of ownership, and so on.

Search Zoom Options.

A number of zoom options for search results are also provided on this tabbed panel: Zoom to Property, Zoom to Block, Zoom to Neighborhood, and Keep Current Scale. Zoom to Property is the default setting.

Enhanced DataTip.

The public user of this atlas needs to see the details on the area in a local image, has little patience for complicated tools, wants instant feedback and to easily explore the available tabular information for any house/parcel in the neighborhood. These requirements are best satisfied by instantly popping into the view the desired known data about any property they visit using the form and/or visit by simply moving the cursor in the neighborhood. This data must be combined from its original tabular form into the statistics of interest using virtual fields. It also should be restructured for easy reading using fonts, tabs, text styling, and employing text and background color to highlight critical information. All of this is illustrated in the enhanced DataTip for this sample atlas and on the accompanying color plate entitled Add Styling to DataTips. The details on all the new features used to structure these DataTips for use in your atlas are discussed in the **TNTmips** sections below entitled Styling DataTips.

How well does this enhanced DataTip meet the needs of public use for which this atlas was designed? It presents all the spatial information in an attractive form derived from several vector layers and attributes ranging from 100,000 parcel polygons to flood zones. None of these layers are showing by default so as not to obscure the image layer. However, they are showing in the LegendView and can be toggled on if their proximity is of specific interest (for example, the locations of public bicycle and pedestrian paths). The enhanced DataTip automatically pops in quickly for any of the 100,000 properties in the city when the cursor hovers over them—you do not even have to click or know how to use a mouse, just move it. It presents the information in a content format easily understood by anyone. Text and background colors are used to highlight a particularly critical issue, which in this atlas is the flood zone status of the parcel.

Image Compression.

This atlas has been designed around the additional idea that its public user will have an interest in, be attracted to, and use a detailed color image as part of this activity. The more detailed the image, the larger it becomes. The image used in this atlas covers the city of Lincoln in 24-bit color at a resolution of approximately 1 foot and was obtained from a public source. The uncompressed version of this image was 49.7 GB. It has been compressed 12 to 1 to fit on the DVD as a lossy JPEG2000 raster object of 3.97 GB. The original and the compressed 12 to 1 image are compared at a highly zoomed level in the accompanying color plate entitled JPEG2000 Compression in Atlases. It is difficult to detect any differences between them.

The display in this atlas of this JPEG2000 raster object and vector overlays at any scale is fast from the DVD and takes only 1 to 2 seconds if the Project File is moved to a hard drive. Using it from the DVD in compressed form is actually faster than if it was uncompressed since less than 1/12 the data is read from the pyramid layer for any view.

A **TNTatlas** can be optionally locked so that no other **TNT** product can access its Project Files. Using this feature and internal JPEG2000 compression of the image, it is possible to encapsulate all the geodata used in this atlas so that none can be extracted in its entirety and then reused in some other manner or product. Using this approach, the user can have complete freedom of use of these materials but could only save or print snapshots at the current view's screen resolution.

Startup Control.

This sample atlas has been designed for a specific objective and public user. However, it still provides all the advanced features and tools of any other **TNTatlas**. These include the visualization and measurement tools, sketching, GPS support, general queries, tabular views, and so on. The focus of this sample and your atlases is set in part by temporarily or permanently hiding these initially confusing capabilities. The user of the atlas can subsequently explore and discover these advanced tools or can be advised how to access and use them by your accompanying instructions. For example, a neighborhood planning group might want to use the measurement tools with this Lincoln atlas to review the impact of a public project on their neighborhood. Or, a high school geography class might like to learn about how a GPS operates and relates to image or map position.

Default Design.

Previous versions of your **TNTatlas** could be simplified by using customization to hide those features not needed and potentially confusing to its user focus. **TNTmips** has extensive controls built in via its tntproc.ini file to determine how a view should appear when you first start or even if you patch or update. The size and position of windows, LegendView width, startup tool, measurement units are just a few examples. These permit your many changes to the defaults to be preserved and reused via this file. Now your **TNTatlas 7.0** can automatically use these same settings via the **TNTatlas** startup file (*.atl). More on this topic is illustrated in the accompanying color plate entitled Greater Control Over TNTatlas/X Startup.

Custom Startup.

A **TNTatlas** can provide special custom tools you develop in the **TNT** geospatial scripting language (**SML**), such as discussed above and in the accompanying color plate entitled Property Finder Tool Script. These interactive tools can be very specific and important to the focus of the user of the **TNTatlas**. Anywhere in your atlas you could pop in HelpTips to instruct the user to choose a specific tool. Remember, a HelpTip is simply a DataTip that pops in after a couple of seconds for any cursor position to provide instructions such as "Choose the Property Finder icon above to locate any property by address or owner name." Since HelpTips are actually delayed-appearance DataTips, the instructions they provide can even be changed by the position of the cursor.

In **TNTatlas 7.0** it is no longer necessary to expect that its user will subsequently discover your key tool by locating its icon or menu entry from your instructions or by chance. You can now designate that your **SML** script be activated when the atlas starts with a layout that contains the custom tool saved for use with that particular layout. Using this new feature, the sample Lincoln DVD atlas starts up in a fashion that focuses its user directly upon what they are interested in—locating a house/parcel. It does not distract or confuse them with the other visible or hidden tools, which they might be more inclined to try later if they get interested in what this atlas can do and if they have initial, uncomplicated success in its use.

Lincoln Sample Atlas.

Details on the use of this sample **TNTatlas** can be found in the ReadMe files (ReadMe.doc and ReadMe.txt) on the DVD. The sources of this public data and general

information about the objects in **TNTmips**' internal format are provided below. All object sizes listed include subobjects.

The property parcels vector object included on the DVD was provided by the Lancaster County Assessor's Office as a 94.2 MB shapefile (size includes auxiliary files, such as the database and projection). This vector object represents the official quarterly property parcels dated 29 March 2004. The imported vector object after additional modifications is 138 MB with polygonal topology and includes 100,099 polygons, 266,214 lines, and 175,737 nodes. The original database structure has been modified to include virtual fields, standard statistics tables, and tables tailored to speed owner and address searches by the Property Viewer tool. This vector object uses map scale control so you don't waste time displaying a solid mass of parcel outlines. This vector can be drawn when you zoom in beyond a map scale of 1:40,000.

Many of the other layers were obtained from the City of Lincoln and Lancaster County Geographic Information System Map Shop (www.ims.ci.lincoln.ne.us/gisweb). All of these files were downloaded in shapefile format (*.shp).

Street centerlines is a 12.0 MB vector object with 5,400 polygons, 18,002 lines, and 12,629 nodes. The complete shapefile was 14.1 MB. Elements from this vector object were extracted to supply two separate vector objects, MajorStreets and MinorStreets, to provide faster initial display of this **TNTatlas**. The MajorStreets vector is 3.28 MB with 4,855 lines and 4,299 nodes with planar topology. The MinorStreets vector is 8.37 MB with 13,134 lines and 11,259 nodes with planar topology. The MajorStreets vector is visible when viewing the full extents of the atlas. The MinorStreets vector comes on when you zoom in beyond a map scale of 1:15,000. Both turn off when you zoom in beyond a map scale of 1:4,000 because the streets are easily seen in the orthophoto layer. Only the MajorStreets and MinorStreets vector derived from the street centerlines are used in the atlas, but all three vector objects are included on the DVD.

Floodplains is a 2.3 MB vector object with 525 polygons, 1,368 lines, and 935 nodes. This layer is hidden by design and can be turned on by you at any map scale.

Lincoln schools are represented by a 74.5 KB vector with 68 polygons, 70 lines, and 68 nodes. This layer is hidden by design and can be turned on by you at any map scale. The complete shapefile from which it was imported was 48 KB.

County schools are represented by a 33.2 KB vector with 21 polygons, 29 lines, and 22 nodes. This layer is hidden by design and can be turned on by you at any map scale. The complete shapefile from which it was imported was 15 KB.

Historic Districts are represented by a 35.9 KB vector with 20 polygons, 38 lines, and 27 nodes. This layer is hidden by design and can be turned on by you at any map scale. The complete shapefile from which it was imported was 12.1 KB.

Bicycle/pedestrian trails imported with additional database modifications became a 528 KB vector with 96 polygons, 671 lines, and 585 nodes. This layer is hidden by design and can be turned on by you at any map scale. The complete shapefile from which it was imported was 511 KB.

Onstreet bike trails imported with additional database modifications became a 292 KB vector with 9 polygons, 167 lines, and 176 nodes. This layer is hidden by de-

> sign and can be turned on by you at any map scale. The complete shapefile from which it was imported was 266 KB.

> Planned county trails imported with additional database modifications comprise a 62.4 KB vector with 7 polygons, 67 lines, and 67 nodes. This layer is hidden by design and can be turned on by you at any map scale. The complete shapefile from which it was imported was 37.3 KB.

> School districts are represented by a 96.1 KB vector with 90 polygons, 182 lines, and 125 nodes. This layer is hidden by design and can be turned on by you at any map scale. The complete shapefile from which it was imported was 81.9 KB.

The cities layer used in this atlas was derived from TIGER data (*.rt1) originally produced by the U.S. Census Bureau and downloaded from GeoCommunity (www.geocomm.com).

> The city boundaries used in this atlas were made by dissolving polygons in Lancaster TIGER 2002 data. The complete TIGER 2002 data in its original TIGER format is 16.8 MB and after import is 14.3 MB. This city vector object is 54.5 KB with 13 polygons, 13 lines, and 13 nodes.

The townships layer used in this atlas was derived from data downloaded from Nebraska DNR (www.dnr.state.ne.us/databank/statewide.html) in shapefile format.

> The township vector object is 57.6 KB with 24 polygons, 57 lines, and 34 nodes. The township names were added by consulting other maps.

LincolnOrthophoto. This layer is a 12:1 JPEG2000 lossy compression raster, 3.97 GB, mosaicked from data available from seamless.usgs.gov that was obtained from City Ortho Imagery (www.mapmart.com/module/cityonefoot.htm). The data was obtained in numerous MrSID 10:1 compressed tiles totaling 4.66 GB on two DVDs. These were batch imported into uncompressed raster objects and mosaicked into a single 46.6 GB raster in **TNTmips**, which was then JPEG2000 compressed to a 3.97 GB raster. If this mosaic had been done in **RV7.0** rather than an early **DV7.0**, the separate compression step would have been eliminated—you can now compress directly to JPEG2000 in the Mosaic process. It is also not necessary to import the original tiles unless you want them separately in **TNT**'s internal format for some reason. The mosaicked raster object has 145,000 lines and 115,000 columns.

The elevation layer used in this atlas is derived from data downloaded from Nebraska DNR (www.dnr.state.ne.us/databank/dem.html) in DEM format (*.dem). Nine 10-meter resolution rasters with elevation in feet were mosaicked into a single raster object with 4,247 lines and 3,273 columns that is 29.0 MB.

Afghanistan Sample Atlas.

The sample data for this atlas has been deliberately designed to fit on a CD. For example, only the Kabul area is covered by the very detailed map sample and maps are available for downloading at most scales for much larger areas. Using a CD will permit almost anyone with a computer to try this atlas, which is of importance in this example because it may potentially be used in areas where even electricity is hard to come by. However, please note that by using compression methods, such as JPEG2000 and others, a large collection of sample data has been included. More information on the pur-

pose and features of this sample **TNTatlas** CD can be reviewed on the accompanying color plate entitled <u>Afghanistan Atlases on CD</u>.

Choose from the 4 different atlases on this CD to experiment with the use of different types of maps and images and scale-range control. Each of the four atlases has its own GraphTip/Display Control Script application. These new interactive features are illustrated on the accompanying color plate entitled <u>GraphTips in the Afghanstan Atlas</u>. These new capabilities are discussed and illustrated in detail later in this MEMO in the sections on <u>GraphTips</u> and <u>Display Control Scripts</u>. However, since you might not have the data used in these subsequent illustrations, they were easily adapted to be tried as part of this sample **TNTatlas**.

DEMOGRAPHICS & HAZARDS.

The DEMOGRAPHICS & HAZARDS atlas includes theme maps in Project File format of population and urbanization at the province and district level as well as a number of externally linked files that provide additional information on population and urbanization, climate, food and health care availability, and presence of landmines. The population and urbanization geodata use province and district boundaries, both of which were imported from shapefiles that were 357 and 718 KB, respectively. In Project File format, the province boundaries are 309 KB and the district boundaries are 664 KB. As you zoom in, scale control is used so that provinces are replaced by districts that are also theme mapped to reflect population or urbanization. The DEMOGRAPHIC & HAZARDS atlas demonstrates a GraphTip that pops in to display the name of the province, the urbanization of the province presented as a pie chart and a percentage, as well as the total population for the province.

PLANIMETRIC MAPS.

The PLANIMETRIC MAPS atlas shows province boundaries at full view highlighting the province that contains Kabul. These are the same province boundaries described for the DEMOGRAPHICS & HAZARDS atlas using different display parameters. You can zoom in and scale control will replace province boundaries with district boundaries, or click when the HyperIndex Navigator is the active tool to open a large (approximately 33" by 23" if printed full size) planimetric map in PDF format for each province or a smaller map (half size in each dimension) for each district where you click. There are about 53 MB of maps in PDF format linked to the provinces and districts. These maps present settlements, boundaries, rivers, and roads. The scale of these maps varies with the size of the province or district. The GraphTip for the PLANIMETRIC MAPS atlas enlarges the label(s) beneath the cursor to make it readable at any scale without all labels being so large that the map is obscured. This GraphTip also deconflicts labels that are overlapping, enlarging and positioning them out from their initial map locations with leader lines to their original map position.

COUNTRY IMAGE MAPS.

The COUNTRY IMAGE MAPS atlas initially presents a color-coded, 16-bit elevation raster for Afghanistan. When you zoom in, this atlas replaces the elevation raster with a Landsat image sampled to approximately 60-meter resolution with 10:1 lossy JPEG2000 compression and a variety of map scale controlled vector layers. The GraphTip for the COUNTRY IMAGE MAPS atlas shows the nearest road line segment in profile. The COUNTRY IMAGE MAPS atlas includes a country-wide Landsat mosaic initially obtained as 6 files in MrSID format compressed 35:1 for a total of 493 MB. This file was imported

and JPEG2000 compressed to 160 MB (including pyramids) although a direct comparison cannot be made because the extents of the original and that incorporated in the atlas are different. The elevation raster was acquired in SRTM format (*.hgt, 456 MB) then imported and JPEG2000 compressed to 133 MB including pyramids. This atlas also includes a variety of vector overlays imported from shapefiles for roads, airports, province and district centers, and hydrology, all of which were imported from shapefile format.

KABUL MAPS.

The KABUL MAPS atlas provides maps of the city of Kabul and surrounding areas at five different map scales. The initial view of this link positions these maps over the same 16-bit, color-coded, elevation raster of Afghanistan seen with the COUNTRY IMAGE MAPS atlas with the addition of these maps in their geographic positions with instructions to zoom in. How well features match across maps of different scales is demonstrated by zooming in to the indicated area. The Zoom In tool is the active tool for this layout, so you just have to click where you want to zoom. The area of comparison shows the seams between 1:10,000, 1:50,000 and 1:100,000 maps. Maps at 1:200,000 and 1:500,000 are also included at this level of the atlas. The GraphTip for this atlas provides the slope and aspect of the topographic surface at the cursor location both graphically and in text form. The collection of Russian topo maps in MrSID format (30:1 compression) as they were obtained was 18.1 MB. They are now in internal Project File format with lossy, best quality JPEG2000 compression and occupy 114 MB including pyramids.

Miscellaneous.

The GeoToolbox permits viewing of cross sections in the other **TNT** products. This feature is now also available in **TNTatlas** and its use can be reviewed from within your **TNT** product by consulting the Quick Guides entitled Cross Sections with Style and GeoToolbox from within your **TNT** product.

The default width of the LegendView when a **TNTatlas** is autorun can be set as well as the DataTip viewing mode via the *.atl file.

The specific tool that will be active and immediately usable (in other words, its icon depressed) when a **TNTatlas** is opened can be set in the *.atl file.

The "navigation" icon buttons can now be removed using the **TNTatlas** Customize window.

TNTserver/clients 7.0

Only minor modifications and adjustments were made in these products since **RV6.9** was released. **TNTserver** is now built weekly on the same schedule as the other **TNT** products and weekly patches are posted. A **TNTclient** can specify the type of image to receive using a menu (in other words, send results as JPEG, JP2, PNG, or SVG). A client option is available to display/not display a list of hyperlinks if only one hyperlink is available in the atlas at the point selected in the **TNTclient**. A transparent panning button can be optionally added/not added by the **TNTclient** at the edges of its view. **TNTserver** uses UTF8 encoded strings for queries when used with an up-to-date servlet engine (such as Tomcat 3.3.2).

DV7.1 – Supporting OpenGIS's Web Map Service (WMS).

This following WMS section was in the MicroImages MEMO entitled Release of RV6.9 of the TNT Products as a planned feature for **TNTserver 7.0**. Other priorities in other products prevented this work from being undertaken. It is now underway so these sections are being repeated here from that previous MEMO.

Introduction.

MicroImages is currently extending the **TNTserver** to implement the protocol specified for the Open Geospatial Consortium's (OGC) Web Map Service (WMS) V1.1.1 (see www.opengis.org/specs/?page=specs). When this is available, **TNTserver** will still access a **TNTatlas** layout and return either a JPEG, JP2, PNG file(s) or a SVG layout, but will then respond to requests issued using either the WMS or the current **TNT** protocol.

What Does It Add?

A browser-based client or any client can issue requests to any available server implementing this WMS protocol and expect it to respond correctly if it has implemented that particular feature of the protocol. As a result, this new version of **TNTserver** will also respond to any of these clients written by others that issue WMS requests. Conversely, a client you write or sample **TNTclients** written by MicroImages can issue requests to any WMS site as well as **TNTserver** and combine the results as appropriate. Furthermore, supporting requests using only the WMS protocol will not require the use of the Tomcat servlet engine with **TNTserver**.

Clarifications.

Supporting WMS protocol indicates that a server will respond to requests that come to it using its documented protocol. The designation that a server (for example, **TNTserver**) implements WMS 1.1.1 protocol does not mean that it will respond to every possible WMS request to it. It also does not prevent that server from responding to requests in any other additional protocol it may support as an alternative to or extension of the WMS. Whether or not a server responds correctly or at all to a specific request can vary widely. Almost all server products listed as supporting WMS are in one category on the OGC site (see www.opengis.org/resources/?page=products) designated as *"Implementing Products, that is, software products that implement OpenGIS Specifications but have not yet passed a compliance test."* Thus, a close inspection of this OGC listing of server products reveals that at present, only 3 commercial server products are certified by OGC as WMS 1.1.1 *"Compliant Products, that is, software products that comply to OGC's OpenGIS® Specifications."* These must be further qualified by OGC adding that *"Compliance tests are not available for all specifications."*

It is also important to understand that a server's implementation of WMS 1.1.1 may be restricted to responding to requests in that protocol. Thus, the designations that a product implements WMS does not mean that the server can issue requests in WMS or any other protocol to other WMS sites either locally or over a network such as the Internet. To issue such requests, the server must support the additional capability of acting as a client to other WMS sites.

Cascading Service.

The use of the terms "client" and "server" in this context can be confusing because they are popularly used to indicate the software implementation for the end users, such as

the party using the browser or other human interfacing product. However, in a generic computer sense, being a server indicates a source of information that will respond to an inquiry. Thus, if the server product supporting WMS has an embedded client capable of issuing requests in WMS protocol it is called a Cascading Web Map Service (CWMS). The WMS 1.1.1 specification states:

"A 'Cascading Map Server' is a WMS that behaves like a client of other WMSes and behaves like a WMS to other clients. For example, a Cascading Map Server can aggregate the contents of several distinct map servers into one service. Furthermore, a Cascading Map Server can perform additional functions such as output format conversion or coordinate transformation on behalf of other servers."

TNTview® 7.0

Price Reduced and Functionality Expanded.

Drastic reduction in **TNTview** price of 50% for NAFTA and 58% for all other nations for use on a Mac, Windows, Linux, and Unix platforms.

Summary of Features.

Regardless of what product you or your institution may now be using for your professional GIS and image analysis, you and your associates and clients can also add and use the most advanced geospatial visualization product available. You can use it with a wide variety of popular geodata files to view 3D, stereo, manifolds, atlases, pinmaps, routings, and other complex visualizations *without purchasing additional expensive extensions.* It also comes with a suite of interactive geospatial tools and a geospatial scripting language to add your own tools and analyses. The only optional feature is for printing larger than A3, A4, or 11" by 17".

Assemble and use geographical overlays in 2D or 3D with composite legends, DataTips, GraphTips, measurement tools, and so on for underline direct display without import of large files of ESRI shapefile, LizardTech MrSID, ER Mapper ECW, Oracle Spatial, and ODBC linked tables together with JP2 (JPEG2000 compressed file), GeoTIFF, JPEG, and PNG, with any raster, vector, shape, CAD, or database objects in MicroImages internal Project File format. Hundreds of other raster, vector, and CAD formats can be added to a view after they are imported.

Add MicroStation DGN and Autodesk DWG to this list via **DV7.1** and then **RV7.1** along with the new ability to double click on any of these formats to automatically open a 2D view in **TNTview** of any of these geodata layers.

Directly view these composite layers in any ISO/EPSG Coordinate Reference System they use for their internal georeference or via a companion external file such as a world file (for example, *.tfw, *.jgw).

Use all the **TNT** selection tools, such as direct element, query, regions, and others to interactively select elements from any layer, internal object, or externally linked file. Display attributes in single record or tabular form.

Use any of the standard analysis tools such as sketch and save as CAD object, measure, View-in-View, regions, and others.

Create, add, use, and distribute your own geospatial analysis scripts for use with these geodata including Tool, Macro, Display Control, Startup, Process, Import, and other scripts, link to and communicate with external Basic, C, or Java programs, or use the **TNTsdk** to extend this product.

New Prices.

Fixed License: **TNTview 7.0** is now US$500 per copy worldwide (formerly US$1000 NAFTA nations of USA, Canada, and Mexico and formerly US$1200 for all others).

Floating License: **TNTview 7.0** is now US$600 worldwide per each seat, which is each simultaneous user.

Adding the large format printing option to a **TNTview** to print layouts and images greater than A3, A4, or 11" by 17" is unchanged at US$1500 for each user.

Items in Package.

TNTview will be delivered on a CD for the operating system specified.

The package includes a USB Software Authorization Key and a serial key can be specifically requested for use with Unix workstations only.

The tutorial booklets entitled Displaying Geospatial Data and Navigating will be included printed in color.

The other tutorials and Quick Guides applicable to **TNTview** will be installed from the CD, can be viewed online from within **TNTview**, and can be printed locally as needed.

Relationship to **TNTmips**.

TNTview is a subset of **TNTmips**, which is available on every supported platform including the new 64-bit version released with **V6.9**. The processes in **TNTview** and **TNTmips** use the identical code. **TNTview** provides all of **TNTmips** that deals with the management and 2D and 3D visualization of geospatial data but does not support its creation or export. **TNTview** provides about 25% of all the code making up **TNTmips**. Your Software Authorization Key or floating license determines the subset of **TNTmips** that will be installed and available for use with your **TNTview** license. Various sites are already using separate floating licenses (but one Software Authorization Key) to serve out their independently licensed seats for **TNTmips**, **TNTedit**, and **TNTview**.

Try it Free.

Try **TNTview** free as long as you like, no time limit, with all your smaller GIS datasets or our samples by downloading **TNTview** as part of **TNTlite** from www.microimages.com /tntlite/. **TNTview** provided as part of **TNTlite** is identical to the professional **TNTview** you buy in all aspects except it limits the size of the geodata it will work with.

Characteristics of Licenses.

Fixed License.

A fixed license is controlled by a physical Software Authorization Key, which must be attached to a USB or serial port on your computer to permit **TNTview** to operate. The USB key, and therefore your license to use **TNTview**, is completely portable and can be moved freely among computers using any of popular operating systems supported by the **TNT** products: Mac, Windows, and Linux. Simply plug this key into the USB port and download and install the appropriate version of **TNTview** for the specific operating

system. **TNTview** portability is further ensured by an identical user interface and operation on all platforms and complete interchange of your geodata sets without conversion.

Floating License.

One or more seats on a floating license are controlled by a physical Software Authorization Key attached to a USB or serial port on a computer on your network. This computer, which can be using any operating system supported by the **TNT** products, must also be running the floating license management software. As many **TNTview** seats as your purchase authorizes can then be checked out to any computer on that network and these computers can be a mix of all popular operating systems (Mac, Windows, Linux, and Unix). Separate seats for **TNTedit** and **TNTmips** can be ordered for use with the same USB or serial key and software license manager.

Inherited New Features.

TNTview 7.0 provides all the following new features introduced in detail in the corresponding sections below for **TNTmips**.

System Changes.

Hundreds of new Coordinate Reference Systems, datums, datum conversions, and related features make up the Open Geospatial Consortium (OGC) Spatial Referencing System used in the ISO 19111:2003 Spatial Referencing System standard. These include all the Coordinate Reference System (CRS) definitions of the European Petroleum Survey Group (EPSG) all of which are updated biannually. These are now all incorporated into **TNTview** in addition to those developed by MicroImages for previous use with your imported or linked geodata. The map calculator can also make all these new kinds of conversions.

Shapefiles and their styles, projections, and other characteristics can be selected and automatically used in **TNT** processes and as display layers. These auto links are much faster in **RV7.0** as they are now made via the **TNT** shape object rather than via a CAD object as in **V6.9**. Now you can also use the Spatial Layer Controls to add **TNT** features to be used with the linked shapefile, such as new styles and groupings and DataTips. GraphTips, virtual fields, implied one-to-one table linkages, new tables, and all the advanced features and properties you expect to have for any geometric data layer in a **TNT** product can be set up from the Group or Layout Controls and saved with the link to the shapefile. Since these advanced properties are stored in the shape object link file, the shapefile and its table are not altered in any way although the originally associated table can be edited in a **TNT** product or ArcView.

The compressed size of all compressed rasters can now be larger than 4 GB if permited by the format's specifications.

JPEG and PNG compressed rasters can now be selected and automatically used in processes and as display layers. Their georeferencing and CRS information is automatically built for them in the link to make their subsequent display and use as fast and efficient as internal raster objects.

All compressed ArcGrid files can now be imported.

Importing non-topological datasets (for example, shapefiles, DXF, Oracle Spatial layers, …) into a vector object applies all the improved deconflation operations as part of the automatic topological validation procedure.

2D Display.

Your LegendView has styled legend entries for a linked shapefile if its AVL (ArcView Legend) file accompanies it. When no AVL file is present, legend entries are all in a single solid color.

CAD layers can now have the same advanced label styling, frames, leader lines, and other features as those used in vector layers.

CAD layers can now have all the many new DataTips, Enhanced DataTips, GraphTips and associated Display Control Script features described below in detail for **TNTmips**.

Linking to and importing from MrSID files in **V6.9** was the only significant **TNTview** feature unique to a Windows system. Now new libraries from LizardTech also make this feature available in **TNTview** for the Mac OS X operating system.

Text annotations can be added in anywhere in the sketch layer overlaying the view. A sketch layer is a CAD layer and can be saved as CAD object for future use in **TNTview** or the other **TNT** products. Since this is a CAD layer these annotations are actually labels and can have the same frame outlines with background colors/transparency and multiple leader lines.

3D Display.

3D views now use only the advanced rendering methods that now all offer the advanced features of the older, slower, lower quality rendering methods, which have been removed from **RV7.0** of **TNT** products. Some of these new features of the 3 new, high-quality 3D rendering methods include direct relief shading, layer transparency, and smooth color/transparent pedestals and fences (upward pedestals) both of which can follow around 3D surfaces with curved edges.

Multiple manifold layers can be vsualized in 3D views with or without surface views. A manifold layer is a raster, vector, shape, or CAD object with 3D georeference that is draped onto a continuous planar, curved, or irregular surface of any orientation in space that can be defined by a collection of 3D coordinates.

Maneuvering around a wireframe representation of the terrain to select an initial 3D observation position is now much faster.

Stereo Display.

Complex multi-layer 2D and 3D views of terrain surfaces and/or manifold surfaces can be converted into high quality stereo views. These stereo modes now include separate frames, column interlaced, line interlaced, and anaglyph to support the use of almost any available popular stereo viewing device. High quality stereo viewing can now be done with a mirror stereoscope using one large or a pair of flat panel monitors and also with the new stereo flat panel monitors that do not require glasses or any other external viewing aid or device.

Rendering of images into stereo views with parallax computed directly from the terrain layer is now faster since they no longer need to be draped on the terrain. This also improves the image quality for stereo viewing.

Importing Geodata.

New vector imports include CARIS ASCII and improved font support for MapInfo. New raster imports are MrSID on the Mac and compressed ArcGrid.

Customizing.

As usual the extensive additional features added to the **TNT** cross-platform geospatial scripting language (**SML**), such as those to create manifolds and new Display Control Scripts for creating GraphTips, are available for use in your scripts to create special tools, display effects, processing features, and so on.

The **TNT** Software Development Kit (**TNTsdk**) is now available FREE with every **RV7.0 TNT** product including **TNTview**. Now you can add your own processes to your **TNTview** menu or anyone else's using all the C++ functions and classes used to build the **TNT** products. For windows you will be working with Microsoft's C++ compiler in Visual Studio .NET 2003, Professional Version. You can compile the same program for use on the Mac, Linux, and Solaris using the current version of GCC.

Please be aware that the **SML** and **TNTsdk** export functions and classes are not available for use in **TNTview** to export geodata for use in other products.

Upgrading TNTview.

To a Different **TNT** product.

Any **TNTview** can upgraded by its original purchaser to a **TNTedit** or **TNTmips** with full credit for its original purchase price (for example, US$500, US$1000, or US $1200) after it has been upgraded at the very low price noted below to the current version of **TNTview**.

Upgrading from an Earlier Version.

If you did not purchase **RV7.0** of **TNTview** in advance and wish to do so now, please contact MicroImages by FAX, phone, or email to arrange the purchase of this version. When you have completed your purchase, you will be provided an authorization code by FAX. Entering this authorization code while running the installation process allows you to complete the installation of **TNTview 7.0**.

Fixed License.
The prices for upgrading a fixed license to **RV7.0** from an earlier version of **TNTview** purchased at the earlier higher prices are US$50 from **V6.9** or US$100 from **V6.8** or any earlier version.

Floating License.
The prices for upgrading each seat on a floating license to **RV7.0** from an earlier version of **TNTview** purchased at the earlier higher prices are US$60 from **V6.9** or US$120 from **V6.8** or any earlier version.

> The above special prices to upgrade to **TNTview 7.0** are valid until the day of the official release for downloading of **RV7.1** of the **TNT** products

Future Upgrades to **TNTview**.

Fixed License.
The worldwide prepaid price for a minimum of 2 or more future upgrades for **TNTview** will be $50 per each version. For example, purchasing your upgrades now from **RV7.0** to **RV7.1** and to **RV7.2** will be US$100.

When **TNTview 7.1**, **RV7.2**, or … are officially released, upgrades to any current version from any earlier version (**RV7.0** or earlier version) will be US$200.

<u>Floating License.</u>
The worldwide prepaid price for a <u>minimum</u> of 2 or more future upgrades for **TNTview** for <u>each seat</u> will be $60 per each version. For example, purchasing your upgrades now from **RV7.0** to **RV7.1** and to **RV7.2** will be US$120 per each seat, which is each simultaneous user.

When **TNTview 7.1**, **RV7.2**, or … are officially released, upgrades to the current version from any earlier version (**RV7.0** or earlier version) will be US$240 per each seat, which is each simultaneous user.

> Note that prepaid subscriptions to 2 future releases of **TNTview** are now only 25% of the price you will pay if you wait to upgrade until after each new version (for example, 7.1) is released.

TNTedit™ 7.0

Inherited New Features.

TNTedit 7.0 provides all the new features summarized just above in the section <u>Inherited New Features</u> for **TNTview**. The following additional new features not available in **TNTview** are summarized here for **TNTedit**. All these new features in **TNTedit** are introduced in greater detail in the corresponding sections below for **TNTmips**.

<u>Georeferencing.</u>
Manifold surfaces can now be created by adding 3D georeference points to a raster, vector, or CAD object to define a manifold object for 3D displays. These point positions and connections can also be edited to shape the surface. There is a detailed discussion of manifolds and their use in a section below entitled <u>Manifolds</u>.

Control points can now have names and IDs. Resampling from geographic (latitude-longitude) coordinates can now create cells specified in degrees/minutes/seconds. The pyramid computation method for an output raster object can be selected from None, Average, Sample, and Automatic.

<u>Editing.</u>
You can now copy from vector, CAD, TIN, region, and linked shape objects (for example, a linked shapefile). During the copy operation, you can now select the irregular area to copy from any of these geometric objects using a region object. This copy area selected from a vector, linked shape, CAD, or TIN layer can be optionally controlled to be Partially Inside, Completely Inside, Clip Inside, Partially Outside, Completely Outside, or Clip Outside the region object.

Regardless of the type of geometric object selected for the copy operation, this sub-area can be pasted into a vector or CAD object. If pasted into a vector object, its topology and database structure will be automatically reconciled (validated) in the target vector object.

Right Mouse Button operations will now allow the toggling through nearby elements (not just vector element types as in previous **TNTedit** versions) for vector and CAD editable objects.

Manifold object geodata content can be edited in a 2D view and the results viewed in a concurrent 3D view.

Database Table Setup.

A simple wizard approach is now used when you set up a new table and its relational linkages. This includes setting up virtual tables.

Exporting Geodata

Geographic Markup Language (GML) can be exported from CAD or vector objects. CAD or vector labels are exported to shapefiles. Exporting raster objects to PNG, TIFF, and GeoTIFF files have improved support.

Exporting geodata via the **SML** and **TNTsdk** export functions and classes <u>are available</u> in **TNTedit** to use to create geodata for use in other products.

Exporting Via Scripts.

Tool and Macro scripts started in **TNTedit** now have the ability to use the MicroImages Import / Export **SML** classes. For example, your special selection tool implemented in a Tool Script could select features and export their results directly to any supported external format while also using all **TNTedit**'s functions to prepare these features.

Geospatial Scripting Language (SML).

Tool and Macro scripts can use the Import / Export classes for **SML** scripts run within **TNTedit** to output edit results to custom formats.

Upgrading TNTedit.

If you did not purchase **RV7.0** of **TNTedit** in advance, and wish to do so now, please contact MicroImages by FAX, phone, or email to arrange to purchase this version. When you have completed your purchase, you will be provided an authorization code by FAX. Entering this authorization code while running the installation process allows you to complete the installation of **TNTedit 7.0**.

The prices for upgrading from earlier versions of **TNTedit** are outlined below. Please remember that new features have been added to **TNTedit** with each new release. Thus, the older your version of **TNTedit** relative to **RV7.0**, the higher your upgrade cost will be.

Within the NAFTA point-of-use area (Canada, U.S., and Mexico) and with shipping by ground delivery. (+$50/each means US$50 for each additional upgrade increment.)

TNTedit Product	Price to upgrade from **TNTedit:**				**V6.4**	
	V6.9	**V6.8**	**V6.7**	**V6.6**	**V6.5**	and earlier
Windows/Mac/Linux	US$350	550	700	800	875	+50/each
for 1-user floating	US$420	660	840	960	1050	+60/each
UNIX for 1-fixed license	US$650	1000	1350	1600	1750	+50/each
for 1-user floating	US$780	1200	1620	1920	2100	+60/each

For a point-of-use in all other nations with shipping by air express. (+$50/each means US$50 for each additional upgrade increment.)

TNTedit Product	Price to upgrade from **TNTedit:**					**V6.4**
	V6.9	**V6.8**	**V6.7**	**V6.6**	**V6.5**	and earlier
Windows/Mac/LINUX	US$400	750	950	1100	1200	+50/each
for 1-user floating	US$480	900	1140	1320	1440	+60/each
UNIX for 1-fixed license	US$750	1200	1550	1850	2000	+50/each
for 1-user floating	US$900	1440	1860	2220	2400	+60/each

Tutorial and Reference Booklets

There are now 77 **TNT** Tutorial and Reference booklets. These booklets provide more than 2000 pages and over 4000 color illustrations. The most important of these booklets are up-to-date with the features in **RV7.0** of the **TNT** products. However, others still show minor differences primarily in the user interface layouts of earlier **TNT** versions. Additional revised booklets will be provided as completed for your downloading via microimages.com. The new booklets provided with this release and those with significant additions are illustrated and summarized in the accompanying color plate entitled New Tutorials.

Each new professional **TNTmips** ships with 3 thick notebooks containing a color printed copy of these 77 booklets. Those of you receiving your **RV7.0** upgrade on CD can view and refer to all of these booklets using Adobe Acrobat or Reader. If you install all these booklets as part of any **TNTmips** product, you can directly access these booklets from the Display menu, by choosing Help / Tutorial Overview and selecting the booklet, or via Help / Search and using the index this provides.

New Booklets Available.

Working with Massive Geodata Objects. (printed copy provided)

Large geodata sets are available or you are assembling them in **TNTmips**. This booklet provides advice on how to structure and maintain them for optimal use in the **TNT** products. Individual rasters and mosaics can use appropriate compression and a null value mask. Compute standard attribute tables (for example, area, …) only when needed. Merge contiguous vector objects to eliminate management and fragmentation of many pieces. Merge line and polygon objects when they need not be kept separate. Dissolve out unnecessary polygon boundaries. Remove excess nodes. Thin down vector lines. Maintain a simpler topology if possible until full polygonal topology is required. Transfer attributes to simplify relational databases and remove duplicate records. Setup the viewing scale for the range of interest for objects. Use DataTips and GraphTips to simplify views rather than turn on many simultaneous layers.

Introduction to Using TNTsdk. (printed copy provided)

As discussed above in detail, **TNTsdk** is now available free to develop additional geospatial software for use with **TNTview**, **TNTedit**, or **TNTmips**. This brief new booklet introduces you to some of the things you should consider, such as getting support, cross-platform issues, and how to ensure that your program can be localized or translated for use in your language. It gives some suggestions on how to set up your **TNTsdk** programming environment and keep it updated and current. It also discusses a sample program included with the **TNTsdk**.

<u>Orthorectification Using Rational Polynomials.</u>

TNTmips now provides a simple procedure to produce orthorectified images from full or partial QuickBird and IKONOS images ordered as Rational Polynomial ortho ready kits. This procedure requires a good quality DEM of the area covered and several well distributed, accurate XYZ ground control points (GCPs). This new booklet covers the procedures available in this new process. It outlines how to obtain and evaluate GCPs and test points of varying quality. Significant modifications of the **TNT** georeference procedures were required to enter and use these XYZ GCPs and test points for this process and are discussed. The various methods built into this process to measure the map accuracy of the ortho image produced are reviewed. A sample exercise is provided using a color IKONOS 4-meter resolution image of La Jolla Mesa, San Diego County, California and the corresponding DEM that will fit within the practice limits of **TNTlite**.

<u>Revised Tutorials with Major Changes.</u>

The following tutorial booklets have been revised since the release of **RV6.9**. They were selected for update since they represent areas of significant recent changes in the **TNT** products. The added functionality of newly released features is introduced by the addition of new pages and examples as noted. As part of this update, their user interface illustrations, terminology, default parameters, and sample data have also been adjusted to be current with **RV7.0** of the **TNT** products.

<u>Managing Relational Databases</u> has been updated to include shape objects and changes to tabular view. The illustrations were updated throughout the booklet and terminology was adjusted to reflect the current interface and defaults. The following new pages were added.
  • <u>Changing Related Only to Directly Linked</u>—how to use directly attached tables to make related only tables into directly attached tables so a database can be simplified;
  • <u>Database Validate and Attachment Types</u>—introduces database validation and discusses the importance and implications of various attachment types;
  • <u>Link to ODBC Data Sources</u>—presents the Link to Data Sources feature in Display and contrasts it with linking during import; and
  • <u>Many Ways to Associate Tables</u>—summarizes the many ways to associate database information with objects in the **TNT** products.

<u>Printing</u> has been updated to include color management and newly supported external formats. The following new pages were added.
  • <u>Color Management</u>—color profiles (ICM and ICC) and how to proof to the screen;
  • <u>Printing to External Formats</u>—converting layouts to TIFF, Adobe Illustrator (*.ai), PDF, EPS, and SVG;
  • <u>Options When Printing to SVG</u>—compression and layer controls; and
  • <u>Hints for Reliable Printing</u>—setting printer defaults and page orientation, do not dither twice, printing transparency efficiently.

<u>Vector Analysis Operations</u> has been updated to include material on creating and using grids with accompanying exercises. The following new pages were added.
  • <u>Grid Analysis</u>—generating grids within reference objects;
  • <u>Grids for Extraction</u>—using generated grids to extract from raster objects;
  • <u>Grids and Surface Properties</u>—getting surface properties for generated grid polygons; and

• <u>Vectors and Surfaces</u>—converting 2D vectors to 3D vectors and using 3D view in editing.

<u>Glossary for Geospatial Science</u> has many new terms added, such as "conflation," resulting in an increase from 64 to 72 pages.

<u>Floating License Setup and Management Guide</u> has been completely updated, expanded, and tested.

<u>Quick Guides.</u>

Quick Guides outline the operation of a small selection of **TNT** features in a very concise form or provide quick reference sheets for things like Hot Keys. They are created in response to user input and support questions that indicate clients are unaware or overlooking specific shortcuts or key features of the **TNT** products. As a result they are not a comprehensive collection, which would require thousands of pages in this Quick Guide format, but only intended to address these special concerns. All previously existing Quick Guides have been revised and updated to be current with **RV7.0**.

<u>Available Online.</u>

All 58 currently available Quick Guides are now installed in PDF format from your CD with your **RV7.0 TNT** product. You can access these Guides online using Display / Quick Guides or Help / Quick Guides. This feature is illustrated on the accompanying color plate entitled <u>Quick Guides Available from Menu</u>. A single search in Abobe Reader will now cover the contents of these Guides as well as the tutorial booklets and the reference manual.

This searching is also now available for the first time in the Mac OS X versions of the **TNT** products. To use this feature you will need to designate that Abobe Reader is your default application for viewing PDF files. Apple wishes you to stay within its own software so Apple Preview is the default for PDF files and the Adobe search indexes are ignored. The same color plate discusses this and how you can switch your default application to Adobe Reader to use these **TNT** searches.

<u>New Quick Guides.</u>

The following new Quick Guides are provided in printed form as part of your **RV7.0** upgrade kit. Some synopsize new features added to **RV7.0** and some cover previous features of which you may be unaware. These and all the other upgraded Quick Guides are installed in PDF from the CD as part of **RV7.0** or can be downloaded from www.microimages.com/didyouknow/.

> **Suggestion:** Print and assemble all the new and updated 1-page Quick Guides into a booklet or notebook and keep them near your desktop for easy reference.

<u>Editor's Right Mouse Button Menu.</u>
Set up a custom right mouse button menu for quick access to a variety of frequently used editing functions.

<u>Database Prompt in the Spatial Data Editor.</u>
Choose to be automatically prompted to enter attributes when elements are added or divided while editing.

Designing Database Forms.
Create a form from a table for data entry and viewing that includes the fields and added labels of your choice.

Cosmetic Database Constraints & Forms.
Change the field prefix to include spaces and symbols not allowed in field names and add text after a field.

Operational Database Constraints.
Place constraints on fields to control how they are filled out during data entry operations.

Adding Frames to Labels.
Include frames for use with labels and leader lines for automatic (on-the-fly) labels.

Automatic Labels and Leader Lines. (new feature in **RV7.0**)
Control label position and the use of leader lines for automatic (on-the-fly) polygon labels.

Cross Sections with Style. (improved feature in **RV7.0**)
Generate a cross section with drawing styles that match the original vector object.

RVC Object Validation. (new feature in **RV7.0**)
Check your RVC files and objects for validity and conflicts using Project File Maintenance.

Copying Objects.
Copy files and most object types to a new location using Project File Maintenance.

Zooming to Full Resolution (1X). (new feature in **RV7.0**)
Choose any raster layer in a group or layout to provide the scale for a full resolution (1X) zoom.

Extract and Trim DRGs.
Select the Digital Raster Graphics (DRG) of a scanned map directly in its TIFF format and automatically extract it to trim off the collar information.

Toggling Map Grid Tick Mark Colors.
Toggle between two colors for interior map grid ticks.

Using Special Characters.
Visually select and insert special characters from the fonts character map window without typing the character's code.

New TNTmips Features

Main or subsections preceded by the asterisk "*" symbol introduce significant new processes or features in existing processes released for the first time in **TNTmips RV7.0.** You will find more sections marked in this fashion than usual in this MEMO. This results from the incorporation into this release of the results of several longer term background recoding and development projects—some stretching over several years.

System Level Changes.

Project Files.

CAD Objects.
Text elements (in other words, strings) stored in a CAD object can now be assigned styling and be displayed with similar appearance properties to those available for vector ob-

jects in **V6.9**. CAD text elements can now also be multi-lined. Each text element can have distinct label frames and use one or more leader lines. Text element alignment can use multi-point label baselines with straight, exact, and spline fits of the text to the baseline. A sample application of these new features of CAD objects will be discussed in more detail in the section below entitled <u>Sketching</u>.

Raster Objects.

<u>Pyramids.</u> A global option is available Support / Setup / Preferences on the Project File tabbed panel to require that all **TNT** processes compute full binary pyramids. Computing full binary pyramids is the defuault. You can turn on a toggle to skip the 2 by 2 pyramid, which will decrease the raster size by 25% and speed up its creation. However, having the full set of pyramids will improve the detail and speed up the display of this raster for you as your zooming approaches 1 to 1.

<u>JPEG2000 Objects.</u> Raster objects can now be greater than 4 GB when compressed with JPEG2000. This will be a common result when mosaicking many orthophoto raster objects into a single JPEG2000 compressed raster object. However, to use this new capability, your operating system must be new enough to permit any file, thus a Project File containing this compressed raster object, to exceed 4 GB and your hard drive must be formatted appropriately. Drive formats that will permit files, thus Project Files, to exceed 4 GB are:
- Windows NT, 2000, XP, 2003: NTFS;
- Mac OS X (all versions):   HFS or HFS Extended;
- Linux (for various flavors): ext2, ext3, ReiserFS, XFS, and JFS; and
- Unix: any current format used.

<u>JPEG Objects.</u> Auto-linking to directly display and use JPEG format files (*.jpg) is now supported. If georeference information is provided it will be used automatically from the companion files with the same name but with the *.jgw (world file) extension.

<u>PNG Objects.</u> Auto-linking to directly display and use PNG format files (*.png) is now supported. If an ICM color profile or gamma/chromaticity values exist, the link to the PNG file will bring it in as an ICM color profile subobject in the **TNT** link file. If an alpha channel exists in the PNG file, an opacity mask raster object will be created in the **TNT** link file. A color plate entitled <u>Directly Use PNG Files</u> accompanies this MEMO to illustrate and further discuss features provided by this new linked format.

Vector Objects.

Validating topology in vector objects in **RV7.0** is now faster. Considerable effort has been expended to optimize computations in the steps used on the graphical elements in a vector object during validation. More information on this topic can be found in the major section below entitled <u>Validating Vector Topology</u>. Reconciliation of the contents of complex relational database structures is still time consuming and will be the focus of future optimization in the validation engine.

Georeference Subobjects.

The georeference subobject is now updated to handle more verbose georeference information. A new georeference type called manifold is now supported in the georeference subobject. The georeference subobject has been expanded to handle control point names and IDs, whether control points are enabled or disabled, linking two control points together to define a hard edge and linking multiple control points to define a

boundary for use in piecewise models, and support for the new Coordinate Reference System (CRS). If the georeference subobject does not contain any of the above features and the CRS can be represented in the georeference subobject format of **TNTmips 6.9** and earlier, the georeference subobject will be usable in earlier versions of the **TNT** products.

Maintenance.

Object Size Information. The Object Information dialog in Project File Maintenance now reports the amount of Project File space a geodata object uses and has a separate entry for the total amount of Project File space for the object and all of the subobjects of that geodata object.

Object Warnings. The hierarchical structure of your geodata is tested whenever a primary object is being copied or the Project File is being packed. Yes, it would be appropriate if every **TNT** process and activity was designed to prevent violations from being created for that object type and this is an area for continued effort. However, violations can occur when data uses older processes, is manipulated by you outside the **TNT** products (for example, via **SML** or **TNTsdk**), or errors occur. If a violation is detected, a dialog will appear to inform you of the problem(s) and what the operation being used will or will not do about it.

The Object Information dialog in Project File Maintenance now also highlights subobjects in its subobject list that violate the allowed hierarchy structure for that primary geodata object type. Normally all information in this dialog is in black text. Text information about a subobject presented in the color Red indicates that this subobject is not valid under the parent object for which it is listed. Magenta text is used as a warning that the subobject is of the same type as another subobject under the same parent and that only one is needed and will be used. Blue text is used as a warning to indicate that the object or subobject has links to some other, possibly external objects or files, and that they cannot be found. The colors are used in a hierarchy at the file level such that if any objects or subobjects would be shown in red, the file is shown in red but may also contain objects or subobjects that are shown in magenta or blue.

Vector Object Standard Properties. The Edit Object Information dialog accessible from the Edit icon button in Project File Maintenance for vector objects now provides another means to optionally enable or disable the maintenance of standard attribute and element ID tables. Remember that if you choose to enable these properties to be continuously maintained, this will slow down processes, such as editing a vector object, which then must continuously correct and maintain these tables. As an alternative at any time you can create these standard property tables by using Process/Vector/Attributes/ Standard Attributes.

* Validating Vector Topology.

Conflation, what is it?

The Random House Unabridged Dictionary defines conflate as "*to fuse into one entity, to merge.*" From conflate comes the word conflation that is defined as *"the process or result of fusing items into one entity; fusion; amalgamation."* This is probably a new word in your vocabulary, but is used by the technologists in the GIS community in reference to maintaining topology.

Conflation is a major objective of the **TNT** vector validate process, to merge line elements that should be the same into a single element in order to maintain correct topology. Incorrect conflation, thus incomplete validation, yields "conflation errors," which means that topological errors have been created. It is not appropriate to refer to these as validation errors in that the validate process does many other things besides merging graphical elements. Often conflation errors take the form of long triangles of microscopic width that are so small as to be practically invisible and might be called "no seeums" or invisible. This example of a conflation error can not readily be detected or filtered out using the **TNT** polygon area filter as it's difficult to detect and its area can not be readily computed due to limitations in the floating point computations involved.

Conflation errors are usually only a very few in number and if they go unresolved and undetected, they may or may not effect some future application with the vector object. For example, if a single, microscopic triangle is created, it may never be a source of difficulty unless by chance in some future merge with another object, a new line happens to bisect it. When this happens, the error in the process being used, such as merging vectors, is difficult to find since it resulted from an undetected condition created somewhere else in the input vector objects.

Conflation errors do not necessarily originate in some vector object process within the **TNT** products. The import of a carelessly prepared or very large CAD or shapefile subsequently used to create a vector object can create a conflation error. It is MicroImages' responsibility to insure that conflation errors do not occur and are detected and resolved by the validate process when they do. Alas, as your vector object size increases, the probability of the conditions occurring that could create a conflation error also increases. Since you are now using much larger, national level or locally high detail vector objects, the probability of geometric conditions existing that create a conflation error have increased. Thus you must now be made aware of this concept, how it comes about, and the considerable software effort invested in **RV7.0** to insure that these errors are detected and resolved <u>every time</u> a vector object is validated.

> Importing large CAD or shapefiles for subsequent use as vector objects creates conditions leading to conflation errors that validate must resolve.

How do you "catch it"?

A common maxim is that "one person's signal is another's noise." You must pay close attention to the disposition of the small features created by combining input objects of any type into a polygonal topology vector object. It may be obvious that you are combining graphical elements when you use **TNT** procedures like Combine and Merge. It may not be as obvious that this is also happening when you perform an Import, Copy then Paste, or use the new Extract process to merge several objects of varying types.

Probably the most common source of conflation problems are those that occur during the import of a very large non-topological dataset(s), particularly from ArcView shapefiles, AutoCAD DXF, and other CAD formats. Single shapefiles are being imported into **TNTmips** that are 1 to 2 gigabytes in size. A lot of complex data might have been overlaid into one of these files with the intention that it would only be used for displaying it as graphics from the CAD or shapefile. Importing these kinds of files into a vector object with polygonal topology may cause conflation errors to occur.

Another way to increase the probability of encountering conflation errors is to make duplicate versions of a vector object containing numerous polygons. Using these identical vector objects as templates, you then subject each separately to a variety of changes, such as editing or merging, that creates many, many new polygons. These result in tiny but rare changes in the vertices of the original polygons due to round off changes in their coordinates. Later, if these vector objects are recombined, these polygons are no longer absolutely identical and in some geometric combinations result in microscopic conflation errors.

Is it a problem?

The small topological graphical features that result from conflation when a vector object is validated can be divided into two groups. Artifacts: those small features that you decide are indeed artifacts for your purposes and must subsequently be removed from the vector object by the polygon area filter. Artifacts can be easily seen if you zoom into your object many times (for example, 10 times, not 10X). Conflation Errors: microscopic differences in the features that should have been treated as identical but do not conflate and yield new error features, primarily due to the limitations imposed by the mathematical precision of the process. Often these microscopic features appear due to round-off errors in the floating point computations on double precision coordinates of previously identical vertices. They would still occur even if greater floating point and coordinate precision were used. They would just be even smaller as they constitute computation noise. Eliminating or preventing the possible subsequent negative effects of these tiny conflation errors hiding in a vector object is the responsibility of MicroImages since we created them.

Can it be avoided?

Many new small triangles and polygons are almost always added when overlapping geometric objects are combined into a new vector object. These may be noise in your application and can be deleted from the new vector object using a small polygon filter. Or, they may be significant new small agricultural plots or movements in the edges of ecotones (transition edges of ecological communities) with an area of a few thousand square meters in a vector object covering an entire province or nation. Another common effect of combining objects is creation of slightly different 2 point features that might result from meaningless displacements in duplicated survey or GPS differences. Conversely these same small displacements can be quite important in a study of the land subsidence or movement using repeatedly measured polygon boundaries.

Understanding what topology is and that it is maintained at a considerable cost in computation time can help you use procedures that reduce the creation of artifacts and conflation errors. For example, you snap to a line between two nodes by any means, such as extending the line or crossing and intersecting it. No matter the mathematical precision used in the computation, the new 3rd node will not be perfectly on the old line at the numbered limits. This is no particular problem in that vector object. However, the original line is duplicated in a second vector object. If the 2 objects are combined the original line and the 2 new lines form a microscopic triangle. No problem as this is easily detected in validate. But it gets harder to do if the original straight line is very long because the acute angles of the triangle get smaller and smaller. No problem here as yet either. But this original line exists in 6 more vector objects since it started in all as a national or provincial reference boundary. All of these have other edit activities performed separately on them and the same original line gets nodes snapped to it at other inter-

mediate positions. Still not a problem—until all 8 objects are combined at one time. Now the geometry for this area gets very complicated with even more microscopic triangles being formed, and in special circumstances it is difficult to resolve the conflation error that results. If you think through this example, you can also understand that if the layers were combined two at a time this error would have a significantly lower probability of occurrence. For example combine object 1 and 2 to get object Z and validate. Next combine object 3 and Z and validate, and so on until object 8 is combined with the previous result. This approach would not take any longer in computer time to do. Furthermore, the order of combining the pairs can also be changed to avoid errors.

Duplicating a vector and then editing the various copies can be convenient. It is important that polygons in all objects be bounded by the same political, project, or physical boundaries. For example, you have provincial boundaries in a vector object and create several duplicates of them in new vector objects to be used as a base for the collection of other graphical features. Subsequently combining these objects may result in an error in conflation that is not resolved in the validation and is detected and reported. When this happens, it is the responsibility of MicroImages to resolve this complex geometry during validation. However, we must have your vector objects to reproduce the complex geometry leading to the error and thus resolve errors of that type in future combination operations.

Can you see it?

Conflation error features are so small that you would have to zoom in to a view scale approaching zero to see them even if you know where to look. This might be 20 zoom in operations beyond where a "0" scale first appears as the **TNT** view scale. A zoom scale showing as "0" means that you are asymptotically approaching close to zero (for example, an actual scale of .01). For example, when you have zoomed in enough to see a conflation error triangle (perhaps a scale of .0001) and use the measurement tool to measure the smallest side of the triangle, you might find that it is a less than a millimeter and even approaching microns on the ground in a vector object with an extent of 1000 kilometers.

What is the effect of the cure?

Creating and continuously maintaining topology is a unique property of the **TNT** vector objects. It is maintained in various processes by the **TNT** validation procedure. Significant effort has been expended in **RV7.0** in improvements in this validate procedure for testing for, detecting, and resolving hidden conflation errors. These low-level, "under-the-hood" changes to validate will not be directly visible to you, but will make subsequent uses of your vector objects, such as their combination, more reliable especially with large vector objects. Detecting conflation errors and repairing them for large vector combination operations does require a lot of CPU time. To offset these new demands for CPU time, the previously routine validation operations have many new optimizations. Thus, you will notice that although validate is doing a lot more work in **RV7.0**, it is faster than **V6.9** when dealing with common vector object operations requiring validation.

Alas, these continuing improvements in validate and its speed are offset by your insatiable desire to create and work with larger and larger vector objects. Using larger vector objects comes at a price. As their size increases, they can slow down validate in a non-linear manner, especially when there is a requirement to reconcile very complex, attached relational database structures. Speeding up this activity in validate will be an im-

provement that you can expect in **DV7.1**. Increasing size also exacerbates the situation by introducing more conflation errors into your operations that combine vector objects. Also importing bigger shapefiles, DXF, and similar graphical files increases the probability that they contain pseudo-duplicated data structures such as crisscrossing overlapping polygons, which create artifacts and conflation errors.

Where are the current capabilities?

Recently you brought to our attention several problems with large vector objects that occurred during their combination or subsequent uses. These were eventually traced to a few conflation errors. A single undetected conflation error creates difficulties and perhaps halts validation in a later step. Fortunately two clients were able to provide Micro-Images with complete datasets that exhibited these problems. These both have provided the basis for extensive effort software development and testing to pinpoint the errors and add code to detect them and then to fix them. Discussing these 2 test cases will help you become familiar with these microscopic but important topological issues.

Large Shapefile Import to a Vector Object.

One test case was a large shapefile containing contours that was obtained by the client from the Internet for import into a vector object. Its size was ~1.4 GB and contained 61,543,650 vertices defining 1,849,392 lines connected by 1,965,573 nodes and 1 table. Since this shapefile had no polygons, they were formed in validate and you might assume that it had no intersections. However, it contained retraced line segments that did initially create microscopic conflation errors during the validation portion of its import into a vector object.

Merging Nation-Sized Vector Objects.

This test case involved the combination in the merge operation of 8 vector objects covering an entire medium-sized nation. The makeup of these vector objects was as follows:

OBJECT	TOTAL SIZE	NODES	LINES	POLYGONS	VERTICES	TABLES
Land Use	744,100,827	105,971	128,522	88,999	42,433,362	14
Land Units	281,452,703	181,842	269,793	106,708	10,995,635	13
Village	35,818,752	15,231	22,544	8,246	1,630,851	23
District	20,660,673	9,517	10,453	1,866	980,289	23
Province	9,726,216	4,068	4,146	1,009	429,896	23
Irrigation	3,764,791	1,266	1,289	1,127	189,388	10
Rainfall	3,458,113	1,116	1,140	941	172,991	9
Temperature	3,568,491	1,095	1,116	923	172,493	24
MERGED	2,909,191,917	905,032	1,661,334	790,413	57,101,680	59

The land use vector object was interpreted from imagery and had polygons and islands smaller than 1 hectare. The national boundary was digitized in **TNTmips** and was very detailed and complex and used as a template that occurred in all 8 vector objects. The village, district, and provincial boundaries were all three derived from the same orginal vector object by additional digitizing. The Land Use object was not only the most complex but was derived in such a fashion from automated image interpretation so as to have boundaries that nearly duplicated those of other layers such as the Land Units objects. Using **RV6.9** about 30 conflation errors of several related types were tracked down by adding tests that report the geographic position were the geometric problem occurs. The validate process in **PV6.9** and **RV7.0** was then modified to detect, identify, and resolve these various classes of errors.

What if I still have it?

As part of this effort to make vector validation more robust, a variety of new error and warning messages were added. The most valuable are those that report the coordinates of the position of a topological problem area. Should such a message occur you can zoom in at that _exact_ coordinate position in the Spatial Data Editor and see if the complication can be manually edited. For this reason in **RV7.0** all error messages in every process are now automatically written into the session log (see below), this log can be sent to MicroImages, along with the vector object to insure that any new type of conflation problem is detected, eliminated, and does not occur again.

Remember you may have to zoom in an excessive amount to a scale of 0 and perhaps way beyond to even see the offending feature. In the testing documented above, it was found to be very useful to extract new vector objects for progressively smaller areas around the reported error position. Eventually this means that validate runs up to the error point in seconds or the error simply disappears, which may help you locate the problem feature and also provides a very small vector object to use to send the problem to MicroImages.

Tracking Process Performance.

Progress Windows.

The progress bar in the status window in all processes now displays elapsed time for each step in the process. From this you can glance at a complex process and determine how long a process has been running at a given step. At the end of the process the progress bar displays the total elapsed time for the entire process.

Session Logs.

How Are They Titled?

A session log is now automatically created for all **TNT** processes. The name of the session log is YYYYMMDD.log where YYYY is the 4-digit year, MM is the 2-digit month and DD is the 2-digit day of the month. Thus, the log file created if you use your **TNT** product on the date on this MEMO will be named 20041117.log. All processes you run on the date used for this file name are logged sequentially in this same log file. The **TNT** products will create up to 10 daily log files using this naming convention. These are not consecutively dated unless you use your **TNT** product for 10 consecutive days. Whenever you start your 11th daily session of your **TNT** product, the oldest dated *.log file will be automatically deleted unless you have renamed it to keep it. A portion of a session log is listed on an accompanying color plate entitled Session Log Files.

 Where Are They Located?

The location of the session log is dependent on the platform and user environment and security settings.

Mac OS X. Under Mac OS X various diagnostic log files and log folders such as the DiskUtility.log and the CrashReported folder are placed automatically in your user Library/Logs folder. The **TNT** products automatically create a MicroImages folder in this Log folder and place the **TNT** *.log session log files (for example, 20041117.log) in this log folder. The Mac OS X Console log application is used to view, analyze, and print the contents of any *.log file in this folder. Any of the 10 **TNT** session logs can be automatically opened in this log application program by double clicking on them.

Windows. The default location created for these **TNT** session log files for Windows XP is in a MicroImages directory automatically created in your "My Documents" directory. For other versions of Windows please search for files with the extension of *.log.

Linux/Unix. The default location created for these **TNT** session log files for various Linux flavors is in userhomedirectory/.MicroImages

What Do They Contain?

The session log file contains date/time information regarding when the process and critical libraries were built. Also recorded are all the messages displayed in progress windows, as well as all displayed error messages.

Each of the key steps matching those displayed in the status window is recorded in the session logs. If the process fails to complete, then the last step recorded will indicate that the process failed in the next step. Providing this session log to MicroImages' support staff with your error report will assist them in diagnosing the error condition you are experiencing.

The cumulative time from the beginning of each step is also recorded for the step when it is complete. The complete elapsed time is also recorded for the process. Of more interest is the additional entry of the incremental time to complete each step in the process. It will indicate where a process seems to be too slow and can be included as part of your inquiry about this to MicroImages' support staff.

Additional reference information may be recorded in the session log by various processes for diagnostic purposes, which is not displayed to you during the use of a process. It is anticipated that gradually more and more diagnostic information will be

recorded in these session logs to help you monitor and perfect your operational procedures and MicroImages diagnose where processes need further optimization or to help you help us diagnose errors.

New Coordinate Reference System (CRS).

Background.

The Starting Point.
MicroImages uses Claudius Ptolemy (circa 100 to 170 AD) as an "inspirational figure" as he is credited with inventing the idea that the curved earth could be represented by projecting it onto a flat surface. What he conceived of has now proliferated into a myriad of different ways to represent and record coordinates on a "sort of bumpy spheroid" and then ways to project them onto a flat surface. Over the intervening 1900 years scientists, mathematicians, and even politicians have been arguing over new approaches and which system is best. Even something as accepted today as the location of the prime meridian was contested for long periods between nations seeking to maintain control of it and their maps derived from it. Today there are almost as many ideas about which system is best as there are geodesists defining how to do it.

Where the Early Initiative Came From.
First nations with empires introduced some level of standardization within their colonies and their maps. The breakup of empires in the first half of the 20th century halted this trend. Starting in the 1920s, oil companies took the initial initiative to collect and collate information about these systems. Today locating on-shore and off-shore well locations accurately worldwide requires dealing with many different national and local map projection and datum definitions. As a result, they had and still have a huge economic incentive for collecting together information about the many Coordinate Reference Systems (CRSs) in use and then using it to accurately convert between all these CRSs. Military applications did not provide early leadership in this area since they simply wanted to enforce a single standard CRS, such as UTM, and only wanted to move one way—from any external materials and information they can acquire into their standard CRS. They also are not willing to share information in and about their most accurate CRS and transformations for international public uses.

Requirements for Accuracy in Geospatial Systems Keep Increasing.
Today striving for highly accurate global scale precision in global Coordinate Reference Systems (CRSs) can be the basis for completely automated flight and safe landings of a commercial aircraft or a pilotless drone. Equally accurate requirements for precision in a local CRS can serve as a basis for legally defining property ownership boundaries rather than the traditional angles and lengths survey. Lincoln, NE and Lancaster County that it dominates now use a special Transverse Mercator CRS to minimize local errors and increase coordinate accuracy, and this is the trend for urban areas around the world.

These varied requirements for high accuracy and recorded precision were not part of the university research and early commercial applications of image processing or GIS 20 to 30 years ago.

GPS first appeared with limited availability in the late 1980s. Even at that late date, measuring more accurate positions of ground coordinates by any other means for the control of imagery was tedious and prohibitively expensive. The initial GPS public reso-

lution of 100 meters was poor, equipment was expensive, and thus it had little immediate impact on the precision required in computer mapping and image processing, which could easily handle this level of precision and its immediate potential for improvement.

Landsat satellite imagery also became readily available in the same time framework. Its initial coarse 80- then 30-meter ground resolution, coupled with the limited ability to georeference and orthorectify it, fit nicely with the available GPS accuracy and the accuracy of then prevalent computer analysis systems.

Computer hardware of this time period, desktop or workstation, was also limited in storage, display, and computational capability to handle the precision and magnitude of these kinds of data sources.

Geodata was scarce and of coarse accuracy. Composite viewing of mixed image and map layers was minimal due to the absence of on-the-fly map projection conversions. The idea of georeferencing and the concept of managing scale for map and image data was not common in image processing systems.

When map coordinates were used in GIS systems, common map projections were used and were accurate enough to be applied over wide areas. Accuracy requiring datum conversions was not required and inadequate computer power was available anyway.

Gradual improvements in these areas coupled with improved geospatial software on minicomputers and soon desktops lead to the ideas of the 1990s. Producing orthoimages and image maps from satellite and aerial imagery began with accuracies in the 10s of meters. DEMs became available for this purpose and for 3D displays. Accurate infrastructure and property ownership data began to appear. GIS data and digital map data (for example, U.S. Census Bureau TIGER maps) became widely available requiring updates. Fusing images of varying resolution began. These and many other applications depended upon and demanded increased accuracy in the coordinates and conversions being used.

These are some of the factors that influenced the design of the Coordinate Reference System (CRS) structure, service, and interface built into the 1980s ancestors of the **TNT** products and the contemporary models of other current commercial geospatial analysis products. Until the onset of the 21st century, the evolution of these early approaches had permitted them to be maintained and patched to keep pace with CRS accuracy and use until quite recently. Standardization in the exchange of CRS information between products was not of concern until recent, standardized geodata exchange formats became popular and other technical users began to demand it and improved accuracies (auto industry, web applications, and so on).

Today the goal is all-electronic in-car navigation, hand-held GPS map display position units, highly accurate survey units, and many more. Only in rugged field conditions does paper remain the optimal media. Electronic uses are permitting instant changes / conversions in composite and 3D viewing, feature position coordinate readouts, combinations of materials in different reference systems, and so on.

MicroImages' Previous Coordinate System Framework.

Managing image and map materials in a georeferenced form so that they could be merged was the very first objective and product goal in the design of the structure of the experimental predecessors of **TNTmips** in the late 1970s, well before its commercialization as **TNTmips** in 1986. In that time framework, the goal was to produce paper image maps: printed images that matched the boundaries, scale, and content of associated

printed maps. These early 1980s experimental products were color printed maps of Landsat imagery georeferenced, warped, and clipped to match a companion USGS 1:24,000 scale topographic map. Before very long, paper published maps were being scanned and overlaid as transparent images or overlaid by the available USGS Digital Line Graph digitized line features and then printed. But PCs were large, slow, and limited in distribution and no large capacity standard distribution media (which means, the CD) was available to consider wide scale electronic use of such material. During these early years, goals were map-centric and oriented toward producing physical map products.

This early map-oriented start subsequently meant that **TNT** was the first commercial desktop product to handle map projection changes transparently, whereas today all professional systems are expected to do this and low-cost units convert data and inputs (for example, GPS) to a common Coordinate Reference System (CRS). Today in the **TNT** products we might start an application by mosaicking a large number of orthoimages in one or more CRS, add many geometry feature overlay layers in various other CRSs, and expect them to accurately fit to each other to the meter, foot, or even less (for example, the enclosed Lincoln Property Viewer **TNTatlas**).

Introducing New Terminology.
Until recently the term *map projection* was convenient and was applied to this objective. Today the application of geospatial systems to produce physical maps is not their major use. Therefore thinking of these requirements to represent coordinates and features as using a map projection physically bound into that map is on its way out. We no longer think of geospatial information as something we carry around in a physical form and, thus, in a fixed map projection. It is data in a geospatial analysis system, database system, or other digital form stored with a 3D Coordinate Reference System (CRS). We expect it to be accurate and usable in that CRS or when transformed into whatever CRS is requested or appropriate. If it is older or in some other datum, we expect this to be transparently converted with accuracy.

Today the concept that your image, map, and combined geospatial data is in a map projection can be misleading as it conjures up the idea of a physical map. Today this information can be thought of as existing and represented in a specific global CRS and be accurately convertible in real time to some other global or local Coordinate Reference System. Tomorrow's end users of geospatial data no longer require or request map coordinates. Today's end user of geodata expects a pleasant voice to tell them to turn right now at this corner for the nearest gas station, and that the road will be there. In the next 20 years they will expect the car to do this automatically. "Road maps and map projections, weren't those things that they used back in the late 1900s?"

Adapting To These New Requirements for Standardization, Accuracy, and Speed.
Change requires change! Capabilities of hardware and our expectations for a professional geospatial analysis system have changed greatly in these 20 to 30 years. That's what keeps it interesting and challenging. To keep pace, the early design and adjustments to managing Coordinate Reference Systems (CRSs) in the **TNT** products required a major overhaul undertaken a year ago even before the release of **V6.9**. **TNT** products and the associated interface had to be modified in the way they handle all these projected materials and adhere to accepted standards. You might think, "but I am working only in the United States," or "Japan," or … In fact, the requirements for more

accurate earth surface coordinates in these nations are some of those that require a new approach. Higher resolution images, more precise GPS coordinates, new high precision datums, the use of empirically derived datums, new local and city projections, secret projections, and other evolving requirements in every nation require changes and standardization in the way CRSs are managed. **RV7.0** introduces a completely new subsystem for managing standard and private CRSs into the **TNT** products while providing for increased accuracy and speed. This new conceptual CRS approach is also discussed and illustrated in the accompanying color plate entitled Spatial Referencing in TNT.

ISO 19111:2003 Standard.

Purpose.

Geodesists, surveyors, physical geographers, and other related scientists have devised a wide variety of map projections and Coordinate Reference Systems. Many of these can be easily transposed to a local area to provide an accurate local fit. Others are designed for regional or global applications. Often their selection depends upon the size and shape of the area they will be used in.

Recently the Open Geospatial Consortium (OGC) took the initiative to collect and standardize the definition of elements (not the actual values) needed to describe as many Spatial Reference Systems as possible. These are documented in their document OGC 03-073r1 entitled Topic 2: Spatial Referencing by Coordinates and located at www.opengeospatial.org/specs/.

In 2003 the OGC was able to get these definitions adopted as ISO standard 19111:2003 entitled Spatial Referencing by Coordinates. The ISO, or International Organization for Standardization, is a network of institutions from 146 nations organizing, testing, and publishing worldwide standards. The complete contents of this ISO standard containing all its coordinate reference system definitions can be purchased from www.iso.ch/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=26016&ICS1=35.

Abstract of ISO 19111:2003 is as follows:

"ISO 19111:2003 defines the conceptual schema for the description of spatial referencing by coordinates. It describes the minimum data required to define one-, two-, and three-dimensional coordinate reference systems. It allows additional descriptive information to be provided. It also describes the information required to change coordinate values from one coordinate reference system to another.

"ISO 19111:2003 is applicable to producers and users of geographic information. Although it is applicable to digital geographic data, its principles can be extended to many other forms of geographic data such as maps, charts, and text documents."

Geospatial analysis systems adhering to ISO 19111:2003 can identify the spatial reference system and standard definitions of the elements used to describe the geodata files, tables, layouts, web content, and so on created by any other system. For this purpose, version **RV7.0** of the **TNT** products now defines spatial reference systems according to this standard.

ISO 19111:2003 does not supply the values used with these definitions. This is the task of geodesists and not a standards committee.

Definitions.
This ISO standards document also provides some definitions of the standard terms used in connection with discussing spatial reference systems. These are now the terms that will be used to refer to these concepts and new features in the **TNT** products.

Coordinate Reference System.
A coordinate system that is related to the real world by a datum (for geodetic and vertical datums, it will be related to the Earth).

Coordinate System.
Set of mathematical rules for specifying how coordinates are to be assigned to points.

Coordinate Conversion.
Change of coordinates, based on a one-to-one relationship, from one coordinate reference system to anther based on the same datum. Example: between geodetic and Cartesian coordinate systems or between geodetic coordinates and projected coordinates, or changes of units as from radians to degrees or feet to meters. (A coordinate conversion uses parameters that have constant values.)

Coordinate Transformation.
Change of coordinates from one coordinate reference system to anther coordinate reference system based on a different datum through a one-to-one relationship. (A coordinate transformation uses parameters that are derived empirically by a set of points with known coordinates in both coordinate reference systems.)

Datum.
Parameter or set of parameters that serve as a reference or basis for the calculation of other parameters. (A datum defines the position of the origin, the scale, and the orientation of the coordinate system.)

Map Projection.
Coordinate conversion from a geodetic coordinate system to a plane.

Projected Coordinate System.
 Two-dimensional coordinate system resulting from a map projection.

Geodetic Coordinate System and Ellipsoidal Coordinate System.
Coordinate System in which position is specified by geodetic latitude, geodetic longitude and (in the three dimensional case) ellipsoidal height.

EPSG Geodetic Parameters.

From the ISO abstract you learn that adopting 19111 standardizes how each Coordinate Reference System (CRS) is defined and the elements needed for this to transform it to other CRSs. It standardizes how each CRS is to be identified (name, units of measure, datum, …) and what geodetic parameters are needed to use it (position of origin such as central meridian and latitude, unit of measure, scale factor, …). It does not standardize in any way how this information and the necessary values for these parameters are

referenced or stored. This is left up to each geospatial analysis system. It also does not provide any values for these geodetic parameters.

Geodesists and mathematicians derive, propose, and adopt geodetic parameters for existing and new map projections, datums, CRSs, and transformations. From these are derived the required numeric values for the elements defined for the spatial reference systems by ISO 19111. Someone then needs to decide if these derivations are useful and correct and provide them in an organized form and readable format for use with the definitions in ISO 19111. There also has to be a mechanism for correcting and changing parameters to adjust their precision and to add new ones.

Early US petroleum exploration and drilling activities had the vast North American continent available to them. They had the good fortune to find coordinated multi-national mapping programs and a coordinated strategy concurrently being put into place. However, early European national and private petroleum companies found that even in their own nations and neighbors they had to deal with problems of differing, secret Coordinate Reference Systems (CRSs), datums, and levels of cooperation. To compete with large multinational companies, this situation gradually led them to a cooperative spirit with regard to assembling and sharing this information. Eventually these efforts gave rise in 1986 to the European Petroleum Survey Group (EPSG) to collect, maintain, and provide these geodetic parameters for thousands of CRSs. As a result, the widely accepted standard source for the numeric values used for each ISO standard spatial reference system is the European Petroleum Survey Group (EPSG) database. From their website at www.epsg.org the mission statement and objectives of the EPSG in this area are stated as follows.

"The European Petroleum Survey Group (EPSG) was formed in 1986. It comprises specialist surveyors, geodesists and cartographers from Oil Companies based in Europe and having international operations. Meetings are held twice yearly to discuss survey and positioning topics within those areas of oil industry business where cooperation is generally agreed to be mutually beneficial.

"A geodesy working group maintains a relational database of EPSG geodetic parameters.

"The EPSG aims to help member companies, and where relevant others, by the dissemination of information. The information will improve oil industry survey practices and procedures, will contribute to increased efficiency, enhanced quality, improved safety of operations and to the protection of the environment.

"Through its membership of specialist professionals, the EPSG is qualified to offer collective expert advice to member companies within the fields of geodesy, surveying, positioning and cartography where they relate to oil exploration, development and production operations."

"EPSG, through its geodesy working group, maintains and publishes a data set of parameters for coordinate reference system and coordinate transformation description. The data is supported through formulae given in Guidance Note number 7. The EPSG Geodetic Parameters have been included as reference data in the GeoTIFF data exchange specifications, in the Iris21 data model and in Epicentre (the POSC data model). The parameters are maintained in an MS Access relational database and may be downloaded from this site."

RV7.0 of the **TNT** products now uses the current EPSG V6.6 geodesy parameters released 20 October 2004 for this purpose. Provisions for integrating their 6 month updates into your **TNT** products are discussed below. Since the ISO definitions are standard and the parameters are found in this common source, the Coordinate Reference System, datum, map projection, and other characteristics can be established in the **TNT** products for geodata provided from geospatial analysis systems that have adopted these same standards.

Expectations in Using a Standard Coordinate Reference System (CRS).

Standardization of Information.
It is up to the developer of a geospatial software product to determine how the standard ISO definitions and associated EPSG geodetic parameters are stored, accessed, and used. All MicroImages' **TNT** products, Oracle's Spatial Layers, and GeoTIFF files use these ISO definitions and EPSG geodetic parameters. If, as is the current trend and case in these products, each of their georeferenced files provides access to the identity of its ISO 19111 Coordinate Reference System (CRS), any other compliant geospatial system can use the same CRS for its activities with that file. This assumes of course that each system can read and interpret the data content in that file. For example, MicroImages autolink to, or import of, a GeoTIFF file finds and uses this standard CRS information. It similarly includes the proper CRS information in the proper place in an exported GeoTIFF. If, as is also the trend, the geodetic parameters in EPSG are incorporated in, kept up-to-date, and used within each system, then the **TNT** products are using the same geodetic parameters and CRS used for coordinate system, map projection, and related spatial activities on that file whether it is internal, linked, imported, or returned from some server.

Identical Results are Still Not Guaranteed.
Even though these standards are in place and correctly used to define a particular Coordinate Reference System (CRS), the internal accuracy of the use of this coordinate system will vary slightly between systems. For example, unless the CRS of a linked GeoTIFF file is identical to the desired projection of the composite view, it may be converted as used to match the reference CRS of the **TNT** view using a fast but approximate affine transformation. Another system may use some other transformation or approach to rapidly adjust for differences in the CRS layers in a composite view, thus achieving varying success in matching the geodata layers in the view. On the other hand, coordinate readouts of a point in **TNT** have a high level of precision as these values are derived by using the geodetic-based transformation of that point for each layer. Conversions of geodata between CRSs may be slightly different in each system at the highest precision depending exactly on its implementation of map projection and transformation equations in that system.

New **TNT** Spatial Referencing (SR) Service.

Implementation.
MicroImages stores the ISO Coordinate Reference System (CRS) definitions and associated EPSG geodetic parameters in XML in a reference file (spatref.xml). Since this is XML, it could be used in other non-**TNT** programs.

A built in software module called the **TNT** Spatial Reference (SR) service accesses and uses the contents of this reference file in every **TNT** process in any **TNT** product and is

automatically available for use in your **SML** script or your program developed with the **TNTsdk**. It will also subsequently be used by the **TNTserver**.

Also included in this SR service's reference file are the additional Coordinate Reference Systems (CRSs) and geodetic parameters accumulated by MicroImages over the past 20 years. These earlier definitions and associated parameters are retained from **V6.9** and, along with new CRSs from the EPSG database, make up a collection of **TNT** "predefined CRSs." These predefined CRSs and "private CRSs" that you defined for your private use are also used by the new Spatial Reference (SR) service. Provision has also been made for the SR service to use new and also private CRSs not included in the ISO/EPSG standard approach. Thus, this SR service permits you to mix and move your geodata between these standard predefined and private CRSs. It also provides the framework for the potential addition of other CRSs, such as those that are geocentric and gravity-related. For example, at the moment MicroImages is experimenting with the use of celestial CRSs (ascension, declination, …) and their associated parameters.

> The **TNT** Spatial Reference (SR) *service* determines how the **TNT** products get and use ISO Coordinate Reference *System* (CRS) definitions and geodetic parameters or those added for you by MicroImages.

Access to Extensive New Collection of CRSs.
The incorporation of the ISO standard and EPSG database into the **TNT** products has added thousands of new CRSs. These consist of predefined combinations of coordinate systems and datums, combinations that you mate together, and conversions between CRSs. As a result it is much more likely that you will find the CRS you require already predefined and directly available to select for use in a **TNT** process. If not, then you can select the coordinate system and datum projection separately to define a CRS and the **TNT** Spatial Reference service will combine them together for all your subsequent uses of this CRS.

Accurate Datum to Datum Transformations.
New datums are not often created. Considerable effort and new scientific advances in measuring and representing the shape of the earth are required for change in this area. For example, today these geodetic measurements require new and more precise satellite systems. Then there is the necessity of getting worldwide acceptance of the new datum, which means getting wide scale acknowledgement that it is needed. So new datums are infrequently encountered except in narrow, scientific endeavors for special purposes or for nationalist reasons.

However, periodically new datums have been adopted because they more accurately describe the shape of the earth. The precision and relative accuracy of the measurements of coordinates in a CRS can be increased if a more accurate datum is used. For these and other reasons, you will find new geodata sources (for example, new high resolution orthoimagery) use a newer datum than some older geodata you need to use as well (for example, older maps). Achieving accurate coordinates and results in your project requires that all computational activities on your geodata refer to it using a common datum.

V6.9 of the **TNT** products automatically converted coordinates from other datums to the WGS84 (World Geodetic System 1984) datum when the objects being combined were

in different datums. Then, if required, a reverse conversion was used from WGS84 to get coordinates and the combined results using the new datum. The same procedure was used when an object was deliberately converted between CRSs using two different datums, neither of which was WGS84. WGS84 as a common datum has been popular since 1984 when it was introduced for use with satellite imagery and orthophotos. Due to its popularity, there are many coordinate transformations to and from it. Thus, using it as a common datum for all geodata is a widely accepted approach, especially in low-cost products where maintaining accuracy to 1 meter or better was not needed when converting from datum to datum and had not yet become an issue.

RV7.0 no longer necessarily uses the WGS84 datum as an intermediate step when converting between two other datums. The new Spatial Reference (SR) service uses the accurate transformations associated with the respective CRSs for direct coordinate conversion between datums such as ED50 to ETRS89, Tokyo to JGD2000, and AGD66 to GDA94. Provision has also been made in the standard CRS structure for adding more direct conversion transformations as the EPSG and other geodesists define them. This direct datum to datum conversion of coordinate systems not only increases the accuracy, but is faster since the two previous transformations (one into WGS84 and one out of WGS84) are replaced by one direct transformation if it has been defined. Geodesists and/or mathematicians can also disagree on the best transformation between datums and then publish and promote alternatives. As a result the new SR service lets you choose which to use if one or more coordinate transformation is available for the pair of CRSs. If the needed datum transformation(s) are not available, then WGS84 is used as an intermediate as in **V6.9**.

Maintains Native Measurement Units.

A Coordinate Reference System (CRS) definition specifies the measurement units used for its coordinate axes and associated computations. The new Spatial Reference (SR) service now imports or creates geodata objects in the native measurement units defined by its CRS. Coordinates of georeference points are no longer automatically converted to meters when stored with the object as was the case in **V6.9**. **RV7.0** uses the native coordinates matching the CRS.

6 Month Updates.

Every 6 months EPSG issues Microsoft Access tables to update their geodetic parameters to refine their precision and to define new Coordinate Reference Systems (CRSs), associated datums, and transformations. MicroImages will acquire this EPSG database and integrate its additions into the spatref.xml resource file. Every weekly patch issued for the **TNT** products includes the latest spatref.xml resource file to update the CRSs available to the Spatial Reference (SR) service. In this manner, any new EPSG additions and changes and the new CRSs you request MicroImages to add will be immediately available in the weekly patch for the current version of the **TNT** product.

These EPSG updates and new Coordinate Reference System (CRS) additions will not be incorporated into the spatref.xml file and patches for earlier versions of the **TNT** products (for example, no changes to the spatref.xml file for **PV7.0** after **RV7.1** is officially released).   The easiest way to keep up with the changes in the CRSs used by MicroImages and other systems using the ISO/EPSG standard is to maintain a current subscription and use the current **TNT** products.

New Interface.

Coordinate Reference System Window.
All **TNT RV7.0** processes use the new **TNT** Spatial Reference (SR) service for object to object, screen to object, linking, import, export, and any other geodata changes requiring a Coordinate Reference System (CRS), coordinate conversion and transformation, and map projection operations. As a result all processes now use this new tabbed interface for selection / setup to control these operations. This new uniformity coupled with these thousands of new choices and combinations require a new user interface. This interface must also permit you to define, name, and save private Coordinate Reference Systems (CRSs) and selected datum transformations. For this purpose a new Coordinate Reference System window with tabbed panels replaces the existing Map Projection / Coordinate System window. This window is illustrated and its tabbed panels described in the accompanying color plate entitled Coordinate Reference System Window. The material covered in this and the 3 following color plates on this topic will be assembled and expanded into a new tutorial reference booklet on Coordinate Reference Systems since the current tutorial booklet on Map Projections is temporarily out-of-date.

All these new capabilities and options for **TNT** Coordinate Reference Systems come at a price. You will have to learn to use this new and unfamiliar user interface to select and control these new operations. At first this window and its operation will appear more complicated as by necessity it has to be designed to deal with many new options to control the new **TNT** Spatial Reference (SR) service. Its use will take some patience and getting used to. MicroImages is interested in hearing your suggestions for its improvement and simplification of this activity keeping in mind that it must still cover all these many objectives.

Predefined Tabbed Panel.
The first and default tabbed panel in this window is labeled Predefined. It provides a hierarchical tree structure that you can use to navigate to any one of the thousands of predefined Coordinate Reference Systems (CRSs). The main categories of this structure are Recent, Global and Regional, and National and Local. The Recent grouping will contain the last 10 CRSs you have used with the most recent at the top. If you constantly use the same CRS, you will only need to reselect it each time from this list. If you are looking for another CRS, you will need to traverse into this geographically structured hierarchy until you can find and select it. This and additional options for setting up other CRSs using this tabbed panel are explained and illustrated on the accompanying color plate entitled Predefined Coordinate Reference Systems.

Datum Tabbed Panel.
When you select a complete predefined Coordinate Reference System (CRS) from the first tabbed panel, it has a datum already associated with it. However, you may wish to change to some other datum. In addition, the Predefined list also includes global and regional Coordinate Systems (such as UTM zones or latitude / longitude coordinates) that can be used with any datum and thus require you to select the datum you wish to use to create your CRS. The datum tabbed panel presents a scrolling list of the available datums. The datum automatically associated with the CRS or that you previously selected for this CRS is automatically highlighted in this list. Use this list to select any datum you wish to use in the CRS.

If the datum you have selected has direct transformations to other datums available, you will be asked to select one from a new list shown in this same panel. If the new target datum is not on the list, the transformation will not be direct and will be a two step operation using the WGS84 datum as an intermediary. These datum selection operations are illustrated in the accompanying color plate entitled <u>Predefined Coordinate Systems Requiring Datum Selection</u>.

Create a Private Coordinate Reference System.

Encountering new datums is infrequent, but just the opposite is true for Coordinate Reference Systems (CRSs) and/or their definitions. You could easily create a new CRS for your site, especially if it's large, such as a major hydroelectric project or even a city-wide high precision GPS vehicle tracking network. You could do this by choosing a CRS and altering the geodetic parameters to center it on your site. Frequently you will find that someone for some reason has already done this and you must deal with geodata that cannot be selected from the thousands of combinations presented by the new **TNT** Spatial Reference (SR) service. The accompanying color plate entitled <u>Custom Coordinate Reference System Setup</u> illustrates how this is done using the new CRS interface. (Note, it was decided to call these Private, not Custom CRSs after this color plate was printed so private = custom.) You can also deal with these situations by getting your CRS added to the **TNT** SR service via the next weekly patch discussed above.

Published Additions.

Some of the 93 counties in Nebraska have a locally centered Transverse Mercator Coordinate Reference System (CRS). City/county officials and the surveyors who work in these counties may use it routinely, especially if they have major urban areas such as Lincoln City and Lancaster County combinations. Rural Nebraska counties may not need that local accuracy and use the generic large UTM zone or each state's state-wide CRS system called the State Plane CRS. If you encounter these kinds of local conditions, it is best to get their CRS incorporated directly into the **TNT** product. This is also the best approach if this new CRS will be widely used in your geographical area. Adding a new CRS to the definitions used by the **TNT** products is easy via the patch procedure if you provide the required parameters in sufficient accuracy. You should also provide some sample data points with paired coordinates for testing our implementation of any new CRS. These are used to test the implementation (parameters and coding) by using them with the new CRS in the **TNT** Map Calculator since it uses the common **TNT** Spatial Reference (SR) service.

Private Additions.

The second alternative is to create, name, and save your own private Coordinate Reference System (CRS). You might choose this route because no one but you would be interested in using this CRS. Or, you might choose this method because the organization you are working for or with does not want this CRS to be publicly available. Once you have set up and named a private CRS, it will appear for selection in a new major category named Saved on the Predefined tabbed panel. The steps in adding private Coordinate Reference Systems are illustrated in the accompanying color plate entitled <u>Custom Coordinate Reference System Setup</u>. Private CRSs that you set up this way are defined and saved in a separate XML reference file (savedcrs.xml) that is not changed or overwritten when you patch or update your **TNT** product.

Adding a private Coordinate Reference System (CRS) and corresponding parameters for use in the **TNT** Spatial Reference (SR) service does not violate the concept of adhering to ISO standardization. You still need these projections to deal with your local and special situations within the **TNT** products.

Backward Incompatibility of New Coordinate Reference Systems.

Minor inconvenience of backward incompatibility is not new.

To avoid producing an irresolvable error in the operation of **V6.9**, Project Files are marked by **RV7.0** as unusable and backward incompatible if they contain an object using a new feature unknown to **V6.9**. This same procedure has been used in previous releases. For example a Project File created in **V6.9** in a **TNTatlas** was marked as unusable in some earlier versions if you specified in the **TNTatlas** wizard that only the Software Access Key used to create it could gain access to objects in that Project File. If you attempt to use such a Project File or one containing such an object in an earlier incompatible **TNT** version, it is then not recognized as a Project File and can not be selected in that older version. In the past this has seldom been a problem since it was obvious to you that you were using a new feature and that the object would not be backward compatible with earlier **TNT** releases. You simply kept that object in its own separate Project File from any other objects, restricted its use to the current version, or did not use the feature.

But temporarily of more significance.

RV7.0 provides 3 new features that if used with an object will make that Project File unusable in any earlier version: using label frames and leader lines in a CAD object; georeferencing a manifold object; and selecting a previously undefined Coordinate Reference System (CRS) for any object. The first 2 pose no special problem as it is obvious that these are not usable in an earlier version of the **TNT** products, are new and special features, and they are easily isolated to their own Project File if you intend to move any associated objects back and forth to an earlier version. However, the CRS is used for every geodata object in the **TNT** products. This, coupled with the many new CRSs added in **RV7.0**, creates circumstances in which this backward incompatibility is more likely to occur and, thus, mark that Project File as backward incompatible. This might occur because you are using both **V6.9** and **RV7.0** on the same machine, have several **TNT** licenses at different versions, or supply a Project File to someone else with an earlier license.

All the Coordinate Reference Systems (CRSs) used in objects in **V6.9** are recognized and usable in **RV7.0**. Correspondingly all the CRSs available in **V6.9** are still available in **RV7.0** and, if selected for an object in **RV7.0**, it and its Project File can still be used in **V6.9**. However, no provisions were made in **V6.9** or earlier versions of the **TNT** products to even recognize that an unknown new CRS available in **RV7.0** has been used in an object. As a result, **V6.9** and earlier can not even inform you that a new CRS has been detected and the Project File can not be selected.

Caution: Picking a completely new and previously undefined Coordinate Reference System (CRS) in **RV7.0** will create a Project File that can not be used in **V6.9** or earlier.

At the bottom of the Coordinate Reference System Window to help you avoid this situation you are presented with a means to tell the **TNT** Spatial Reference (SR) service how to deal with this condition every time the SR service is used in any process. It permits you to select this global "Compatibility with TNT version 6.9 and earlier" from 3 options.

Warn if not usable. This is the initial default and every time you choose a Coordinate Reference System unknown to **V6.9** you will be warned that the new object and Project File it is in will not be usable in **V6.9** or earlier. If you are working primarily in **RV7.0** and seldom use Project Files in earlier versions, then this may be your best choice.

Required. This setting will prevent you from selecting any new Coordinate Reference System that is not available for use in **V6.9** and earlier. If you are frequently moving Projects Files between **RV7.0** and earlier versions for some reason, you should use this setting.

Not checked. Use this setting if you do not have any earlier version of your **TNT** product installed and do not intend to do so.

Will become insignificant again in future releases.

About this point you are asking, if only one object in a Project File uses a new feature, such as an unknown new Coordinate Reference System, why does this make the entire file backward incompatible? Previously this never posed an issue for you or MicroImages with earlier versions for the reasons already noted. In part this was also due to the fact that before the current efficient **TNT** patching system and your access to it by a broadband connection, you were less inclined to maintain and use two versions of your **TNT** products (for example, The Tried and True and Something New). Thus, no provision was incorporated in any earlier version of the **TNT** product to record with the object the minimal version that is needed to use the object.

Recording the version of the **TNT** product that created or modified a geodata object has been added to **RV7.0** for future use. For example, if **DV7.1** or **RV7.1** adds a new feature to an object making it unusable in **V7.0** or earlier, this restriction will be understood and applied by **V7.0** at the object level, and not the Project File level. Thus, adding an object with new features restricting it for use in the current or new versions, would mark only that object in the file as incompatible for the earlier versions. **V7.0**, and future versions, can then recognize this, deny access to that object only, and tell you that the object's use is not permitted in the older version you are running due to new features. However, it will not be able to tell you what new feature you have used to create this condition since they are unknown at the time that the earlier version of the **TNT** product was created. But, **V6.9** exists and has no ability to recognize this object level version tracking system added to **RV7.0**. Altering **V6.9** for this purpose via a patch would be complicated and risky. After a couple of additional new releases, this will no longer be a problem at the Project File level and any new Coordinate Reference System can be used without these complications.

And forward compatibility is ensured.

As you have come to expect, great effort is expended in ensuring forward compatibility of your **TNT** object and Project Files to protect your investment in data creation and its analysis. As in the past, **RV7.0** of the **TNT** products maintains forward compatibility for all your existing Project Files created with earlier versions. As new procedures and features are added to the **TNT** products, the associated processes continue to recognize and use older Project Files and objects created earlier. Modifying these earlier objects

in a new version may automatically update them to support their use with improved performance in newer versions unless you deliberately prevent this from happening for backward compatibility. For example, pyramid layers are added to raster objects and optimization applied to vector objects automatically to improve these objects performance for both display and analysis.

Miscellaneous.

At the request of various clients, the following new projection methods are available:
- General Oblique Mercator for various locations,
- Krovak Oblique Conic Conformal for the Czech Republic and Slovakia,
- Lambert Conformal Conic single standard parallel for SE Asia,
- Transverse Mercator South oriented for South Africa,
- Bonne, and others.

A high-accuracy grid method has been added for converting between Tokyo and JDG2000 datums.

Shape Objects.

The concept of the use of a shape object in a **TNT** Project File was first introduced in **RV6.9** as a work in progress that continues in **RV7.0**. The design of a shape object is database-centric, that is, it has the easy maintenance of a complex database structure as its principal goal. Primitive graphical data elements (points, lines, arcs, …) are treated as fields in the tables. The relationship and information about how these primitive elements are assembled into features is maintained in the database structure.

Why Not Use a Vector Object?

A vector object must maintain very rigorous topological relationships to enable advanced spatial analysis. It can be thought of as designed to be area- or topology-centric. Maintaining attributes for these features in an external linked database can be difficult especially when that database must be secure and/or controlled by others. This is easier to accomplish if the attributes and other database structures are in **TNT**'s internal relational database format, but this may not meet your project's requirements.

Why Not Use a CAD Object?

CAD objects, usually imported from external CAD files or captured as sketches, have no topological features and can be very complex in graphical content with many lines and polygons constantly crisscrossing and in very close proximity. The CAD object has been designed to be graphics-centric. CAD files and, thus, CAD objects maintain no concept of area in a geographic sense. Very complex relationships between elements can also occur in an external CAD file and any associated database. These can be difficult to preserve when converted into a vector object as they create complex topology due to the many overlapping features and rendered blocks, which in turn create cumbersome relational database structures. A CAD object is closer to a shape object than a vector object but is designed to optimize its graphical structure, geometry, and contents and not its relational database structure.

Why Use a Shape Object?

When fully implemented and supported, this database-centric design of a shape object is most effective for use with geodata layers whose extensive attribute data is being maintained in external databases (for example, Oracle, DB2, MySQL, and others). In

these cases, the graphical elements can be maintained in the shape object without topology while the tabular material can remain in the external database or is imported into the shape object for use in the **TNT** internal relational database structure. Alternatively, all the original tabular and associated graphical elements can be retained in their original external structure and a link, or wrapper, automatically created when they are selected for use as a layer in a **TNT** view or as input to an analysis process. This is the initial use of the shape object to support the efficient and direct use of database-centric geodata structures of other systems such as Oracle Spatial Layers, ESRI shapefiles, MapInfo TAB files, and others.

Linking to a shapefile in **V6.9** treated it as a CAD object and had to take the time to set up all the database associations between the elements and the records. The shell of a shape object was introduced in **RV6.9** to provide for the direct link and use of Oracle Spatial Layers.   **RV7.0** uses this same shape object concept to provide a faster and more flexible link to a shapfile. This new link file contains a description of how the shapefile is to be interpreted to make it respond as a shape object to the **TNT** processes.   It also provides the basis for storing information to enhance the use of the shapefile to provide features not originally supported by the shapefile. Several of these are provided by the new, fast link to shapefiles and are discussed in the section just below entitled Direct Display of ESRI Shapefiles.

2D Display.

Direct Display of ESRI Shapefiles.

Linked Via Shape Objects.
Shapefiles are now widely used as a public means to transfer graphical geodata and associated attributes especially on the Internet. As a result, many software products of varying quality are creating them. More and more shapefiles are being encountered that do not conform to the published ESRI specifications but may work in an ESRI product due to undocumented flexibility, features, or adjustments. Changes to the **TNT** products to detect and accommodate these non-standard features in shapefiles are made as they are encountered, and these adjustments become available to you through the weekly patches to the **TNT** products. However, shapefiles are now being encountered that can not be used in the appropriate ESRI product. Solutions to these cases are not guaranteed and they may need to be returned to their source for improvement.

RV6.9 permitted the selection of shapefiles as layers for use in displays or importing including their area, line, and point styling.   As noted in the section above entitled Shape Objects, the direct display capability for shapefiles is now handled via a link through a **TNT** shape object rather than a CAD object. This and associated changes have enabled several new and useful features to be supported for linked shapefiles. These features are all enabled via the link file and the original shapefile is not altered and can be used with its original characteristics and limitations in an ESRI or other product. Shapefiles can still be imported and converted to vector objects with topology or CAD objects. As yet they can not be imported to an internal shape object since the use of this new object type in other processes is not yet fully supported.

The shape object Project File created for this link is merely a shell. It contains the equivalent **TNT** styles, font identities or substitutions, additional tables, table indexes, and other reference information to make this external shapefile or an Oracle Spatial

Layer appear to all **TNT** processes as if it was an internal shape object in a Project File. (For a more detailed discussion of the use of the shape object as a link to Oracle Spatial layers see the MicroImages MEMO entitled Release of RV6.9 of the TNT Products.) This is the same approach used in the transparent linking to and direct display of images in JPEG, JPEG2000, MrSID, and other raster formats. Just as for shape objects, these links make the external raster appear to the **TNT** processes as if it were actually an internal raster object.

Faster Links.

The most significant benefits of linking to shapefiles via a shape object is that it is much faster as it does not import or change any of the contents of the shapefile. The previous linking in **V6.9** via a CAD object was slow as it had to reconcile element and attribute associations. In **RV7.0** selecting a shapefile as a layer for a complex view will now create its link sufficiently fast so as to make it unnoticeable that a link is actually being built. And, with the addition of the new legend for the shape elements and the standard **TNT** features such as map projection conversion, the direct use of shapefiles is quite transparent! Shapefiles can still be converted to vector or CAD objects by importing them.

Coordinate Reference System.

Shapefiles may, or may not be accompanied by the ESRI projection file (*.prj). This is the problem with having many component files for your project. If this file is not present, then the shapefile may be in latitude and longitude coordinates or may not have any projection. When a *.prj file is available, it is used to establish the Coordinate Reference System (CRS) in the shape link file. If no *.prj is present, then it is assumed that the shapefile is in latitude and longitude coordinates as long as its coordinates are in the range of latitude and longitude (which means, +/-90 and +/-360, respectively). If no *.prj is provided and the coordinates exceed these limits, then the shapefile is assumed to be in an engineering or arbitrary CRS. It can be displayed alone or with other layers that are present, which probably are in the same engineering CRS. However, if other layers are added to such a view that are using a projection, then a warning about mixing arbitrary or nongeoreferenced layers with georeferenced layers will appear.

Legend Entries.

An important addition created by linking to shapefiles via a shape object is gaining access to the styles used in the AVL style file (*.avl) associated with the shapefile. The styles accompanying the shapefile in its *.avl file were first used in **V6.9** to style its elements and have been expanded to support their use in the LegendView especially via network linked files. Now these styles are used to create legend entries in the LegendView, which appear and behave just the same as those for an internal vector object.

Linked shapefiles also now use the built-in advanced **TNT** styling procedures and these enhance the appearance and usefulness of the AVL legend entries for that layer. A single AVL style can be subdivided into new style entries, such as a population range. Or, 25 colors might be assigned as styles in the AVL file to 200 national boundary polygons creating 200 legend entries with the duplicate colors repeated. The LegendView process can detect this, make 25 color entries, and place multiple country names next to each color. Both of these and other related improvements applied via a linked shapefile and its associated ArcView legend are illustrated in the accompanying color plate entitled Direct Display of Shapefiles/Legends/Styles.

Alas, the needed AVL style file may be missing when the shapefile has been created particularly outside the ESRI Products and where the third party product is using the shapefile merely as a convenient format in which to deliver graphical data. If the shape-file is provided without its AVL styles, then **TNT** styles can be assigned to the elements.

> **Note:** Many shapefiles are being created to hold graphical geodata and associated attributes but are not provided with associated styles in an AVL style file.

DataTips and Multiple Tables.

Shapefiles have only a one-to-one linkage between the elements and the attributes. A **TNT** shape object has an implied one-to-one linkage permitting an element to derive in-formation directly from more than one attached table. The shape object link to a shape-file is used to define and contain any modifications of this type, such as creating additional tables for the shapefile elements. This permits the advanced features used for database attributes in **TNTmips** to be used with these layers without altering the original shapefile. These include adding additional tables, creating virtual tables, creat-ing single and multiple line DataTips, and other unique **TNT** features for this linked shape layer as illustrated in the accompanying color plate entitled Direct Display of Shapefiles/Legends/Styles. Now, when a shapefile is linked to and used in a **TNTmips** view, it can be set up to provide the kinds of features you expect to have available.

Unit Conversion.

If a numeric value is needed in multiple units in a shapefile, it has one field for each con-verted unit. **TNTmips** provides more than 50 units and their conversion. Identifying the units of a single field in a shapefile permits a DataTip or multi-line DataTip to display these values in any other units for features in the layer even using virtual fields.

Frame Color.

The default color for the background for your DataTips can be set using Support / Setup / Preferences. Select a color to make them more visible for their associated view layer. No more pale yellow DataTips on yellow or faded white map backgrounds!

Raster Display.

Automatically use the binary "null mask" subobject if it exists. This subobject is created by raster mosaic, reprojection, and extraction when a single null value is not specified or is ambiguous due to inputs having multiple or no null values.

Vector Display.

When adding a vector layer, a "density check" is now performed to determine if it may be inadvisable to display the vector at full view. If the vector is determined to be too dense, a verification window is displayed with options to not add the layer, add as nor-mal, set maximum visible scale, and initially hide the layer. The default maximum visible scale is set automatically based on the density. This setting helps avoid displaying the vector when the time required may be long or the features may not be visually sepa-rated. This new feature helps you avoid long delays and its use is illustated in the ac-companying color plate entitled Managing Display of Large Vectors.

* CAD Object Display.

Layer Controls.
The CAD Layer Controls window for the display of CAD objects has been redesigned to use tabbed panels to support the many new options for rendering CAD elements. This window is now modeless, meaning that all you need to do at any time to see these changes in the view is to press the "Apply" button in the lower right corner and/or click on the Redraw icon in the view window without closing the CAD Layer Controls. The window has three tabs: Object, Elements, and Label.

Object Panel.
The Object panel contains the object, style, and georeference selection controls, but adds the "Warp to Model" and "Scale Range Visible" controls that were available in the **V6.9** Vector Layer Controls.

Elements Panel.
The Elements panel consists of the "Select" and "Style" controls and now provides the DataTip controls for easier access. In **V6.9** the DataTip settings were made via a Tools icon menu selection.

Label Panel.
Options. The Label panel contains all the new controls for new CAD text styling and rendering capabilities added in **RV7.0**. The new option to "Clip Elements to Label Boundaries" operates in the same way as the vector control of the same name available in **V6.9** and causes the clipping out of a section of all the CAD elements around each label. For example, lines are clipped around, and do not run through labels. The "Show Label Baselines" option will show the CAD text element baselines used to position every label for rendering.

Frames and Leaders. In **RV7.0** the Frame Style button brings up a tabbed window to enter label frame and leader line parameters. This is the same panel as provided in **V6.9** for designing vector labels and is also illustrated in the accompanying color plate entitled Enhanced Sketch Annotation. Using the Frame tabbed panel, the labels' frame shape and margins; border style, color, and width; and fill style, color, pattern and transparency can be designed. Using the Leader Lines panel the labels' leader style can be set as a line with a width and color or as a triangular leader whose properties (for example, line style, background color, and transparency) match those of the frame it will extend out from.

During import or from some other **TNT** activity, each CAD text element could have its own individual label frame style assigned. Thus if "Style By Element" is selected, the label frame styles set up using this control will not be used in favor of the individual element frame styles.

GeoToolbox.
The cross section generation tool now optionally generates a manifold object for the cross section drawn on a vector object. This is discussed in detail in the section below entitled Manifolds.

Annotating a Sketch Layer.
All the **TNT** products including the FREE **TNTatlas** and except **TNTsim3D** permit you to create a sketch layer in a view that can be saved as a CAD object. You can create at-

tribute records in a table as you add features to the sketch. You can set up this table before or when you decide to draw a new element and create new records to go with the elements. A sketch layer is a quick way to sketch in data over an image in a field setting using a FREE **TNTatlas** or to create a graphical annotation layer to add to the group for the current view, perhaps for use in a layout.

Labels are added to your sketch layer using text tools provided in the GeoToolbox. **RV7.0** permits you to improve the appearance of labels used for annotation purposes by adding frames, frame background color, and leader lines to labels. These labels can have all the cosmetic properties previously introduced for labels, such as rounded frame corners, transparent backgrounds, and triangular leader lines. A single label can also have multiple leader lines to point to several common features. The accompanying color plate entitled Enhanced Sketch Annotation illustrates the use of these new sketch features for annotating an image.

Profile View Tool Updates.

A new mode was introduced in the Profile View tool. For a given set of points it reads values from a mutiple raster set (hyperspectral set, time series, and so on) and generates a profile where the x axis is the raster ID number and the y axis presents the values from the raster cells. This new profile is illustrated in the accompanying color plate entitled Graph Values from Multiple Rasters by Cell Location.

Styling DataTips.

Background.

DataTips continue to be a powerful feature that is relatively unique to the **TNT** products and are easy to set up while producing more attractive results. Conceptually DataTips provide value and/or text metadata about a specific feature without cluttering up the geographical features in the view. In **V6.9** the standard background, border, and text colors of DataTips and ToolTips can be uniformly defined for all pop-in features via Support / Setup / Preferences / Interface and use the ToolTip Colors button (now the ToolTip and DataTip Colors button) to open the Color Editor window for this purpose. Remember that after changing any of these from the default and selecting OK, you must exit and restart any open process for the changes to take effect.

Styling Text and Values.

RV7.0 permits the DataTip contents to be much more attractive in form by the addition of the use of text formatting control codes. The text strings and value or virtual value of each line in the DataTip can now be styled by including the **TNT** text style codes in these lines. All the {~} **TNT** text formatting control codes can now be used to attractively structure the appearance of the DataTip. These include defining the text style and font, color, tabs, and many others.

Dynamic Frame Backgrounds.

A special text code has been added to permit you to set and dynamically change the color of the background in the DataTip frame. Use {~BG=red} or {~BG=90,10,10} to set the background color of the text string for the DataTip to the color "red" or to R=90%, G=10%, and B=10%. This format code can be stored with or derived and added to a DataTip via a virtual (computed) field or added to the prefix for the DataTip in the Layer Controls. Thus several {~BG} codes might be inserted in a DataTip string from various real and virtual sources and unlike text format codes, only one background color can be

applied to all of the DataTip. The first {~BG} code encountered is the one that will be used. The accompanying color plate entitled <u>Setting DataTip Background Color</u> illustrates this added feature.

As noted above, a color background can be set up for all the DataTips using the Support menu. Subsequently a virtual field can insert a new {~BG} code to override and change this default background color. The first layer with a background color specified for the nearest element determines the background color of the DataTip, so the background color may change depending on which layers are included in the DataTip for the current cursor location.

To support this expanded use of the DataTip text string for format codes, the prefix for each DataTip has been expanded from 31 to an unlimited number of characters. The application of these codes is illustrated on the accompanying color plate entitled <u>Add Styling to DataTips</u>. All the current available text formatting control codes (except ~BG, which was added after this plate was printed) are documented on the reverse of this color plate.

<u>Use with CAD Layers.</u>

Important: CAD layers can now have DataTips with all the current features available for use with vector layers!

The new CAD Layer Controls window via the Elements tabbed panel now presents the same DataTip setup controls as the Vector Layer Controls window. Now CAD layers can also have the new GraphTip and Display Control Script features discussed below.

<u>HelpTips.</u>

Remember that DataTips can be set up in a special form referred to as HelpTips. These are multiple line instructions that are spatially sensitive and pop in depending upon where the cursor is stopped for a moment on the view. This is an automatic transient pop-in effect. HelpTips were introduced in **V6.0** of the **TNT** products and can be seen in the color plate entitled <u>Data Logger APPLIDAT</u> and now located at www.microimages.com.

HelpTips are made up by attaching a table with a long string field containing these instructions. The vector is used to control the action of the cursor. When the cursor is moved around the view and hovers, the instruction of what to do next are a popin HelpTip, which is simply a text only, time delayed DataTip. For example, the HelpTip might pop in to instruct the user to "depress the left mouse button to select …" while elsewhere in the same view it may present other instructions. With the new format codes and enhancements, these HelpTips can now be more attractively structured and presented.

<u>GraphTips.</u>

RV7.0 adds new, unique capabilities in the **TNT** products to provide for interaction with the view, hidden layers in the view, or with objects not in the view at all but that match some area of the view in extent. The user selectable methods of using Tool Scripts, Macro Scripts, Display Control Scripts, and others make up one group of scripts all of which are implemented using the **TNT** internal geospatial scripting language (**SML**).

The second group contains information that is set up in advance to occur interactively. DataTips and HelpTips were members of this group in **V6.9**. **RV7.0** adds new and powerful capabilities of this type with the additional implementation of Enhanced DataTips, GraphTips, and Display Control Scripts. The editorial section above reviews how these features have evolved in **TNTmips** by our joint efforts with you.

These new capabilities also grade into each other and the terms DataTip and GraphTip are loosely applied to convey the appearance of what these methods look like to the end user when they pop into the view. The underlying code and procedures for establishing these results is the earlier DataTip procedure that has been extended to accommodate formatting codes and other new extensions. Now the new Display Control Script is the basis for the pop-in display of a GraphTip and more complex spatially determined GraphTip applications. The Display Control Script is saved with the **TNT** layout or group and a simple extension of the display process detects it and runs the script to monitor the cursor movement and position. If you add this layout with an associated Display Control Script to your **TNTatlas**, it will be automatically run in that atlas. To assist you in reviewing some of the properties of DataTips, GraphTips, and Tools (Tool Scripts) a color plate entitled Use a DataTip, GraphTip, or Tool? accompanies this MEMO.

Few alterations were required to **RV7.0** to enable these various new powerful features. To get things working together and tested, implementing a series of examples was needed. The ability to explain these interactive samples in text is limited. They are better illustrated by a series of sample applications. The sample CD atlas of Afghanistan was prepared to permit you to try 4 of these concepts. The sample DVD Property Viewer atlas for Lincoln, NE also illustrates Enhanced DataTips based on extensive property ownership records.

Sample Display Control Scripts.

Each of the following sample Display Control Scripts (DCS) can be downloaded from the **TNT** script library at www.microimages.com/sml/. Depending upon their size, all or a unique part of these sample Display Control Scripts is printed on the reverse of the color plate that illustrates it. These printed versions are annotated to help you understand the script's structure and procedures.

Local Time Zones.

This sample Display Control Script (DCS) displays the current local time as a clock for any pause position of the cursor on the view of the outline map of the world. The color of the clock indicates if it is an acceptable time to call into that time zone based upon a test of whether the current time there is within or outside the programmed definition of local calling hours.

This sample script uses only a display of the global political boundaries layer from the DVD entitled Global Reference Geodata distributed with **V6.9**, polygons of time zones from a hidden vector layer, and the time set on your computer. You could dress up this map by adding the world image layer to this display from this same DVD. This GraphTip resulting from this DCS is illustrated in the accompanying color plate entitled Local Time Zones.

Pie Chart and Bar Graph.

These sample Display Control Scripts (DCSs) show two simple examples of how data relationships can be better illustrated in a GraphTip than using text in a DataTip. One

presents a pie chart GraphTip of the family structure of the households in Nebraska counties using **TNTlite** tutorial geodata supplemented with population information. This GraphTip is further enhanced by providing both the identification of the sectors and the actual values of the sectors in matching colors. The DCS simply draws what appears to be a text only DataTip below the pie chart. The results of this DCS and a discussion of its structure are presented in the accompanying color plate entitled Pie Chart and Bar Graph. This DCS in a slightly modified form can be interactively tested using the TNTatlas of Afghanistan shipped with this **RV7.0** of your **TNT** product. Its operation in this **TNTatlas** is also illustrated in the accompanying color plate entitled GraphTips in the Afghanistan Atlas.

The bar graph GraphTip illustrates how a DCS can provide another method to present interrelated data. This bar graph GraphTip presents the age groups in Nebraska counties using **TNTlite** tutorial sample datasets. Most of this DCS is devoted to drawing these features. It can serve as a model for your GraphTips that are oriented toward presenting histograms. The results of this DCS and a discussion of its structure are presented in the accompanying color plate entitled Pie Chart and Bar Graph.

Enhanced DataTips and GraphTips.
Similar results can be automatically displayed quite differently in a DataTip versus a GraphTip depending upon your objective. The accompanying color plate entitled Enhanced DataTips and GraphTips illustrates this by presenting the same information in both forms. The DataTip is easily set up and formatted. It presents slope and aspect numeric values in an attractive format for the current cursor position on the color-infrared image in the view. Both of these values are virtual fields computed from the cell's center at the cursor position. This presentation is more than adequate for a forester studying the vegetation distribution.

The corresponding GraphTip example uses a DCS to compute and graphically present these same values as gadgets. In this example, the cursor is being moved about on a geologic map enhanced by the addition of shaded relief and a contour map. Making these same slope and aspect computations in the DCS and presenting them in this GraphTip form is oriented toward the way in which a geologist measures and evaluates them. Also note that the reference orientation for each of these computed properties is obvious in these gadgets (which means, the baseline for the slope and the reference direction for aspect). This information is not obvious in the DataTip version but is easily deduced by the forester from the image. This DCS in a slightly modified form can be interactively tested using the TNTatlas of Afghanistan shipped with this **RV7.0** of your **TNT** product. Its operation in this **TNTatlas** is also illustrated in the accompanying color plate entitled GraphTips in the Afghanistan Atlas.

Profile of Nearest Line.
For any position in a view, a geospatial script can detect the nearest point, line, or polygon within a specified radius. This has been available for use in Tool Scripts and other **SML** processes to find the closest element to the cursor position at which the mouse is clicked. Now this can also be used in a Display Control Script (DCS) to automatically detect the nearest element of the designated type and layer. Thus a DCS can automatically detect, access, and process the nearest element within the specified radius when the cursor pauses.

The accompanying color plate entitled <u>Profile of Nearest Line</u> illustrates this and also that a GraphTip can actually be a graph. This example is for a drainage network used as a vector object overlaid on the display of a DEM raster object. Whenever the cursor pauses near a drainage line, it is detected and highlighted by the DCS. The script then traces the profile of the drainage line along the DEM. It then presents a GraphTip that is the elevation profile of the highlighted drainage segment. The elevation of the drainage at the nearest point on it to the cursor position is also indicated.

In a second example, the drainage overlays a color orthophoto but the GraphTip is still its elevation profile. In this case the DCS points to and uses a DEM, which is a hidden layer in the view or it can be simply a raster object in a known path location.   One of the "under-the-hood" features of this and other geospatial script applications is that it can automatically take advantage of the powerful transparent spatial data management aspects of the **TNT** products. For example, an off-line DEM raster object (in other words, its path only is specified by the script) not added to the view can be of any map projection, cell size, and extent as long as it covers the requested drainage segment or part of it. The script will still be able to automatically trace the drainage across it and present the profile. In fact some other program or action could substitute a new off-line object of the same name and geodata type and the GraphTip would still be presented. Even with all these various automatic geospatial conversions, the GraphTip still pops in within a fraction of a second.

This DCS in a slightly modified form can be interactively tested using the <u>TNTatlas of Afghanistan</u> shipped with this **RV7.0** of your **TNT** product. In this atlas the nearest road segment is detected, and the GraphTip is the elevation profile of the road. This would be a particularly useful means of quickly choosing a route for rapid movement in this mountainous terrain. Its operation in this **TNTatlas** is also illustrated in the accompanying color plate entitled <u>GraphTips in the Afghanistan Atlas</u>.

<u>Display Control Script Approach Versus Tool Script.</u>

To present a GraphTip, a Display Control Script is automatically run for each pause of the cursor in the view. A Tool Script is a tool selected by an icon from a number of tools/icons on the icon toolbar of a **TNT** view. Some of these tools/icons are connected to preprogrammed, built-in **TNT** features (in other words, Zoom In, Select, View-in-View…). However, if they are connected to a Tool Script, they run the associated script. A common Tool Script procedure in such a script is to await a mouse click in the view and then act on that position in the view. Once a pause is detected in a DCS or a click in a Tool Script, quite similar results can be achieved since both then have access to and use the extensive capabilities of the **TNT** geospatial scripting language. However, the DCS is automatic and pushes information at you, while the Tool Script requires interaction and is used to pull information to you. As a result, while these scripts can have results, they are different in some aspects of their structures as illustrated by the following sample scripts, which could produce an identical visual result.

<u>Spyglass View Display Control Script.</u>
This example illustrates that a Display Control Script (DCS) can present GraphTips that display portions of any **TNT** raster or geometric object. When the cursor is paused in a view, this DCS detects the position of the cursor and inserts a circular view of a specified **TNT** layer or **TNT** object into that circlular area. This GraphTip closes when the

cursor is moved and reappears at the next pause position. It acts something like an automatic View-in-View.

The contents of the interior can match in scale and features at the edge of the circle (as in these examples), be zoomed, or whatever you define in the script. The contents can be from a raster, vector, shape, or CAD layer or directly from an object not used in the current view. When an object is used, it does not have to be in the same Coordinate Reference System, datum, cell size, scale, element size or length, and so on. All these possible conversions are handled automatically in a geospatial scripting language, such as **SML**.

The accompanying color plate entitled Spyglass View illustrates a DCS that fetches a matching circular area from a color image raster object and displays it in a view of a topographic map. A second illustration on this plate shows a circular view fetched from a soil map vector object. This GraphTip contains the soil polygons matching the map scale and filled with transparent colors so as to not obscure the underlying topographic map features. Note also that each time this GraphTip moves, it may have a different subset of the soil types within it. Thus, the LegendView is also updated to identify only those soil types currently exposed in the circular view.

Clearly a lot of activity is being conducted by this kind of DCS and yet it is interactively able to push these GraphTips into the view in a second from large objects. This is because years of work have gone into the **TNT** processes (pyramiding rasters, optimizing vectors, indexing tables, …) and, thus, **SML** toward seeking speed in accessing small areas from what can be potentially very large geodata objects. Any shape and size of an area that can be defined or computed in this DCS or the Tool Script that follows can be used instead of a circle. Some examples would be to compute a region(s), a viewshed, a route, buffer zone, and so on. A geospatial scripting language is ideal for such purposes. However, complex scripts may take seconds to complete and would be more suitable for running only on demand in a Tool Script.

Pop-In View Tool Script.
A Display Control Script can present dialogs but often does not as its purpose is to automatically present or push information to you. Thus, a DCS is usually designed around your setup of known layers and objects in known postions such as in a **TNTatlas**. A Tool Script runs on demand from an icon. As a result the geodata, control parameters, and other inputs it uses can be obtained at the time of its use by including XML defined dialogs in the script. As a result Tool Scripts can be designed to provide a widely used and reused tool since the location and type of geodata each uses can be requested from any user. Their operation can also be modified by the user, such as setting the radius or picking a shape for the GraphTip in this example. They can also be used to present forms, populate tables, and start other programs, such as a browser with a URL containing the cursor's position.

The accompanying color plated entitled Pop-In View illustrates a Tool Script that also fetches and inserts matching circular views from a raster object and from a vector object that are not part of the current view. However, this tool differs because when its icon is clicked, it requests the type, location, and name of the object to insert into this circular area. Once you have provided this input, the circular view of that object is inserted at any position of the cursor when the mouse is clicked. It remains in the view until a new position is clicked, another tool is selected, or the view is refreshed. Since this is a Tool

Script and requests all its needed inputs, it can be added to the icon tool bar and reused with any **TNT** desktop product.

The color plate illustrates two results. In one the object selected for the interior of the Pop-In View is a raster object that contains a combination of a vector object of a geologic map overlaying a shaded relief raster object. The image in the view is a color orthophoto. The second example uses the 1-foot color orthophoto raster in the Lincoln Property Viewer **TNTatlas** in the view. The Tool Script then inserts a circular view of the vector object for the floodplain polygons from the floodplains vector object in this same atlas. These polygons are found, clipped, and inserted into the circular area with transparent colors so that the image features show through. As noted above, you can download this Tool Script from www.microimages.com/frestuf/scripts.htm and add it to your icon tool bar using the instructions on page 47 of the tutorial entitled <u>Writing Scripts with SML</u>. You will also find in this tutorial 14 pages of information about other Tool Scipts, Tool Script templates, and how you can create you own tools.

<u>Miscellaneous.</u>

The default mode for DataTip viewing is set to "all layers" if you have not previously set it to something else.

An option has been added to not draw labels until other layers in the group have been drawn.

When the scale range for viewing a layer has been set, it is added to the DataTip that pops in when you hover over the layer name in the LegendView.

You can now set which raster is to be used when a 1X zoom is requested. This is set on the Options panel of the Raster Layer Controls. It can be used to control which raster to use in situations where rasters of significantly different cell sizes are mixed.

A new zoom mode icon (red magnifier with a "+" sign) is now provided by default on the icon bar of the view window. Selecting this icon puts the cursor in the mode to continually zoom in 2X at the feature you point to when you click the mouse. If you click the numeric keys 1 thru 4 in this mode the zoom will be at the cursor and have the same result as if you were in any other mode. For example, if you type "1" the zoom will be to full resolution and centered on the cursor.

You can now highlight and show an element from a hidden layer.

When a view has any hidden layers/groups then by default these are hidden in the View-in-View tool.

* 3D Display.

<u>Surface Rendering Modes.</u>

The rewrite of the **TNT** 3D rendering engine and previously available features is complete in **RV7.0**. Dense Ray Casting, Variable Triangulation, and Sparse Triangulation surface rendering options have been fully implemented. These rendering modes (selected from the Surface Layer Controls dialog) determine the elevation accuracy and speed of rendering of the 3D surface model on which your other geospatial layers are draped. The two original surface rendering methods of Ray Casting and Triangulation have been removed from **RV7.0 TNT** products as their older code and further application serve no useful purpose. Now all their special features such as pedestals, stereo

viewing, … have been implemented and improved for the 3 new surface rendering options.

The accompanying color plate entitled 3D Surface Rendering Modes compares these 3 modes and discusses their speed versus quality differences. The conceptual design of these surface rendering modes was introduced in this same section in the Release MEMO for **V6.8**. All three surface rendering options also can be used in combination with any of the advanced texture filters described in the Release MEMO for **V6.8**. Now that surface-rendering and texture-filtering options have been revamped, effort will be directed toward speeding up these rendering methods to enable more interaction between concurrent 2D and 3D views. Another possible area of improvement in this new rendering engine would be to preserve more of the vector nature and attributes for overlaying geometric objects.

Displaying non-horizontal, planar or curvilinear structures called manifolds has been added and is discussed in detail in the section below entitled Manifolds. Since the display of manifolds is in a **TNT** 3D view, it does not use DirectX or OpenGL, but internal MicroImages code. This means that manifold viewing is cross-platform and automatically incorporates many important 3D view features, such as the ability to render a high resolution version of the current view into a file for printing, extension via **SML**, direct integration and geographic correlations with the 2D views, and so on.

Faster Wireframes.
Moving wireframes around is significantly faster because it now uses the appropriate terrain pyramid tier to generate the wireframe. Wireframe manipulation is commonly used for quick preview of this skeletal form of the terrain to make adjustments to the viewpoint.   **V6.9** always used the full surface raster layer for this purpose requiring more data to be read in a situation where it was not needed.

Faster Flat Surfaces.
Rendering of multiple texture layers on a flat surface (which means, without a terrain surface) is much faster. This is actually how a vertically-oriented stereo view is rendered, as discussed and illustrated in the Stereo section below. In a stereo view parallax is introduced into the textures from the terrain layer, but their time consuming depth rendering is now bypassed.

Transparent Layers.
The transparency properties set for individual texture layers are now applied in all surface rendering modes. When multiple texture layers overlap in any given perspective view, their transparency effects combine in the order in which the layers are rendered, which is from the bottom of the layer stack (first layer added) to the top (last layer added). This statement applies to multiple texture layers assigned to a single terrain surface as well as to overlapping textures from different vertically-separated terrain surfaces.

This kind of transparency, called layer order transparency, was available in **V6.9** only with the old Ray Casting surface rendering mode. Now you have this capability available for use with all of the high-quality surface rendering modes in your 3D views, both on-screen and in printed layouts for data areas of any size. For example, you can set a different transparency for each vector polygon fill style and it is used when this layer is draped over an image. Or, you can set the transparency level directly in the 3D controls

for an entire raster object, such as a scan of a geologic map, to visually merge the map with an underlying opaque relief shading or panchromatic image layer. Examples of the use of layer transparency are illustrated in the accompanying color plate entitled Transparency and Relief Shading in 3D Views. Remember that these transparencies are cumulatively applied bottom to top as you view the layers in the current perspective. Any opaque layer that is encountered will obscure the view of earlier layers for that screen pixel.

Relief Shading.

Relief shading can now be requested and manipulated directly while using any of the new 3D surface rendering methods. (In **V6.9** relief shading in 3D only worked with certain of the older surface rendering modes.) You can vary the sun elevation and azimuth, as well as its intensity, via the vertical scaling of the terrain layer. The relief-shaded layer can then be used as a base texture layer and partially exposed by making the 2nd and subsequent added texture layers, such as an image or map, partially transparent. Adding this shaded relief base enhances the visual clues in a 3D view and creates the illusion of a sun position for all views. Of course if the image texture layer has obvious feature shadows, this will dictate the best angular position of your sun settings. The accompanying color plate entitled Transparency and Relief Shading in 3D Views illustrates various uses of relief shading.

Pedestals.

Adding cosmetic pedestals to your 3D rendering has been improved and is available for all 3 new surface rendering methods. A pedestal for a texture layer is drawn vertically down from the outermost edge of real data values in the texture or its underlying terrain. A curving real data boundary, therefore, produces a pedestal with curving walls. Pedestals now also provide other advanced features not previously available, such as smoothed color, color shading, and transparency.

Height.

A pedestal is drawn vertically downward from the real data edge to the base elevation specified for it in the Raster Layer Controls dialog. This pedestal base elevation is a value you select relative to mean sea level.

Color and Transparency.

The color of the pedestal is selected from any color using the same dialog as above. This color is automatically shaded according to the current position of the sun, which can be set using the 3D Viewpoint Controls dialog. You are even able to set a transparency level for the pedestal color. The use of this feature is particularly effective for upward pedestals called fences discussed below. However, pedestals with a high transparency setting might also be used to put a frame around a 3D view with multiple, but offset, terrain layers.

Irregular Terrain Boundaries.

Almost all published illustrations of 3D views with pedestals show views that have an outer boundary in the shape of a parallelogram or trapezoid because the rendering process shows the full rectangular extents of the geodata. In the **TNT** products, your single 3D view can be irregularly bounded and use stacked or edge matched terrains that are irregular in shape. If your terrain and/or texture edge is irregular, then the pedestal follows that shape. This is illustrated in the accompanying color plate entitled Pedestal

estal and Fence in 3D Views. You are no longer restricted, as previously and in many competitive products, to using a pedestal only around a rectangular data area. If your terrain(s) or texture(s) have holes in them, then appropriate pedestal sections can be viewed through these holes as a function of the view angle.

When pedestals are curved, they are attractively shaded as illustrated in this same color plate. Pedestal shading requires a complex process of smoothing the edge of the data area that generates the pedestal shape, since this actual edge is always defined by raster cell boundaries and so is not inherently smooth but saw-toothed. There is also the issue of deciding when an inflection in the curved edge of the data is a real abrupt inflection in edge that should be observed and appropriately shaded versus being only meaningless spatial noise along what should be interpreted as a smooth edge. These subtle but important considerations are why irregular pedestal boundaries are not supported in other products. However, if not overworked, **TNT** produces very attractive shaded pedestals for your irregular area. You can mask out marginal surface areas that have distracting or ugly features, such as an existing development, and these areas are then not rendered in the view. The pedestal surrounding the remaining real data area focuses attention on the site of specific interest.

Fences.

This new 3D view embellishment is simply a pedestal drawn upward. Since a pedestal and fence can be applied simultaneously to the same texture in the view, these features have their own independent sets of identical controls for height above base, color, and transparency. The meaning and operation of these controls is discussed above.

An effective use of a fence is illustrated in the color plate entitled Pedestal and Fence in 3D Views. In the illustration, the pedestal is rendered downward and opaque to provide a base and frame for the rendering. It also emphasizes the 3D depth with its irregular terrain intersection with the texture along the front edge. However, even in this small print it can be seen that the upward highly transparent pale blue fence adds a subtle corner effect further creating the illusion of depth. Fences with high transparency can create this corner effect or with low transparency build a sandbox effect around the terrain.

Stereo.

Rendering a 3D perspective view as a stereo pair is now supported for all 3 new surface rendering methods. Once a suitable 3D perspective view has been created, it can now be viewed in high quality stereo using a stereo viewing device such as a 3D monitor or a mirror stereoscope. Simply select one of the 4 available stereo display modes. You can include any of the new 3D viewing features in your stereo view including the new manifold surfaces, advanced mipmap texture filtering, and all the other features introduced incrementally in the previous **TNT** releases of this 3D viewing process. If you wish to create a straight down view in stereo, simply adjust the viewpoint controls to place the viewer above the terrain with a 90-degree pitch.

The **TNT** products can render the stereo view in any of 4 stereo modes to match your choice of stereo viewing device. To select the stereo mode, open the Stereo Viewing Options dialog by choosing Stereo Setup from the Perspective View window's Options menu. These various rendering methods are illustrated in the accompanying color plate entitled Stereo Viewing Modes. Almost every common stereo viewing device available

uses one of these 4 display methods. Recommended viewing hardware for use with these methods is discussed below.

> **Note:** 2D and 3D views can be switched into stereo mode in the FREE **TNTatlas** and **TNTlite**, the new low-cost **TNTview**, and **TNTedit** and **TNTmips**.

Separate Frames.

The Separate Frames mode is new to the **TNT** products with **RV7.0** and displays separate side-by-side images with parallax added. This is the mode that provides very stable stereo viewing specifically for use with a mirror stereoscope. Dual high quality images can be displayed side by side on a 21" or a larger flat monitor or a pair of flat monitors and a stereoscope set up over them. To adjust the placement of the side-by-side views to fit your stereoscope, measure the distance between its optical axes and enter this value in the Stereo Viewing Options dialog. Since the use of dual monitors introduces a bezel area between the 2 views, the width of this obstruction also can be entered in this dialog to further adjust the frame separation.

Interlaced Columns.

Interlaced Columns mode creates images with appropriate parallax in a single view. One image is displayed in the odd-numbered columns and the other in the even-numbered columns. This mode, depending upon the viewing device, reduces the horizontal resolution by a factor of 2. This mode is used by direct-view stereo monitors (no glasses, shutters, …) that use a special screen surface to optically deflect the odd-numbered columns to one eye and the evens to the other.

Interlaced Lines.

Interlaced Lines mode creates two images that are spliced in the opposite direction from column-interlaced mode. Image lines from one image are displayed in odd-numbered screen lines and from the other in even-numbered lines. Parallax is introduced by slightly offsetting the starting positions of the interlaced lines. On older interlaced display systems, shuttered eyeglasses are synced with the display to force each eye to separately view each of these images. Another approach uses a shuttered screen and polarized glasses to create stereo. Both of these methods, even in their latest incarnations, can quickly introduce eye strain.

Anaglyph.

Anaglyph support is included because of its simplicity and the ease with which the viewing device can be acquired. Its biggest advantage is that stereo images can be cheaply printed and distributed in any quantity with a free pair of glasses. There are no special settings required in using this option. In the Stereo Viewing Options dialog, it's simply a choose it and use it option. A color plate entitled Anaglyph Stereo Viewing accompanies this MEMO to compare this method of viewing with those that follow and require special equipment.

Stereo Equipment Recommendations.

Stereo viewing on a monitor has been an entertainment gimmick except when required for special purposes such as soft photogrammetry. If good quality stereo viewing was available, we would all be using it for TV, for games, and our geospatial visualization. Low-cost viewing devices produce flicker and quickly give you a headache. Better qual-

ity devices have cost too much for general purpose use. For these reasons, minimal previous effort has been expended in this aspect of visualization in the **TNT** products. However, now some approaches do produce acceptable results. Hardware devices are becoming available that make it possible to view stereo for longer periods without flicker and at acceptable additional cost. This hardware and corresponding stereo modes in 3D views may now make stereo viewing of increased interest to you. Suggestions for more photo-like **TNT** stereo stations are discussed and illustrated below. For more information on stereo add-on devices and monitors please see www.stereo3d.com.

Stereoscopes.
The analog, tube monitors of the past were commonly multisync/multiresolution with a continuous phosphor coating and had a tendency to jitter at the pixel level. They were also large and bulky adding to the difficulty of using them in pairs with a stereoscope. Now, digital flat panel monitors display images at a single resolution to specific discrete cells. This pixel stability enhances their use to present a pair of photo-like stereo images for viewing with a mirror stereoscope. A single, large monitor can be used or a pair of smaller units. The stereoscope has been around almost 100 years as a low-cost means of viewing pairs of images in stereo with minimum eye fatigue. Using these devices can produce near photo quality stereo, which can be viewed longer than other approaches with a minimum of eye fatigue.

Inexpensive Mirror Stereo Station. The accompanying color plate entitled Inexpensive Stereoscope Viewing shows the lowest cost mirror stereoscope design. It uses twin 15" or 17" flat panels, 1024 by 768 pixel monitors you may already be using for your **TNT** products. These can be positioned side by side laying flat or on an angle with their bezels in contact in the middle. The plastic mirror stereoscope (called a GeoScope™) can be positioned across them and the stereo view mode selected in 3D display. As noted above, the separation of the stereo frames can be set by entering the distance between the optical axes of your stereoscope, and can be automatically adjusted for the dual-monitor setup by entering the width of the 2 monitor bezels. These values need to be set only once for this setup. Since you are already using dual monitors with your **TNT** product this is a US$200 approach.

Mirror Stereo Station. The accompanying color plate entitled Stereoscope Viewing shows more expensive, higher quality mirror stereoscope design. It uses a single, 23" pan-wide flat panel monitor of 1920 x 1200 pixels yielding 960 by 1200 pixels for your stereo view. It is available from Apple, Sony, and HP in an identical form factor and price and is also an excellent choice for the general operation of your **TNT** products if you like to use only 1 monitor. A popular high quality mirror stereoscope with first surface mirrors and quality lens fits almost perfectly across this single monitor over your photo-like stereo images. You only need to set the optical axes default separation. This kind of monitor is US$2000 and getting cheaper while the stereoscope is less than US$800.

Direct View Monitors.
Flat panel monitors are now available that directly display stereo images without any glasses or other secondary media. These monitors display dual images that are column interleaved. These alternating columns of pixels are then deflected odd-numbered columns to the left and even-numbered columns to the right by a special surface on the screen. Each of your eyes then sees only one of these color images. With a high frame

rate the two parallax-shifted images merge into a 3D image projecting out from the monitor's surface. Using alternating images for stereo cuts in half the horizontal resolution of this monitor. However, at any time you can physically shift these monitors from this stereo behavior to flat mode and use them just like any other monitor for 2D work at full resolution. At this time, none of MicroImages' staff have first hand direct experience with the quality of the stereo produced on these monitors.

Sharp Direct View 15" 3D Monitor.
In 2003 Sharp released a portable (model Actius RD3D) with a 15" flat panel with column interleaved stereo using their parallax barrier technology for direct viewing at about US$3000. Late this year they began shipping a stand alone 15" flat panel monitor (model LL-151-3D) using their direct view stereo technology for US$1500. This is a 1024 by 768 resolution monitor that can be switched between normal 2D and 3D display modes in software or with a physical button. The 3D mode repeats the columns in the view for each eye. This halves the resolution from 1024 to 512 by 768. This monitor is only now becoming readily available. MicroImages clients who have used it for viewing **TNT** manifolds and surfaces in 3D report it is very good.

MicroImages has taken delivery on this monitor and the unaided stereo viewing is very sharp and clear. If the monitor is switched out of stereo to full resolution 2D viewing, you can not detect that this is a stereo monitor. The only drawback is that the viewing position is very narrow. However, you can move your head closer or father from the screen and maintain stereo as long as your head remains in this narrow viewing angle. This is particularly important to those of you who wear glasses, and especially those with bifocals and trifocals. Holding the head still for playing games on it would be difficult. For professional applications where the view or simulation is going to be studied, this is more of an annoyance when its crystal clear stereo quality is compared to any other stereo viewing device. For example, everyone is familiar with viewing images with a stereoscope that requires a very specific position for your head! More information about this monitor can be found at www.sharp3d.com and it has many reviews on the Internet.

 Larger Direct View 3D Monitors from SeeReal.
TNT stereo views of manifolds, surfaces, and other 3D results were recently demonstrated at a show to geologists using the larger but much more expensive SeeReal monitors manufactured in Germany. These monitors use a different technology to route the images to each eye than Sharp's monitor but use the same **TNT** column interlaced mode. They have several products in this line and their top model is the C-nt at about US$10,000 (current prices are not posted anywhere on the Internet). It is a 20-inch flat panel with a 1600 by 1200 pixel resolution. Again, in stereo the horizontal is halved to 800 by 1200. More information about these direct view stereo monitors can be found at www.seereal.com/EN/products_cnt.en.htm.

Non-Topographic Stereo Applications.
Since the costs and quality of stereo are now in an acceptable range (US$200 to US$3000), your potential uses of stereo should not be limited to obvious conventional applications such as viewing images, geologic and topographic maps, and manifolds, all of which require a DEM. There are more exotic forms of stereo and 3D viewing in the **TNT** products that do not require a DEM or vertical manifold georeferencing. The following are some sample ideas. Consider how you can extend these suggestions for non-

DEM related stereo applications to the interpretation of your project's research materials and objectives. It is also important to realize that stereo applications are not restricted to georeferenced geodata. Your rasters and graphical datasets need only be internally registered, such as derived from the same source rasters, or in the same engineering or Cartesian coordinate framework to be used in stereo in the **TNT** products as outlined below.

Vegetation Stereo.

A common stereo application is to compute the green canopy biomass raster object from a color infrared airphoto or satellite image using a vegetation index equation (for example, NDVI and many others). This new raster will register exactly with the original multispectral images. It can then be chosen as a pseudo-DEM and the natural color or color infrared renditions of the original images draped over it in 3D and stereo. If the imagery is a color infrared airphoto or 1-meter synthetic satellite image of a crop field, the variations in its canopy biomass within each crop field will be dramatic. If the color image is derived from a 15-meter Landsat, then the variations in forest canopy density and conifer (needle) versus deciduous (broad leaf) species will be enhanced in stereo and perspective.

Image Ratios.

Geologists frequently interpret multispectral images by using special color band ratios selected to enhance the surface distribution of a group of geologically related materials. From these, a rough map is sketched of the distribution of materials in that enhancement. Then another enhancement and its grouping of materials is mapped and so on. As this procedure moves along, the inter-relationships between these groups is worked out by going back and forth between the ratio images and overlaying the current composite surface map and its subsurface extrapolations.

Many image processing steps may be used to enhance these ratio or other image presentations to aid in this interpretation such as vegetation removal, corrections for terrain induced radiance and atmospheric effects, some level of auto interpretation, orthorectification, and so on. However, in the end it will be the expert geologist that interprets these rasters and builds the electronic or physical map of the geology of the area.

Geologic interpretation and its refinement gets an obvious improvement when a DEM is used to present these enhanced image products in stereo and perspective, along with subsurface profiles as manifolds, and their current interpretations as overlays. The initial sketching, revision, and mapping activities can then be carried on concurrently in a separate 2D map view. However, these geologic interpretations can also be improved if stereo and 3D perspective viewing are used to enhance the geologic characteristics of the area rather than the topographic relationships. The following is an example of how stereo can be used by deliberately omitting the DEM and using stereo with just the enhanced imagery to improve the interpretation of the inter-relationships between groups of geologically associated surface materials.

A color enhanced ratio raster that has been optimized to help map a group of related surface materials (class A) can be displayed in stereo and 3D using as a "pseudo-DEM" a second ratio raster optimized for another group of surface materials (class B). Relationships between these groups will now be enhanced in stereo and interpretations made taking these stereo effects into account (for example, class A can be here but that means class B can not be). In **TNTmips** it is then easy to toggle a third or new ratio

raster in as the "pseudo DEM" and compare in stereo a new combination of surface groupings (class A over C) to refine the interpretation of the location of the group of surface materials in the color raster (ratio class A) before drawing any lines. These procedures are easily applied to images from multispectral image sources such as Landsat or ASTER. Viewing combinations of more advanced automatic interpretations derived from hyperspectral images in this way can create many possibilities of this type where final material identification can not be completed or trusted entirely to the automated processing, such as in a military decision.

<u>Water Quality.</u>

Subtle variations in water features, such as the boundaries between algae concentrations and pollution levels, are often hard to quantify. Often this is improved by enhancement of multispectral images or the addition of thermal images. If visual interpretation and mapping are used, these kinds of enhancements can be combined in stereo as above to improve their interpretation.

<u>Stereo Plans.</u>

Tentative plans include adding manifolds to **TNTsim3D** since DirectX and OpenGL can be readily used to introduce stereo viewing into this real time simulation. Stereo support can then be easily added to use this in **TNTsim3D**. This combination will permit you to move the viewpoint of a stereo view around in real time to help you understand the spatial relationships in a simulation using 3D terrain surfaces and/or manifolds. Communicate what you need next in stereo visualization to get it on the development list.

<u>* Manifolds.</u>

<u>Background.</u>

TNT products and some other advanced commercial geospatial analysis systems are often referred to as 2.5 dimensional (2.5D). The Z axis for features created, used, and visualized in these systems is measured in a vertical axis orthogonal to the 2D projection of these features onto a map plane. Often this plane is defined at or referenced to mean sea level. Generally, the available 3D data such as DEMs, bore hole profiles, seismic profiles, and 3D coordinates for maps fall into this category. All these 2.5D systems store and use only minimal information about relationships that occur in the 3rd dimension. For example, 3D topology is not maintained, in other words the topology is only 2D and refers only to the projected surface. While vertical overlapping area features can be defined in a CAD or shape object, true 3D relationships (for example, caves, concavities, and the general idea of volumes) are lost in a polygonal topology vector or single raster object.

The few 3D and 4D geospatial systems that do exist are specialized, expensive, and/or developmental in nature and focus on geologic, air-space and atmospheric, oceanic, and outer space related special applications. Upon careful consideration you will find that geodata with Z coordinates that are not measured orthogonally from the projected map plane and/or preserve volumetric relationships is very hard to collect and, as a result, is very expensive and sparsely available. Thus, it is natural that commercially oriented geospatial analysis systems focus upon the plentiful 2D geodata and on 2.5D when DEMs are available. Desktop commercial geospatial analysis products, such as **TNTmips** and its competitors, are not viable unless they are based upon, and work with, widely available geodata.

Fortunately there are still many new and useful 2.5D applications of geospatial analysis similar to the introduction in **RV7.0** of the use of manifold surfaces and stereo viewing. Other recent MicroImages 2.5D introductions included the free **TNTsim3D** program for publishing your simulations and the continuing improvements for higher quality, faster 3D perspective viewing. Future 2.5D opportunities might include editing 2.5D geodata in stereo; editing using several geolocked orthogonal views; or sketching in 2D, 3D, and or stereo views with the results simultaneously added to each. These past, present, and future developments can exploit the sources of Z-coordinate geodata just becoming widely available for use with your 2D geodata. These include more widely available and accurate DEMs ranging from the global SRTMs to local laser-derived DEMs to collecting accurate elevations with a GPS unit.

Some applications of 2.5D geodata are obvious and are the basis for the myriad of products that create a realistic 3D perspective view or real time simulation of a 3D surface. These products strive for speed and realism in games and some use real geodata for applications like flight simulation or guiding the driver of a car. However, in many site specific professional geospatial applications, the level of the integration of these 3D visualization subsystems into the total system is of even more importance than realism. For example, can they use the same geodata layers and scripting tools? Are the 2.5D capabilities and 3D capabilities tightly integrated with 2D capabilities for visualization, interpretation, and editing, such as in **TNTmips** and **TNTedit**? Are high quality 3D and acceptable quality stereo created with or without a DEM to help visualize complex surfaces to create 2.5D geodata relationships, such as manifolds in 2D views?

Only now in wealthy nations are we getting into position with our data collection and analysis systems to keep our geodata systems updated rather than creating static, one-time geodata sets and their interpretations. And this is generating a monstrous amount of digital data much of which may never be used. Obviously these nations have a tremendous amount of effort at hand just organizing and using these 2D and 2.5D geodata.

Recently a senior project manager for one of the largest intelligence and homeland security contractors to the U.S. government was overheard to say that it will take 25 to 50 years to actually integrate the local, state, and national geodata into a comprehensive and maintained 2.5D geospatial system. It's not just a technical issue—spend the money and get it done. A myriad of local and other laws, institutional barriers, and political issues must be resolved. Funding must be available, channeled to the working levels in local, state, and federal government, and standards truly adopted. There will have to be unpopular sacrifices of and safeguards for personal freedoms within our basic democratic framework. For example, even the limited amount of geospatial data available is already used to gerrymander election results.

We have plenty of work cut out for us worldwide just coping with our 2.5D geospatial future. True 3D and 4D systems are truly long range goals that can be worked toward only if and when sources of appropriate 3D geodata become available. The first step will be to move toward 3D geocentric and geodetic coordinate systems to properly record positions in a geodetic or geocentric system.

MicroImages and other developers are adding more of these 2.5D applications as demand, time, and most importantly the availability of 2.5D datasets allow. However, as is characteristic of the MicroImages **TNT** products, working with new 2.5D applications as they are introduced will not require that you assemble the needed software from several

pieces that are available only on a specific platform, OS, or use one graphics engine, such as DirectX or OpenGL. As a result you will not become entangled in a variety of prices, release cycles, data formats, user interfaces, and so on. All those details end up controlling the ease of use and integration of your 2.5D geospatial applications. This may mean that other specialized products reach selected 2.5D goals faster in some cases, but a truly professional 2.5D geospatial analysis system requires careful integration.

Manifold Surfaces.

Definitions.

The word *"manifold"* has numerous and quite different meanings in English and in the Random House Unabridged Dictionary, for example, a manifold is a part of an automobile engine or a pipe network. Alas, *manifold* is the word already accepted elsewhere in earth resources to refer to a curved surface in space. It is this dictionary's 12th definition that is most appropriate: *"a topological space that is connected and locally Euclidean."* Note that this definition says nothing about how the manifold surface will appear in space.

This term can be extended to cover its use in the **TNT** products. A *TNT manifold object is a raster, vector, shape, or CAD object (internal or linked) that has been georeferenced in 3D to define its functional surface in 3D space. Furthermore, its content must be appropriate to be viewed as a texture projected onto the TIN or manifold surface defined by these georeference points.* From this basic definition even more new terms have to be introduced and defined so that this new capability of the **TNT** products can be unambiguously explained here, and in future discussions of these types of **TNT** geodata and shapes.

Manifold Object.

A **manifold object** is a raster, vector, CAD, or shape object that has 3D georeferencing. When a manifold object is selected in a 3D view, including in the Spatial Data Editor, a TIN will be formed from its 3D georeference points and the contents of the associated raster, vector, shape, or CAD object projected onto that surface as its texture. Georeferencing is now both a 2D and a 3D process and is used to enter and edit the 3D control points needed to define a manifold object. The GeoToolbox in Display and the Spatial Data Editor can directly create a vertical cross section manifold object. Since a manifold object is georeferenced in 3D, it can be represented and visualized anywhere in a 3D space, and it may or may not intersect a terrain surface. The surface of the manifold object can be planar, curved, or creased and folded.

Obviously the raster, vector, shape, and CAD objects can be combined or merged in various ways before the 3D georeferencing is added to them to define a single manifold object. However, they can also be kept as separate manifold objects and projected and viewed in order onto the same manifold surface. For this purpose the 3D georeferencing of a manifold object can be conveniently transferred from one raster object to another or between vector objects as long as they have matching extents, just as with the georeferencing of 2D objects. For example, you create a raster manifold object, a matching vector overlay manifold object to delimit boundaries, and a CAD manifold object containing annotations.

Manifold Surface.

A ***manifold surface*** is the TIN surface formed in 3D space each time the manifold object is used in a 3D view. The shape of this TIN remains the same for every new viewpoint of it. Its shape can only be changed in the Georeference process using the new tools provided for this purpose.

Manifold Texture Object.

A ***manifold texture object***, or a *manifold texture*, is the special name that refers to the raster, vector, shape, or CAD object with the 3D georeferencing needed to use it as a manifold object. The texture object is projected (called draping) onto the manifold's TIN surface every time the 3D view is created, refreshed, or the viewpoint is moved.

Manifold Layer.

A ***manifold layer*** refers to the current view of a manifold texture object draped onto the manifold surface in a 3D view. The 3D view can have other manifold and topographic layers in it.

Terrain Surface.

You are already familiar with the use of a ***terrain surface***, which is the TIN formed in a 3D view using one or more elevation rasters. Depending upon which of the 3D models is used, the shape of this TIN can change slightly to refine it for each new viewpoint.

Topographic Texture Object.

You are already familiar with the use of a ***topographic texture object***, or a *topographic texture*, which is the 2D raster, vector, shape, or CAD object you select for projection (called draping) onto the terrain surface every time the 3D view is created, refreshed, or the viewpoint is moved.

Topographic Layer.

A ***topographic layer*** refers to the current view of a topographic texture object draped onto a terrain surface in a 3D view. The 3D view can have other manifold and topographic layers in it.

Sample Applications.

Most software products used to build and view manifold layers and other volumes from geodata and visualize them in 3D are highly specialized and expensive. A popular current application is to use them to build the walls in a seismic/geology immersion room used in oil exploration and costing hundreds of thousands even up to a million dollars. A picture taken inside one of these rooms can be found in the article entitled The End of Cheap Oil by Tim Appenzeller in the National Geographic Magazine of June 2004. In these specially built facilities, something like a very early holodeck, experts manipulate seismic profiles projected onto all the walls of the room as manifold layers. Now in **RV7.0** you and your standard **TNT** products can begin to explore the possibility of using these kinds of 2.5D manifold layers in your applications.

The uses of manifold layers range from simple graphical representations in publications to complex 3D visualizations. Their use is common in geology; geophysics; mineral and petroleum exploration; mining; archaeology; monitoring groundwater pollution and other subsurface environmental properties; geotechnical, road building, and excavation engineering; and others. To introduce you to the appearance of these layers in a 3D **TNT**

view, several different kinds of manifold and associated topographic layers are illustrated in the accompanying color plate entitled Manifolds in 3D Views.

Most of the geodata available to MicroImages and suitable for constructing manifold objects is geological in nature. Crisscrossing or "egg crate" like intersecting subsurface profile manifold layers are common in geology and are called fence diagrams. Geologic cross sections are available on printed geologic maps and in their digital equivalent. Any cross section can be created from a geologic map by a trained geologist. Seismic data is widely used but quite proprietary in nature. As a result, the orientation of the rest of the color plates used to describe this manifold process in this MEMO use these kinds of data sets starting with the general illustrations in the accompanying color plate entitled Visualize 3D Geology Using Manifolds. Another accompanying color plate entitled 3D Subsurface Model Using Manifolds illustrates the distribution of an ore body determined from drilling, mine shafts, and expert interpretation. It is hoped that you can make the extrapolation from these examples to creating and using manifold objects from your geodata.

3D Visualization.

A raster, vector, shape, or CAD object with the necessary 3D georeferencing is a manifold object and can be selected for display in 3D as a manifold layer. Since this uses the same **TNT** 3D visualization models as rendering topographic layers, multiple manifold and topographic layers can be rendered in the same 3D or stereo view. This is a unique way of visualizing the relationships between topographic layers or other horizontal reference layers in proper geospatial relationship to manifold layers representing subsurface or above-surface profiles, transects, and layers with other content and orientations.

Depending upon the viewpoint, adding several topographic and manifold layers means that they can obscure each other. The ordering of their 3D rendering is back (farthest away) to front (nearest). Transparency can be used to help you see the underlying layers in a rendering, but can create confusion over which layer is actually being viewed. Faster reorientation of a composite 3D, better means of temporarily unmasking obscured layers, adding the use of manifold surfaces in **TNTsim3D**, and stereo viewing are all areas of future development needed to provide more means of visualizing the 3D relationships manifested in these potentially complex multilayer views.

As you begin to more fully understand this new capability, you will also find that even the 2.5D geodata needed for this application is not widely available. However, it can be put together from various sources starting directly within the **TNT** products (for example, your geologic interpretations of 2D geodata such as bore hole profiles and geologic maps). Unlike all the 2D geodata already available or that you assemble, subsurface, oceanographic, atmospheric, and other such specialized data can be hard to find, often incomplete, and recorded in unusual units (for example, seismic propagation times). Getting these external 2.5D sets organized into **TNT** manifold objects will require effort and potentially the use of the **TNT** geospatial scripting language (**SML**) for data conversion, formation, and importing into a manifold texture object with its 3D georeferencing.

Create a Manifold Cross Section.

You can use a new tool option in the GeoToolbox in a 2D view to quickly and easily create a simple vertical manifold object. This is illustrated in the accompanying color plate entitled Create Cross-Section Manifold Objects. This procedure uses a 2D vector object

overlaying an elevation raster object in a 2D view. You use the GeoToolbox to draw any kind of connected line representing the desired cross section on this view in 2D. The line does not have to be straight, but must be continuous. When you are finished drawing and editing the line, use the Generate Cross Section icon in the GeoToolbox window to create your new manifold object.

This manifold texture object you are creating hangs down or projects vertically upward from the trace of the cross-section line on the terrain surface. Thus you are prompted to enter the base level elevation of this vertical cross-section manifold texture object in the Cross Section Options window. This elevation value is measured relative to the base elevation of the elevation raster object, typically mean sea level. The value you enter will be used to position and create the edge of the manifold texture opposite the topographic profile formed by the trace of the cross-section line on the terrain surface. Since you can enter any value for this elevation that is greater or less than that of the values in the elevation raster object, this manifold object can go up, down, or intersect the terrain surface.

The polygon boundaries in this new manifold texture object are the map polygon boundary lines that the cross-section line intersects in the 2D view, projected vertically down or up to the horizontal edge you defined by the base-level elevation. Wherever the cross section line intersects a 2D polygon edge, a vertical polygon boundary is created. Thus, all the polygons in this manifold's texture object have vertical edges that are parallel in 3D and intersect the cross-section edge at the same points as the 2D polygons. These polygons in the manifold texture object are all automatically assigned the same styles and other attributes as their corresponding 2D polygons as they must match along their intersection of the 2D vector object and the manifold texture object. The vector object created as the manifold texture object has polygonal topology.

The georeference control points created automatically for this manifold object define the TIN used to shape the manifold surface upon which the vector texture object is draped. These control points define a vertical surface that starts at the terrain surface. One set of points traces out a cross-section edge that conforms to the terrain surface. These points vary in XYZ. A corresponding set of paired points traces out the opposite edge as the vertical projection of these terrain surface points up or down to the plane of the elevation you entered. These points all lie in the same X-Y plane and, thus, have the same Z value. Since this manifold surface is vertical everywhere, no additional georeference points are needed to define its position in space, just these matching pairs of top and bottom points.

Editing a Cross Section Manifold.

The simple polygon shapes in the initial cross-section manifold texture object can be edited and shaped to meet the below/above ground conditions on this vertical manifold surface. Load this manifold object in the Spatial Data Editor; it automatically displays in a 2D view and as a manifold layer for reference in a 3D view. It will be stretched out and flattened in the 2D view by using the z coordinate on the y axis of the 2D view. Proceed as usual to use the Spatial Data Editor to create the revised representation of the below ground polygons. This editing to create a representation of this manifold texture object with the subsurface volume features is illustrated in the accompanying color plate entitled Edit Manifold Objects.

Any time you refresh your 2D edit view, you see how your current changes appear when projected as a texture onto the manifold surface in the 3D view. As usual you can add any other manifold or topographic layers into this same 3D view for reference purposes. For example, if you have already designed a manifold object that would intersect this new manifold object, you would want to view both layers in the 3D view. If you are building a fence diagram, all polygons must match at the intersections of the manifold surface as illustrated in several color plates. If you have a stereo viewing device set up on a second monitor, your 3D manifold layers and corresponding topographic layers can be rotated and viewed in stereo as you edit their polygon shapes in the 2D view.

This cross section creation and editing procedure duplicates the way in which most vertical cross sections are created by drawing them. It quickly provides an initial vector manifold texture object and its vertically-oriented manifold surface for your use as a starting point. It creates a basic manifold object as a starting canvas for your more complex 3D interpretations of a geologic, archaeological, geotechnical, or any other manifold layer. For example, this replicates the way geologic sections are inferred and sketched and resketched by hand. But instead of sketching them by hand, they are created as vector objects. This provides that opportunity to view these scenarios and intermediate results in 3D as they are created. This is especially important when multiple manifold layers are being created that will be interrelated in 3D.

Georeferencing a Manifold Surface.

Creating a complex manifold surface for a manifold texture uses a collection of XYZ points in a geospatial or a Cartesian coordinate reference system to define its surface. These XYZ control points must be obtained by some method. For example, they might represent the coordinates measured to various layers in a bore hole, from towed sensor arrays, or computed from transects. These 3D control points become the vertices of the triangles that define the shape of a TIN onto which the manifold texture object is draped when viewed in 3D. Using triangles to define a manifold surface could render a faceted surface. However, modeling a surface in this manner is very common and used in many games, 3D viewers, and other 3D computer simulation products. Whether or not the surface appears curved, folded, faceted, and so on depends upon factors such as the density of these points, the designation of edges as fold lines or some other special edge, distance to the triangle, surface texture projection and shading technique, and so on. In **RV7.0** these 3D georeference points and special triangle edge effects they define are added to a raster, vector, and/or CAD object to create a manifold object using a new procedure in the georeference process, which has been significantly expanded for this purpose.

Choosing the new 3D Piecewise Affine model from the menu in the Georeference window permits you to enter XYZ coordinates for any position you select on the raster, vector, shape, or CAD object in the 2D view. For example, suppose the raster object represents a single, flat vertical seismic slice. To define this vertical plane, you will only need to select the position of 4 points near the corners of the raster and enter their XYZ coordinates in the control point table in the Georeference window. Since these 4 points lie on a plane, the manifold surface will be defined by a TIN with 2 coplanar triangles. If the 4 points are not coplanar, the TIN will have 2 triangles that are not coplanar and the common edge will be a fold edge in the manifold surface. If you want the top of the manifold surface to conform to the terrain, then more control points are needed along

the top. If you want to curve the manifold, then you begin to enter XY values for points that do not define a plane.

The accompanying color plate entitled Georeferencing Manifold Surfaces illustrates the positioning of these 3D georeference points and their tabular entries. In this example, as is usually the case, the positions of known XYZ coordinates on the manifold texture object are not at the corners of the object. If no georeference points are provided at the corners and along the edges, the TIN created would be smaller than the area of the manifold texture object. The edge areas of the manifold texture object would have no manifold surface to project onto and would simply be clipped off and lost in a 3D view of this manifold object.

To preserve all the surface area represented in a rectangular manifold object you may want to extrapolate from the measured and known georeference points to add additional control points at the corners of the manifold texture object. This can be done automatically using a built-in procedure. It extends the plane of the edge triangles defined by your georeference points. It uses these planes to interpolate coordinates for the corners of the manifold texture object and adds them to the control point list. This is also illustrated in the accompanying color plate entitled Georeferencing Manifold Surfaces. Adding new control points adds new triangles around the edge of the TIN to increase its area. However, these triangles are coplanar extensions of the edge triangles created by the 3D georeference points you entered. You can edit the XYZ coordinates of these added control points in the table in the georeference window to modify the orientation of these added edge triangles.

Once you have entered four 3D georeference points for your manifold texture object, as near to the corners as possible, you can now open a 3D view in the Georeference process. It will show you how your manifold surface or object is shaped and positioned in space from any viewpoint using a wireframe view of the current TIN or with the manifold texture object projected onto it. Since this is a standard 3D view, any other manifold and topographic layers can be added to it for reference purposes. Views with multiple manifold layers are common and are illustrated on the color plates. You can then proceed using the 3D view as reference to edit the positions of the four 3D georeference points or add more, add 3D interior points to shape the manifold surface, extrapolate from the interior points to the corners, add exterior points to expand the surface, and edit the edges of the TIN using procedures discussed in the following section.

Editing a Manifold Surface.

Sparse Known Control.
The number of 3D georeference points you have to enter to define the manifold surface can be few in number; a minimum of 4 are required. However, georeference points that are known in 3D position and can be located on the corresponding manifold texture object (the raster, vector, and/or CAD objects) are difficult and expensive to obtain for manifold objects extending above and below the earth's terrain surface. The new 3D Georeference process permits you to use your understanding of the shape of the manifold surface represented by the manifold texture object to add in additional XYZ control points. These points can be used to modify the shape and edges of the TIN that will define the manifold surface.

Expanding the Control.
You can insert control points into the list of georeference points for the manifold surface without knowing their XYZ coordinates or locating their positions on the manifold texture layer. In positioning and editing these control points to improve the shape the surface you can use anything you have available:

* the current 3D view of the manifold layer and various topographic layers, such as a drape of a surface geologic map, or natural color or enhanced image overlay, such as image ratios;
* boreholes, radiosond or other atmospheric observations, towed sensor arrays;
* all other available non-digital map, image, historical data, and lore about the area and its volumetric relationships; and
* most importantly, your personal expertise and skills in 3D inference.

This new feature in the Georeference process also permits you to edit the triangles of the TIN formed from these control points to extend and shape the outer edge of the TIN to conform to the rectangular or irregular edge of the contents of the manifold texture object.

Matching Texture and Surface Objects.
The manifold texture object will be larger than the coordinate area covered by the TIN connecting the 3D control points unless there are points at each corner of the object. Conversely you may have a manifold texture object that has null area representing irregular edges and holes. Holes present no problem as they automatically become transparent holes even though the manifold surface is defined for them. Irregular or null edges can create irregularities when this manifold layer is viewed with a topographic layer and other manifold layers. You may want to use a single manifold texture object that does not curve around in space but has definite folds. You may want to add 3D points to your TIN to better shape it in 3D space and in the view. These special considerations and conditions require that you edit the TIN you are creating in the georeference process. You edit the TIN defining the manifold surface in a 2D view. However you can monitor the results by opening a 3D view of the manifold object in the Georeference process. If you have a stereo viewing device set up on a second monitor, your 3D manifold layer and its corresponding terrain surface can be rotated and viewed in stereo as you edit the shape of the manifold surface in the 2D view.

Available Tools.
Choosing the Georeference process opens the table for entering 3D coordinates and a 2D view of the current TIN and manifold texture object in flattened 2D form in the Object Georeferencing window. Choosing the 3D Piecewise Affine model opens a new Piecewise Control window to provide tools to specify the special connectivity properties to use when the lines are generated in the TIN to connect all the control points. This new window and its use and the effects of using these edit tools are all illustrated in the accompanying color plate entitled Editing Manifold Surface Triangulation.

Adding Hard Edges.
You can use this tool to select any edge in the TIN and designate the connection between these two control points is to be a hard, or fold, edge. This hard edge will be preserved through any activities applied to the TIN built from these control points. Hard edges are drawn in the TIN in a different color to differentiate them from soft edges.

Removing Hard Edges.
This tool is used to select a previously designated hard edge and remove this special connectivity property from the pair of control points. Thus, the designation of this edge as hard is deleted and the points may be connected by a soft edge in the TIN.

Remove Edges.
This tool selects an exterior triangle's exterior edge, thus designating that 2 control points at its end should never be connected in the TIN. This removes the area of this edge triangle from the TIN usually because it is null and not covered in the irregular area of the manifold texture object or because it obscures some other layers when viewed with this manifold layer.

Add Control Point.
This tool inserts a control point into or outside a triangle without requiring that its coordinates be manually entered. If the position of the point is inside any triangle, its XYZ values are interpolated from the surface of that triangle. It then becomes a valid control point and all the surrounding points connected to it with soft edges. If the point is selected outside the area of any current triangle, its XYZ position is extrapolated by extending the plane of the nearest triangle. New triangles are formed to redefine the edge. In either case, once these points that have been inserted into the list and TIN by this tool, or any other, their XYZ values can be manually edited in this list in the Georeference window to move them from their initial interpolated/extrapolated positions. In this manner, the added interpolated control points can be used to shape the interior of the TIN or the extrapolated edges. When used together with the Remove Edges tool, you can shape the outer edge of the TIN to match the irregular edge of the manifold texture object or match a terrain layer.

Remove Triangles.
When a triangle is selected that has an outer edge not shared with any other triangle in the TIN, the outer edge is removed and its area is no longer included in the TIN. While this tool has the same result as the Remove Edges tool, it is sometimes easier in a complex TIN to select a triangle using its interior rather than directly selecting its outer edge.

Extrapolate Boundary Control Points.
This tool insures that the TIN is a parallelogram onto which all the rectangular manifold texture layer can be projected. This tool has been discussed above in the section on Georeferencing Manifold Surfaces as it is often used immediately in connection with entering the known 3D georeference points and viewing the initial manifold surface in a 3D view. Its use is illustrated in the accompanying color plate entitled Georeferencing Manifold Surfaces.

Recover Deleted Elements.
This icon will undo all previous control point editing back to the last save of the georeference object. Using this tool with periodic saves will untangle your editing results when the triangulation gets too complicated.

As previously discussed above in more detail, all this edit activity with these tools is performed on the current representation of the TIN formed from all the current control points and their connectivity relationships. However, while you appear to be adding and

removing triangle edges, you are actually merely establishing new relationships between pairs of points in the 3D georeference subobject for the manifold texture object(s).

Create a Manifold Object Using a Script.

Both a manifold texture object and its manifold georeference subobject can be created using new classes and functions added for this purpose to the **TNT** geospatial scripting language (**SML**). Using these tools, you can build a complete manifold object in geo-space or in some arbitrary Cartesian coordinate space. The manifold texture object can be imported or computed from equations using **SML**. Similarly the control points to define a manifold shape can be imported or computed from equations The simplest application would be to convert a large tabular collection of XYZ points, too numerous to enter by hand, into a large georeference table. The introduction of these new classes and functions along with more suggestions for their uses occur in the section below entitled Geospatial Scripting Language (SML).

Backward Incompatibilities.

If any object is georeferenced with 3D points only in **RV7.0** for use as a manifold object, that object and the Project File that contains it can not be used in any **V6.9** or earlier **TNT** product. The reasons for this are identical to those explained above in detail in the section entitled Coordinate Reference Systems / Backward Incompatibilities. To avoid this limitation, it is suggested that any objects you intend to georeference in 3D for use as manifold objects be kept in a separate Project File if you are also still using **V6.9** of your **TNT** product.

Cartoscripts.

MicroImages' Reseller in Italy has made their collection of geologic line styling Carto-scripts available for you to download and use at www.spaziogis.it/index.php?option=com_docman&Itemid=71. While these represent lines accepted for use in Italian geologic maps, you can use them as starting points and modify the scripts for your own nation's map conventions.

Georeferencing.

There have been major changes in this process and these are discussed in detail in the section above entitled Manifolds. Some of these changes, such as the ability to name your control points, will effect you if if you are not using any manifold operations in this process.

Raster Resampling Using Georeference.

This interface has been redesigned to use a window with tabbed panels. The Rasters tabbed panel shows the list of selected rasters along with properties, including dimensions, georeference extent, and Coordinate Reference System. The Settings tabbed panel shows all available settings so there is no longer a need to browse each of the menus to see what the various options are set to.

When resampling to match a reference raster in cell size and orientation, the output raster cells will now exactly align with the reference raster cells regardless of the Extents setting. This is useful when there is only a partial overlap with the designated reference raster.

When resampling to geographic (latitude-longitude) coordinates, the cell size is now specified in degrees/minutes/seconds. As usual, values may be entered in decimal degrees, though they will be shown for the cells in degrees/minutes/seconds.

Options are now available for choosing the pyramid computation method. Available choices are None, Average, Sample, and Automatic. The default Automatic choice will use sampling when the resample method is nearest-neighbor and averaging when bilinear or cubic convolution is used.

The reference raster and related settings are automatically reset when a new set of input rasters is chosen.

A null mask subobject is no longer created for the output raster if the input raster does not have a null value defined and set.

Raster Mosaic.

The **TNT** products are superior to any other in displaying and managing massive images. Integrating all the pieces of your images (for example, DOQQs or orthoimages) into a single, large layer can be very convenient for your further analysis, for use in a **TNTatlas**, **TNTsim3D**, **TNTserver**, and so on. This is even the best procedure if your ultimate objective is to break up the image into new, smaller geographic units after your analysis. A common example is to assemble orthoimages into a single, large image with a common coordinate system, work with this mosaic, and then divide it into new pieces and the map projection required in some other system.

Your use of the mosaic process to create these massive but convenient images has been discussed briefly in the Editorial section above. Additional detailed information about the creation of compressed massive images was discussed in detail in the MEMO entitled Release of RV6.9 of the TNT products and dated 31 December 2003 in the section entitled JPEG2000 Compression. **RV7.0** of the mosaic process has no dramatic change in its interface or many features. However, considerable attention has been addressed to increasing its robustness and optimizing its performance for these large tasks.

Null Mask.

Mosaic now automatically generates a null mask layer and its pyramids to define non-data areas and null cells in the output raster. It, and any other process that displays this output raster, will automatically use this null mask as will other processes converted to do so. This also significantly improves the mosaic's handling of input rasters that have no null value or different null values.

First Raster Overlap.

An overlap mode of First Raster has been added whereby cells from the first raster in the list covering each output cell will be used. The mode of Last Raster was available in **RV6.9** and earlier, but now you do not need to reorder your selections to use the first raster.

* Output to JPEG2000.

RV6.9 of the **TNT** products required that you mosaic your raster and then use the Extract process to apply JPEG2000 compression to it. The mosaic process in **RV7.0** permits you to apply lossless or lossy JPEG2000 compression to your mosaicked output raster object. The many objects you select for input to mosaic can be any of a mixture

of uncompressed or objects compressed with JPEG, JPEG2000, or in any mixed coordinate reference system (CRS). Note that DPCM, or Differential Pulse Code Modulation, is now called Standard Lossless compression in **TNT** dialogs. Also selected and mixed in can be linked external rasters with or without compression such as GeoTIFFs, MrSID, ECW, TIFF, and others as long as they are georeferenced and their CRS identified internally or via an auxiliary file. To permit this flexibility, the Mosaic process still requires that it be provided with adequate drive space to create the entire mosaicked raster object in its final uncompressed and also compressed form if compression is specified. Also, as discussed earlier in this MEMO, using tiles during the compression procedure to avoid creating temporary storage for the full uncompressed raster then compressing it, can have detrimental effects at the tile edges and legal ramifications. The accompanying color plate entitled Mosaic Directly into JPEG2000 provides sample results from mosaicking 100 GeoTIFF images directly into a single JPEG2000 raster object.

Temporary Storage Requirements.

In **RV7.0** each input raster object is uncompressed as needed and resampled into this large raster object using your desired CRS, sampling method, overlap method, and so on. The size of this uncompressed temporary mosaic can be closely estimated in advance from the extents of your input objects, compressed or not, and your setting for the mosaicking process. However, if you are requesting that your mosaic produce a compressed output raster object (for example, a lossless JPEG2000 result), this temporary raster must coexist in your storage system at the same time as the uncompressed result. However, the exact size of a compressed raster may not be accurately estimated. It can be closely estimated for a JPEG2000 compression (for example a request of 10:1 lossy compression). However, the size of a mosaic object using JPEG compression or JPEG2000 Best Quality is not so easy (for example, a request for a 75% JPEG lossy result). If you target a compressed raster output, then at the onset the mosaic process will liberally estimate this additional storage requirement and warn you if the temporary and total drive space available would likely be insufficient to complete the final compressed or uncompressed mosaicked object.

Sample Applications.

The following kinds of test applications have been used to challenge and confirm the robustness of the Mosaic process especially for producing a JPEG2000 compressed raster object.

Lossy JPEGs into Lossless JPEG2000.

Lossy compression should never be applied to images to save storage space when those images will be used for some form of computer image analysis. However, using lossless JPEG2000 or standard lossless compression (formerly called DPCM) can be specified for a mosaic result intended for additional analysis. Keep in mind that Mosaicking images, depending upon your settings, may alter them by resampling, by feathering the edges, and so on. However, many orthoimages, especially those collected by digital cameras from the air, are being distributed as JPEGs or as lossy compressed TIFFs. To avoid excessive additional changes in these already lossy compressed images, you might want to link to and select them as input for your mosaic and choose lossless JPEG2000 as the compression method for your mosaicked raster object.

Over 6000 units of color Digital Ortho Quarter Quads (DOQQs of 3.75' by 3.75' ground areas) are available from the site of the Nebraska Department of Natural Resources. http://www.dnr.state.ne.us/databank/fsa03.html. These DOQQs were acquired using an airborne digital imaging system and are in 24-bit color with 1-meter resolution. They are provided for downloading in both UTM and Nebraska State Plane CRSs using JPEG compression. Remember, JPEG is always lossy compression! Although the JPEG compression is about 20 to 1, no JPEG artifacts are evident and image quality color balance between units is good. These JPEG DOQQs (*.jpg) files are each provided with a georeference via a companion world file (*.jgw) file of the same name. It is a simple matter to select hundreds of them in mosaic, which will autolink to them. Mosaic can then assemble them into a single JPEG2000 lossless output raster object representing a county or some other project unit. Since the input objects were heavily compressed JPEG files, the lossless JPEG2000 mosaic is also of a significantly reduced size. A future development in mosaic would be to permit it to use a region defining the irregular boundary of a county or project to control the portion of the input objects to mosaic and even to automatically select the objects needed from a common directory(s).

<u>Lossy MrSID into Lossy JPEG2000.</u>

Landsat 24-bit color orthoimages of 15-meter resolution can be downloaded for almost all the earth except for the poles for circa 1990 and circa 2000. These NASA sponsored orthoimages are in 6 by 6 degree units and are compressed about 30 to 1 into MrSID files. These MrSID images (*.sid) can be downloaded with their georeference provided in a companion world file (*.sdw). Mosaic can then link to these files and convert them into a single province- or country-covering raster object and apply lossy or lossless JPEG2000 compression. Now you can prepare and substitute a 15-meter color image coverage of your nation in place of the 1-kilometer MODIS images distributed with **RV6.9** on the Global Reference Geodata DVD. Using reasonable compression for your JPEG2000 results will permit you to use these large coverage images in your projects including their free distribution with **TNTatlas**, **TNTsim3D**, and via **TNTserver**.

Predefined Raster Combinations.

Statistics for corresponding cells in a set of rasters can be computed using the Statistics operation under the Algebraic combination category. This procedure computes two output raster objects, one containing the cell-by-cell mean and the other the cell-by-cell standard deviation for the selected input raster objects. This operation might be used, for example, to compute cell-by-cell statistics for a time-series of vegetation index rasters (or rasters containing any other measured or computed numerical value).

An Exclusive Union (XOR) logical operation can be performed on a set of binary raster objects. Like the previously-available logical AND and logical OR operations, the XOR operation produces a binary raster object. When performed on a pair of input rasters, XOR produces a cell value of 1 if either input has value 1, but not both. Thus the result is 1 if the two corresponding input cells have different values (0 and 1) but 0 if the two input cells have the same value (1 and 1 or 0 and 0). When you select more than two input objects, the operation is performed sequentially: input 1 XOR input 2, result 1 XOR input 3, result 2 XOR input 4, and so on. In general, the cell result will be 1 where the number of input 1's is odd and 0 where the number of input 1's is even.

Raster to Vector Boundary.

This process will now warn you if you are requesting it to convert a highly variable input raster into a vector object. Since this is a somewhat qualitative appraisal by the program, you can override this warning and attempt to proceed.

Converting a raster object to a vector object is generally applied to categorical or theme rasters or to the results of automated image processing which categorizes the image into a few classes grouped into clusters of cells of equal value. It is not usually meaningful or useful to convert a highly variable raster object such as an unprocessed image to a vector object. Representing a cell as a vector polygon with topology will inflate the storage for that cell by about 100 times. This is not due to the vertices for the polygon but the overhead associated with the definition of a polygon. This overhead is not increased appreciably when the polygon bounds a meaningful area of uniform cells, but is prohibitive when each cell or a small number of cells make up each polygon. It is also very time-consuming to make this large number of conversions. Thus, this inappropriate kind of conversion will either take so much time to complete that you would conclude that it was not working or produce a huge object. Another result would be that it would run out of storage space since the storage can not be estimated before the vector object is complete—it could easily grow to 100 times the count of the cells in an image.

Import/Export.

Vector Import.

CARIS ASCII graphical data files can now imported. CARIS is a vendor of GIS-oriented products focused upon hydrographic and coastal applications.

MapInfo MIF files now import with improved support for text fonts, color, and styles.

Vector Export.

Geography Markup Language (GML) files conforming to version 2.x can be exported from vector or CAD objects. GML (*.gml) is the OpenGIS's XML encoding for the transport and storage of geographic information, including both the geometry and properties of geographic features. Specifications for GML can be found at www.opengis.org/specs/?page=specs.

ESRI shapefile export can now export vector or CAD label elements as shapefile point elements with the label string as the database record entry for the point.

Raster Import / Linking.

ESRI ArcGrid files can now be imported in all forms including even when they are compressed.

Images in the Robinson projection can now be imported from the ArcGrid format.

PNG (*.png) import will now recognize the ICM color profile tag in the PNG file and import the ICM color profile as a subobject of the raster object. If the ICM color profile does not exist but the gamma and chromaticity values do, then an ICM color profile object is created under the raster to contain the gamma and chromaticity values.

MrSID files (*.sid) can now be imported or autolinked on all supported platforms (Mac OS X, Linux/Unix, and Windows). In **V6.9** this capability could only be used on Windows-based platforms. Now MrSID files can also be used interchangeably on all **TNT** supported platforms.

TIFF import and auto-link will now convert the metadata in the TIFF directory to a metadata subobject in the Project File.

Sun Raster (*.ras) import will look for the companion world file (*.snw) of the same name and transfer its georeference into the corresponding raster object.

Raster Export.

When export georeference to "descriptive text" all Coordinate Reference System (CRS) details are included.

PNG export process now exports the opacity mask for the file as the alpha channel. The export will also export the ICM color profile if one exists under the raster object.

TIFF export now optionally provides "pack bits" compression for 8-bit rasters and uses it by default instead of LZW compression.

GeoTIFF export now optionally creates a conamed companion world file (*.tfw) containing its georeference data. Some other products read a GeoTIFF as a TIFF and expect the georeference information to be available in this world file. The scale factor for the Lambert Conformal Conic projection is now also included in the GeoTIFF.

Font Management.

Previous issues of this MEMO have discussed in detail the issues of font management that plague this industry due to font copyrights, varied font rendering methods, and other similar issues some of which must date all the way back to Gutenberg. Your problems arise when you move projects and results between various computers and are even more likely when the move is between platforms with different operating systems. This even occurs when your cross platform activities (for example, Windows to Mac) are totally within the **TNT** products. The new location or operating system may not have the same fonts available and you may have used one that can not be moved due to a copyright, can not be rendered well on the device (paper versus monitor), and so on. At that point the software at the destination has no choice but to make font substitutions with or without your input.

Font substitution is likely to occur in published results such as the **TNTatlas**, SVG layouts, and PDF documents that can be designed to run across all platforms. To minimize the impact of this, MicroImages has continued to improve how font substitutions are made within the **TNT** products and your project results. Two forms of font substitution are now used in **RV7.0**: "considerate automated substitution" or in the order of your pre-programmed list of "designer specified substitution."

Considerate Automatic Substitution.

TNT font substitution is automatically used when you have specified only one font and it is not available. It is "considerate" because it does not make arbitrary substitution, which is common, but matches up fonts that have similar appearance, for example sans serif fonts are replaced by other public domain sans serif fonts. These **TNT** substitutions are preprogrammed for various font styles. The substitutions are listed in a table on the accompanying color plate entitled Font Substitution in the TNT Products.

Designer Font Substitution.

When you choose a font name or family during the design of your project, you are attaching that font name to that text string (for example, {~FArial-Bold.ttf}), which would

render the character string with this format code in Arial Bold. However, you can define your preferred substitution using the form {~Farialbd.ttf,Helvetica.dfont;2,Arial-Bold.ttf}. This will be interpreted by **TNT** processes to mean use the Microsoft version of Arial bold if it is available, if not try for Helvetica, then try for the Sun version of Arial bold. If none of these fonts can be found, then automated substitutions will be made. The superior results of using designer or considerate automatic font substitution for a DataTip created with Arial fonts in Windows and then moved to a Mac to find and use Helvetica is illustrated in the accompanying color plate entitled Font Substitution in the TNT Products.

Map Calculator.

The map calculator use and operation remains about the same as **RV6.9**. However, it now takes complete advantage of the new Coordinate Reference System (CRS) introduced in **RV7.0**. See the above major section entitled New Coordinate Reference System for details on these many new, possible conversions.

* Advanced Geometric Object Conversion.

Diverging Objectives.

CAD software has a very large user base; why doesn't this software dominate the GIS application area? Vector topology provides the basis for many useful area oriented operations; why is it not maintained in GIS systems? Geo-oriented games have the largest installed user base of all and have their own graphical storage structures.   IT managers are in charge in large, centralized enterprises that build their business infrastructure on databases software including any geographical data. Web servers have their own preferred graphics formats, which they try to adapt to fit their geographic requirements.

All of these important spatial endeavors are built up on graphical data structures. However, all these various structures are quite different since their primary application, while it may be spatial in nature, is quite different. All of you have experienced this in attempting to convert CAD data to GIS data and vice versa in some software package. It can be done, but the results can be unusable. Converting a CAD drawing with many blocks and individual lines with their own part description into a vector object can produce a very bloated vector object with complex topology. Converting a vector object to a CAD object can also produce complex results as everything can be in pieces and no concept of organized subparts, such as blocks, will be represented. In fact, shape type data storage structures evolved into existence to better fill the gulf in the middle of the CAD, vector, and database structures.

Resulting Complications.

Alas, if you are truly engaged in geospatial analysis, not just isolated in GIS, engineering, database management, … you will quickly learn the value of these different structures. You also quickly learn that the geospatial analyst has to deal with each and all of them with facility. A typical simple urban project will have property information in CAD form, ownership records in some database structure, historical data such as deeds in paper form or as scanned PDFs; requirements to upgrade it all with MrSID, JP2, or JPEG images; images of buildings in JPEG; a desire to go online to serve its internal needs (intranet) or public access (Internet); and so on. And this simple problem is repeated over and over worldwide with varying degrees of existing data preparation and

quality. Major nations do not even have a documented cadastre or records of where things are on or in the ground. These kinds of issues get much more complicated when the source materials that do exist are not only in these different formats, which are "optimal" for their current use, but also jealously guarded in that format for compartmentalized business or military turf or other compartmentalized reasons.

Integrating Disparate Strategies.

All of this is already clear to many of you who, by buying your **TNTmips**, understood the need to deal with using each of these project components in its optimal form. You also realize that at some point in a geospatial analysis process, you will need to move geodata between these formats with as much facility as possible or use them together such as in a **TNTatlas**. Perhaps this is merely a requirement to link to that data structure and add it as a display layer. Perhaps you need to edit that data structure. Eventually you will need to move from one structure to another.

As an encompassing geospatial system, not a GIS, CAD, database … system, **TNTmips** and its associated products are focused upon meeting all these diverse requirements. **RV7.0** makes significant gains in improving the integrated use of these common, but marketed different data structures that you will encounter and use. This is an evolutionary process and never will be truly easy. Gradually **TNTmips** is supporting the direct use of these data structures as layers, without import, directly from their various native formats. Shapefiles can now be used in this manner. JPEG and PNG rasters have also been added to this list.

Geometric Conversion Engine.

Improved Integration.

RV7.0 introduces into several key processes a new Geometric Conversion Engine, which consolidates the fragmented code used in the processes to convert between vector, shape, CAD, TIN, and region data structures. This immediately made it possible to create and plan for many new features in those **TNT** processes that previously only extracted and/or copied geodata within a specific object type. Using this new engine, Copy and Paste and the processes to Extract and Merge can now automatically convert data between these geometric data types (for example, CAD to vector). This powerful new engine also incorporates all the "transparency" properties you expect in a **TNT** process. For example, the Coordinate Reference System (for example, projection) of the source data (which means, the copied area) may be different from that of the destination (which means, the paste layer) and will be converted as it is inserted.

Expanded Capabilities.

In these reincarnated processes, you can use any of the **TNT** selection procedures to determine what source elements to use in the conversion process. This inherent **TNT** capability also takes advantage of the new and greatly expanded Coordinate Reference System released in **RV7.0** and discussed elsewhere in this MEMO. You can now also elect to use a complex region boundary to define the area to be converted in these processes in addition to how the edge effects should be handled (which means, partially inside, completely inside, …). And bigger objects being converted to vector form use the faster and more powerful validation engine and its new abilities to resolve conflation problems when the source and destination objects have many complex overlapping features as discussed in detail elsewhere in this MEMO. With these powerful new capabili-

ties now in place in **RV7.0**, you can expect more capabilities along these lines to appear in the **TNT** products to further define what a geospatial analysis system should be capable of. The current new conversion capabilities are summarized in the following subsections and a sample is illustrated in the accompanying color plate entitled <u>Geometric Object Conversion</u>.

<u>Faster Operation.</u>

Merge, Combine, Extract, and copy/paste operations to a vector object is now faster due to improvements in the topological validation step. While this step is faster in **RV7.0** its result is greatly improved as it is checking for and resolving conflation problems in the output vector object.

<u>* Geometric Object Conversions.</u>

Using the new integrated common code Geometric Conversion Engine "Vector to CAD," "CAD to Vector," "Region to Vector," and "TIN to Vector" processes have been replaced by a new set of processes called "Geometric to Vector," "Geometric to CAD," and "Geometric to Region." The term "Geometric" refers to any spatial object that is not a raster, raster set, or hyperspectral object. The current geometric set includes vector, CAD, TIN, shape, and region objects. Therefore, the new "Geometric to Vector" process will allow selection of CAD, TIN, shape, and region objects to convert to vector objects. "Geometric to CAD" will allow the selection of the vector, TIN, shape, and region objects to convert to CAD objects. "Geometric to Region" will allow the selection of vector, CAD, and shape objects to convert to region objects. All of the "Geometric to…" processes now support selection of multiple files.

The Geometric Conversion Engine that is used in the conversion processes can accept subsets of the source objects using the options "By Script," "By Attribute," and "By Element" to generate which elements to convert. "By Script" is used to select elements via query, "By Attribute" is selecting elements via record attachment, and "By Element" uses the elements selected via the user interface. These all work in conjunction with the region selection capability. For example, you can choose a CAD object, select some of its elements via a script and limit the area using a region to convert or merge to a vector object.

In the Geometric to CAD process if a vector object is selected, a line is created in the destination CAD object if the vector line has an attachment to a record in a user defined table, even if the vector line is part of a polygon that was transferred to the CAD object as well.

<u>* Merging Objects.</u>

Process / CAD / Merge… and Process / Vector / Merge… now allow selection of other geometric objects to be merged into the destination vector or CAD object. These geometric objects include vector, CAD, TIN, shape, and region objects.

The Geometric Conversion Engine that is used in the Merge processes can accept subsets of the source objects using the options "By Script," "By Attribute," and "By Element" to generate which elements to convert. "By Script" is used to select elements via query, "By Attribute" is selecting elements via record attachment, and "By Element" uses the elements selected via the user interface. These all work in conjunction with the region selection capability. For example, you can select a CAD object, select some of its ele-

ments via a script and limit the area using a region to convert or merge to a vector object.

The vector Merge process now allows the selection of the topology type (polygonal, planar, and network) for the resulting vector object or the merge process will automatically determine the best topology level given the source objects.

* Vector and CAD Extraction.

These Extract processes are now integrated into the Geometric Object Conversion process discussed above. They can still be accessed on the menu under this older entry to avoid confusion.

CAD Object Warping.

CAD object warping now supports densification of the elements.

Spatial Data Editor.

* Copy.

The Copy / Paste operation now has significantly expanded capabilities using the new Geometric Object Conversion engine discussed above. You can now copy from a vector, CAD, TIN, region, or linked shape object (which means, shapefile) including linked objects. During the copy operation, you can select the irregular area to copy from any using a region object. This copy area selected from a vector, linked shape, CAD, or TIN layer can be optionally controlled as appropriate to the source object type to be Partially Inside, Completely Inside, Clip Inside, Partially Outside, Completely Outside, and Clip Outside the source object. An example of the application of this feature is illustrated in the accompanying color plate entitled Copy/Paste between Geometric Objects.

* Paste.

Regardless of the type of geometric object selected for the copy operation, the subarea can be pasted into a CAD object or into a vector object and their relational database structures will be reconciled. The topology will also be validated if the target is a vector object. Future capabilities will permit other geometric objects as the generic paste destination (for example, a shape object). This strategy is another big step forward in permitting your **TNT** application to understand, interchange, integrate, and take advantage of the unique and useful properties of each of these widely, but usually separately used geometric data structures.

Toggle Through Mixed Elements.

Right Mouse Button operations will now allow you to toggle through nearby elements (not just vector element types as in previous **TNTedit** versions) for vector and CAD editable objects. For example, two or three vector labels lie on top of each other as a result of label auto generation. Pressing the right mouse button will select one of the labels, then pressing the tab key will toggle through the other labels and any lines, polygons, nodes, and points that are nearby, allowing the selection of the label you want to move. For CAD elements, holding the right mouse button and pressing the tab key will toggle through all of the CAD elements it found within its search distance allowing you to edit elements that are hard to select. These time saving actions are illustrated in the accompanying color plate entitled Step through Elements with Tab Key.

Manifolds.

Creation and / or editing of a spatial object with a manifold georeference is now supported. When opening a reference or editable spatial object with a manifold georeference, the editor will generate a set of dialogs for a separate 3D view. This 3D view will contain a layer referring to the manifold georeferenced object in the Editor's View window. Any other reference layers can be viewed in the 3D view window. Creating a new object over the reference manifold georeference object will copy the manifold georeference to the new object. All reference and editable layers in the Editor's View window must have the equivalent manifold georeference. When all of the layers that have a manifold georeference are removed from the edit view, the associated dialogs are closed.

Undo.

Changes made in the Numeric Edit tool can now be reversed using the "Undo" button.

Database Features.

Table Setup.

Background.

A single graphical element can have many attributes accompanying it in the fields and records in a relational database structure. Some projects require that you think out very carefully the required tables and then design their internal record structure including records, fields, and value data type. You should also carefully structure these tables so that their relational structure simplifies them and their subsequent use. A single flat database table can quickly grow huge to have hundreds or thousands of different fields and millions of records with a poor design and extensive duplication. A relational structure has small compact tables with linkages to minimize this record and table duplication. An intelligently designed structure can make your geospatial analysis much easier. If you were trained and/or experienced with database systems, you knew all about this. If you are a geospatial analyst, you need to learn this skill quickly. As soon as you begin combining geometric layers, you will quickly see the impact of your skill level in this area and improve it. **TNT** provides the tools you need to create your tables and structure, monitor their hierarchy, and to simplify, revise, and restructure it.

Wizard.

A simple wizard approach is now used when you set up a new table in the Spatial Data Editor or any other process and its steps are illustrated in the dialogs in the accompanying 2-sided color plate entitled Database Table Creation Wizard. After you designate the new table's name and description you are prompted in a dialog to select from the 6 attachment types you can use for the records in this table (for example, one element per record, one record per element, …). If you choose any except the first option on this list, you are creating a directly related table and are next presented the Table Definition dialog to set up its contents. If you select the first attachment type, "Relate to another table through a key field," the next wizard dialog will prompt you to select the field and table that the new table you are creating will use as a relational link to your graphical elements. If you have chosen a primary key in the old table as the link field for your new table, you will now be taken to the Table Definition dialog so you can continue on to design the contents of your new table. If you choose any other field in the old table to link to, then the wizard will ask which table should contain the primary key field for their link-

age. When this selection has been made, you are given the Table Definition dialog to design the internal structure of your new table.

Virtual Tables.

Virtual fields are those whose value is defined at the time of their use, such as when they are presented in a DataTip. Virtual fields are computed or string expressions that can be selected in the Table Definition dialog from the "Field Type" button. Once a virtual field is set up, it is used and managed just as if it were a real field. Virtual fields can be used to compute a DataTip's contents (using an equation or a script) and to format the result (using string expressions and format codes). Virtual fields can be used for many other geospatial applications, such as computing a spatially varying URL link and then starting a browser with it. For example, selecting a zip code polygon can insert its real field zip code value into a virtual field that already contains the rest of the string expression needed to start a browser and retrieve the weather page for that zip code.

A virtual table contains only virtual fields. This is analogous to setting up a "View" if you are familiar with relational database products. When using virtual fields, it can be convenient, even necessary, to create virtual tables in your relational table structure to contain them and support the special features they provide. A table you set up using the wizard will automatically be virtual if it does not have any real fields and you use the Table Design dialog to create one or more virtual fields in it. Once established in your relational structure, a virtual table looks and operates as if it were a real table. It can be seen in your database hierarchal tree view, transferred, reused, altered, and so on. An example using a virtual table and the sample scripts defining its virtual fields is in the accompanying 2-sided color plate entitled <u>Database Wizard and Virtual Tables</u>.

Database Management.

Deleting duplicate records now detects if the table attachment type would prevent a record from becoming attached to multiple elements and, if so, gives you the opportunity to change the attachment type to something less restrictive.

Current attachments are retained when changing the table attachment type from "implied one-to-one" to another direct attachment method.

Text Editor.

Tabs can now be set in text blocks using the tab key. This is especially useful in creating vertical alignment of your text, especially in DataTips as illustrated in the multi-line DataTip on the accompanying color plate entitled <u>Property Viewer Atlas for Lincoln, NE</u>.

Fonts can now be specified by their family name ("Times New Roman") as well as by font file name (times.ttf) when using text formatting codes.

When specifying the font for a character string in a text block using {~} codes, you can now specify multiple fonts in case the preferred font can not be found. The order in which the font names are entered will determine the order of your preference for their use.

Double-clicking on a word now selects the word instead of the whole line. Triple clicking now selects the whole line.

Keyboard shortcuts for Cut/Copy/Paste have been changed at your request to ctrl+x, crtl+c, crtl+v to conform to common use in most other software.

A keyboard shortcut (ctrl+s) is available for Save.

Style Editor.

Styles are now sorted alphabetically.

Map Layouts.

Antialiased and Thin Line Width Hinting settings are now being controlled on an individual layer by layer basis (this effects vector, CAD, TIN, map grid, shape, and region objects). This means layouts will render consistently from machine to machine. In **V6.9** these setting were made in user preferences and globally controlled both antialiasing and thin line width hinting. Antialiasing and thin line width settings are now also used in 3D renderings.

Render to SVG.

Scalable Vector Graphics (SVG) is the graphics format developed and promoted by the World Wide Web Consortium (W3C) based on XML. The optional features added to control the rendering of a **TNT** map layout into SVG continues to expand: partially because SVG is an excellent layout structure for use in web applications, especially for interactive maps, and partially because it is a format for communicating graphics information between a **TNTserver** and the **TNTclients**. You continue to expand your use of this format and request these kinds of optional control features.

A new SVG class in the geospatial scripting language (**SML**) permits scripts to render objects or views into SVG. All the SVG output rendering options are available.

It is best to refer to SVG as a layout since it can carry with it linked fonts, linked style sheets and styles, linked rasters in several formats, and other files. The graphics and their use of these the components are in a file but these other items need not be.

SVG Control Window.

Rendering a layout to SVG is about 2 times faster in **RV7.0**. The Render to SVG window has been redesigned to present the **RV6.9** and many new options via tabbed panels. These are summarized on the accompanying color plate entitled Render Complex Layouts to SVG. More will be added as needed, particularly to control the operation of additional JavaScripts, which you can append to the SVG file. The accompanying color plate illustrates this window and summarizes the options it provides.

The Render to SVG window initially has two active panels: Options and Raster Controls and the rest are inactive. It also has toggle buttons that can be used to indicate which special feature JavaScripts to append to your SVG. Adding these will enable the SVG viewer or other application to automatically use DataTips, Measurement tools, Layer Controls, and Coordinate Display features in your SVG. When any of these optional tool toggles is selected, the corresponding tabbed panel is activated and can be optionally selected to change the default settings controlling how that feature will function by altering the JavaScript that is added. The JavaScript for Coordinate Display has no options and, thus, no corresponding tabbed panel. The reverse side of the accompanying color plate entitled Render Complex Layouts to SVG reviews the functions of these JavaScripts and their optional operations.

Options Panel.

Resolution.

The final use of your SVG can vary widely from its use as a conveyance for a subset of graphics for a limited area of a screen view, to a complete, high resolution map in a

portable format. For example, a thin network client (minimal local capability) responding to a minimum bandwidth requirement might request the SVG scale controlled coverage (thus, the portion of a vector or CAD object) that covers the current view.

A thick client designed to do a lot of local work with the server's data and using a broadband connection might simply get all the map layout's contents (vectors, database, …) in an SVG layout and work with them locally off line. In the thick client example, the precision of the coordinates and the resolution of the rasters need not exceed that for the current view. The client will come back and request a new SVG to revise the view. Since this is the same engine that renders to SVG in **TNTserver**, the options panel accepts a resolution value to control the graphics and raster precision for your targeted SVG application. Using the value of 100 will produce an SVG layout that is minimal in size and only matches the precision of your conversion to the current view. A value larger than 100 will increase the detail transferred from the objects in the **TNT** layout into the SVG layout. This value applies to all layers and if set very high will transfer all the detail available but no more.

Toggles are available to control the following, some are new and some are not:
- render the full layout including hidden and layers currently turned off for the view scale;
- clip output to the current view;
- link to style sheets to share them and avoid duplication versus using inline or embedded style sheets to insure they are available;
- inline, or embedded, styles to insure they are available rather than linking to them for sharing with other SVG files without duplication;
- apply gzip compression to the XML file and replace extension *.svg with *.svgz (the accepted convention denoting this compression);
- use XML entities for strings if you plan to edit the XML of the SVG layout;
- embed the SVG file into an HTML framework (for use in Internet explorer only);
- embed TrueType fonts to insure they are available (for use with Adobe or Batik viewers); and
- optimize for use with Adobe Illustrator to avoid issues with scale controlled views.

Raster Controls Panel.
Toggles are available to control the following:
- embed images in the SVG file to insure they are always available rather than simply linking to them so that they can be shared with other processes;
- use only PNGs, which use lossless compression, because it may be better suited to your image data;
- set a preference to use JPEG lossy compressed rasters; and
- change the JPEG compression from approximately 35% to some other desired level.

DataTip Panel.
It is important to keep in mind that DataTips in the **TNT** products can make extensive use of virtual fields, which are evaluated at the time they are exposed. For example, DataTips presenting material from several layers could change if the tables/records/field values being evaluated are changing in the tables. This capability is not supported in SVG DataTips. When you choose to include **TNT** DataTips using virtual fields in your SVG, they are all evaluated and converted to real fields as part of the rendering process. The reverse of the accompanying color plate entitled Render Complex Layouts to

SVG illustrates how a multi-line DataTip defined in **TNT** using a virtual field is converted into SVG and then pops in using the Adobe SVG plugin for Internet Explorer.

As discussed above in the section on GraphTips, a **TNT** Display Control Script provides for complex mouseover events. A simple application is to detect that the cursor is over a small symbol or label and automatically balloon it up so it can be read. By modifying this DataTip JavaScript, this same effect can be added for your labels and pinmapped symbols showing in your SVG. When your cursor is over one of these elements, they will automatically zoom up according to the Symbol Enlargement Ratio you set on this panel, which defaults to 2X. Note that these are labels and symbols that are already showing in the SVG view and this effect is separate from the **TNT** pop-in action associated with any DataTips you have included. The accompanying color plate entitled Render Complex Layouts to SVG shows that positioning the cursor over a symbol can enlarge it by this factor and also pop in an associated DataTip for the same feature.

This panel also programs this JavaScript to change the transparency of the frame from the default of 50%. It also toggles the highlight for the element used for the DataTips from the default, which is your selected highlight color for the **TNT** products, to complementary highlighting and can be set to blink the highlight selected to draw attention to it.

Measure Panel.
At this time this panel has only one option, which determines the drawing paradigm: click and drag (toggle on) or click for each vertex (toggle off) to add the JavaScript for the chosen paradigm. An illustration of the use of the measurement tool is illustrated on the reverse of the color plate entitled Render Complex Layouts to SVG.

Layer Controls.
At this time this panel has two options, which are to add the Adobe Menu JavaScript for layer control in the SVG or a layer control panel. You can choose either, neither, or both. The Adobe Menu JavaScript will present Adobe's layer controls via the right mouse button and only in the Adobe SVG viewer. This Layer Control Pane now has a toggle icon and a "close" button to allow users the option of making its usage visible or hidden. The layer controls added by **TNT** and Adobe JavaScripts are both illustrated on the reverse side of the accompanying color plate entitled Render Complex Layouts to SVG.

Rendering to PDF.

Print to PDF / Illustrator now renders the PDF based on the layout settings rather than requiring adjustments in the print dialog (essentially they needed to match). This makes it easier to switch back and forth from rendering to one print destination to another by allowing you to use the same layout for printing to a printer and subsequently rendering to a PDF. In **RV6.9** you would nearly always need to make a different layout for targeting a local printer for hardcopy and for quality control and then rendering to a PDF.

Color Matching.

The release MEMO for **V6.9** entitled Release of the RV6.9 Products and dated 31 December 2003 discussed color matching in detail. It noted that ICM profiles are not provided for all large format HP color printers, especially older models. It was subsequently found that you can download these ICM profiles for your large HP color printers from Pantone at www.pantone.com/support/support.asp?.idArticle=72.

Geospatial Scripting Language (SML).

Introduction.

The **TNT** scripting language used throughout the **TNT** products (formerly the Spatial Manipulation Language) is now referred to as the geospatial scripting language since this better reflects its current utility. It may also be referred to as **SML**, geospatial scripting, **TNT** scripts, or simply scripts or scripting when the context is clear.

Considerable programming effort has continued to be invested in **SML** to provide a clean, documented, powerful scripting language aimed at those who have special geospatially oriented objectives. **SML** continues new uses such as in the new Display Control Scripts and startup script applications added in **RV7.0**.

TNTmips is a broad-based geospatial analysis system designed to complete as many industry-common projects as possible using widely available geodata and to do them fast and efficiently. However, it is not reasonable to expect that any such system can solve specific unique project needs and research activities. What **TNT** scripting provides is a means to add, extend, supplement, prepare data, … to resolve these special but needed steps or activities.

When a complex task is at hand, especially if it is to be repeated, time spent to automate its steps with **SML** can be very productive. In the paper cited below by Wada and Ohira, its authors credit use of easily created scripts using **SML** macro-like geospatial functions and classes combined with the **TNT** processes to reduce the time to implement their complex research analysis to 10% of what was previously accomplished with some other competing product.

Yokio Wada and Wataru Ohira. 2004. Reconstructing Cloud Free SPOT/Vegetation Using Harmonic Analysis with Local Maximum Fitting. 25th Asian Remote Sensing Conference, Bangkok, Thailand. 5 pages.

This study was completed using **TNTmips 6.9** and **DV7.0** and **SML** scripts written by the authors. It used 36 SPOT/VEGETATION images collected 1 January to 21 December 2002. The PC was a Zeon 1.7 GHz with 2 GB of RAM. This paper is not copyrighted and is published at www.microimages.com/papers/acrs25.pdf and the authors can be contacted at yukio@jafta.or.jp.

Abstract. *"The satellite data of low resolution such as SPOT/VEGETATION, NOAA/AVHRR and TERRA/MODIS etc. are very effective in vegetation analysis on global scale. Especially, the satellite data that are observed everyday is suitable for time series analysis such as illegal logging, forest fire, seasonal vegetation change and forest change. But, in these satellite data noises due to influence of cloud and mosaic are included, and disturb due analysis. The result is always an image with data gaps. This study aims to reconstruct time-series data without cloud, noise and gap. Basic ideas used for the reconstruction are Harmonic Analysis and Local Maximum Fitting (LMF) algorithm. We tried to reconstruct smooth and gapless data. This Harmonic Reconstruction (HR) process was applied to 36-image series of SPOT/VEGETATION S10 product NDVI data of 1 year covering most Asian region. S10 product is 10 days synthesis by Maximum NDVI method. First, Local Maximum Fitting was conducted to exclude abnormal data. Next, amplitude strength and phase parameter classified by period were calculated by Harmonic Analysis. By fitting these in cosine equation, the data were reconstructed. As a result, it could reproduce smooth data with which influ-*

ence of cloud and noise is little. In addition, it should be noted that specification of the used PC and the remote sensing software are not more than standard ones. It could also save the processing time by 90% or more in comparison with the ones by other similar model fitting process. For user's convenience difficult programming is not necessary and this process is simple to handle."

SML and now **TNTsdk** are available for this purpose and will both automatically extend your results across all supported platforms and in your language. There are many strategies in the **TNT** products for using scripts: batch run scripts, scripts for queries, Tool Scripts, Macro Scripts, Display Control Scripts for GraphTips, and other automatic activities. Scripts can be used in **TNTsim3D** for controlling or extending simulations. Scripts can create display layers. Scripts can make forms, add constraints, start and communicate with other non-**TNT** programs in VB, C++, or Java.

Writing scripts may seem to be daunting at first for non-programmers, but MicroImages is now providing lots of good support help in this area. If you do not want to learn to script for yourself, there is always a student around who wants to earn some extra money. Those with some programming experience will find geospatial scripting interesting because it can accomplish visually interesting results with a single page of script as shown by many of the sample scripts. A good introductory tutorial is available entitled Writing Scripts with SML. Hundreds of professionally written sample scripts are available at www.microimages.com/freestuf/scripts.htm to be used as examples, models, and sources of code snippets for your scripts.

Sample Scripts.

Using Crystal Reports.

Periodically MicroImages is asked how to communicate with other non-geospatial commercial products such as Access, Excel, and so on. Previous MEMOs and associated **SML** scripts and color plates have addressed the topic of how to communicate with these other programs. These scripts have illustrated how **SML** can be used to start another Visual Basic, C++, or Java program and transfer data to it. That program in turn can use the API of other commercial products to start and use these results. The reverse has also been demonstrated where other product's results, such as updates to external database table(s), can use an **SML** or a custom program to update a table view or a pinmap in a **TNT** view.

The accompanying color plate entitled Create Crystal Reports with SML illustrates the results and lists the content of a very short sample script for displaying **TNT** results using this commercial product. The table used to generate this report is a simple flat table attached to a vector object. However, much more complex results could be prepared using **TNT** processes and/or this script. For example, a **TNT** query could be composed and interactively tuned to select the features of interest and an **SML** Macro Script from the **TNT** menu to assemble their attributes from relational tables to create this kind of report.

Computing Terrain Curvature.

This is a sample script showing how to set up and compute special raster properties yielding new raster objects. This script computes geomorphological curvature properties of terrain. The accompanying color plate entitled Terrain Curvature illustrates the results and lists this script, which computes profile curvature and plan curvature raster ob-

jects from an elevation raster. Everyone has different ideas about how these kinds of properties should be computed—kernel sizes and shapes, coefficients, surface fit, and so on. This script provides a template that can be modified to handle these different objectives and as the basis for computing other special terrain and raster properties.

Identifying Coastal Mosquito Habitat.

This Tool Script was created in close collaboration, including a visit from a long term MicroImages client, to accomplish a similar task in a **TNT** script as that in an ESRI Avenue script. Its objective is to permit this expert to statistically examine the correlations of occurrence with habitat of a specific species of mosquito restricted to coastal areas. It uses climatic and geomorphological rasters to characterize the habitat, vector buffer zones to set test positions, relational databases of mosquito trapping results, a Tool Script approach to identify the test positions, and CartoScripts to illustrate the statistical results. The accompanying color plate entitled Mosquito Habitat Statistics (U-Test) illustrates and explains the tool in more detail.

This Tool Script is representative of the very specialized tools that can be created to explore the spatial relationships between spatial features and massive databases. It is typical of a design used by experts in geological, biological, and other complex analyses whose "expertise" can not be "coded." It is not designed to be a blind data-in and data-out geospatial analysis because there is no definitive answer. What is required is to keep the expert's unique knowledge of the subject tightly and interactively integrated into the tool so that generalities can be drawn to serve as the basis for the next hypotheses. What is also required is a geospatial framework that maintains tight integration and access to all the types of geodata available, not a GIS, image processing, or CAD system.

Profiling Pipes in an Urban Infrastructure.

This Tool Script shows a sample use of interactive feature selection in a 2D view to present graphical results in an attractive custom window and is illustrated in the accompanying color plate entitled Infrastructure Graphical Profile. The input for this sample script is a network vector object of pipelines overlaying an elevation raster. The cursor can be used to interactively select a sequence of lines in a 2D view. You can use it to select or deselect lines that connect to either end of the line selection you are extending in the 2D view. Your connected line selections are highlighted in color in the 2D view. Use this section of this script to select and connect multiple end-to-end lines in your scripts before using the line in subsequent steps.

At any time a connected line has been selected, a right click of the mouse draws a profile of the line in the profile window created by this script. This part of this script illustrates how to draw complex graphical results in a window. The surface of the ground is drawn from the trace of the line on the elevation raster. The pipes are drawn at their depths below the ground profile. Each pipe can be styled to reflect its material type and its diameter.

General Features.

Hash variables can now be used like arrays but you don't need to specify a size in advance and the subscripts can be numeric or strings.

A "switch" statement can be used and has a syntax identical to that used in "C."

Function "prototypes" can be used just like in "C."

The exclusive or (XOR) operator is available.

The **SML** Editor now uses syntax highlighting.

Creating Manifold Objects.

New classes are available so that a script can create the 3D georeference to define a manifold surface and combine it with another object to create a manifold object. Use these to create a script to read and use 3D control points from an external database that could change dynamically to change the surface shape when viewed in 3D. Many data mining results are presented and viewed in this fashion. Even more dynamic results can be achieved when manifold objects can be used in a **TNTsim3D** and are shaped and changed in shape from an external database.

Googling SML.

All the **SML** sample scripts, script names, brief descriptions, and related materials have been incorporated into the MicroImages website in such a fashion that it is now being indexed by Google. Thus, you have one more way to find that function or script of interest. Simply choose the Search Site tab on the MicroImages home page and let Google present you with the links to these materials using your key words.

New Functions.

Database functions. (8)
DatabaseCreate( )
    Create a "standalone" database object.
TableCopy( )
    Copy a database table from one object's database to another.
TableDelete( )
    Drops a table from its database.
TableGetRecordElementList( )
    Get list of elements with a given record attached or related.
TableGetRecordListElementList( )
    Get list of elements to which a given list of records are attached or related.
TableRemoveDuplicateRecords( )
    Deletes duplicate records from the table.
TableRemoveUnattachedRecords( )
    Deletes unattached records from the table.
CloseDatabase( )
    Close an open database instance.

Raster Functions. (5)
ComputeMeanRaster( )
    The output raster contains the mean value (at each cell) of all the inputs.
ComputeStdDevRaster( )
    The standard deviation (at each cell) of all the inputs is assigned to the output raster.
RasterCompress( )
    Copy compressed source raster to the destination raster.
GetMaxPossibleValue ( )
    Get the maximum possible data value in the raster.
GetMinPossibleValue ( )

Get the minimum possible data value in the raster.

Vector Functions. (3)
    Vector Copy Elements( )
        Returns Vector with elements from source that meet the query selection criteria.
    VectorIsEquivalent( )
        Determine if two Vector objects are equivalent.
    VectorWarp( )
        Warp the source vector from the transparm's source to destination projection.

Object Functions. (4)
    FindInvalidObjects( )
        Search the Project File (*.rvc) for invalid objects.
    PackRVC( )
        Eliminates unused space from the Project File (*.rvc).
    RecoverProjectFile( )
        Recover Project File copying to new file.
    SetObjectName( )
        Change the object name of an existing object.

System Functions. (1)
    GetLastError( )
        Get the last error encountered in the script to test if a function succeeded.

String Functions. (1)
    StrToDeg( )
        Convert string in degrees, minutes, seconds format to decimal degrees.

Georeference Functions. (2)
    CreateSimpleGeoref( )
        Create simple raster georeference.
    GeorefSetCoordRefSys( )
        Set the coordinate reference system for a georeference object.

Style Functions. (1)
    StyleReadHatchPattern( )
        Read a hatch pattern from a style object into memory.

CAD Functions. (2)
    CADReadPolyLine( )
        Read a CAD element into the polyline.
    CADWritePolyLine( )
        Write a CAD element from a given polyline.

TIN Functions. (2)
    CreateTIN( )
        Create a new TIN object without prompting user to select file.
    OpenTIN( )
        Open a TIN object without prompting user to select input file.

Resource File Functions. (1)
    ResourceAugment( )
        Add user-defined text resources to allow localization of dialogs created in **SML**.

Geodata Display View Functions. (1)
    ViewRedrawLayer( )
        Redraw the specified layer in the view.

Object Conversion Functions. (4)
    ConvertCADToVector( )
        Convert CAD object to vector object.
    ConvertTINToVector( )
        Convert a TIN object to a vector object.
    RasterToTINIterative2( )
        Converts elevation raster to TIN object as contour lines.
    RasterToVectorContour2( )
        Converts elevation raster to vector onject as contour lines.

Raster Global Functions. (3)
    GlobalMedian( )
        The median cell value in the raster object.
    GlobalMode( )
        The cell value occuring most often in the raster object.
    GlobalMost( )
        The number of times the GlobalMode value occurs in the raster.

Vector Toolkit Functions. (2)
    VectorAddPolyLine( )
        Add a vector line/polygon from the given polyline.
    VectorChangeNode( )
        Changes the location of an existing node in a vector object.

New Classes.
    RVC_GEOREFERENCE
        Completes all georefrence object manipulations including those for manifolds.
    TRIANGUALTOR
        Handles triangulation of points with break edges and clipping regions.
    BOUNDARYLIST
        A list of boundary node arrays.
    EDGEINFO
        Information about edges in a TRIANGULATION.
    TRIANGLEEDGES
        Structure to hold the edge numbers of a triangle.
    TRIANGLEINFO
        Information about triangles in a TRIANGULATION.
    TRIANGLENODES
        Strucuture to hold the node numbers of a triangle.
    TRIANGLETRIANGLES
        Structure to hold the triangle numbers of neighboring triangles.
    SVG
        For writing SVG layouts.
    MieARCE00RASTER
        For import/export parameters.

HASH
> Similar to an array (Perl programming).

ELEMENTREF
> Container for spatial element specifying type and number.

GRE_LABELS
> Class controlling labels and their placement.

GRE_LAYERDC
> Layer drawing context containing information needed to actually draw layer on a particular view.

HATCHPATTERN
> Containter class to hold hatch pattern information.

LABELATTACHMENT
> Class for attaching lables to their elements.

LABELPLACE
> Class for keeping track of where a label is on the screen.

LABELSTYLE
> Structure for holding style information for a label.

MieCARIS
> CARIS format import/export parameters.

REGION2D
> An in-memory region representation.

SR_COORDOPDEF
> Spatial reference coordinate operation definition.

SR_COORDOPPARM
> Spatial reference coordinate operation parameter.

SR_COORDREFSYS
> Coordinate Reference System.

SR_COORDSYS
> Coordinate System specification.

SR_DATUM
> Spatial reference coordinate datum specification.

SR_ELLIPSOID
> Spatial reference ellipsoid specification.

SR_PRIMEMERIDIAN
> Spatial reference prime meridian specification.

UNIT
> UNIT specification for units of measure.

Upgrading TNTmips.

If you did not purchase **RV7.0** of **TNTmips** in advance and wish to do so now, please contact MicroImages by FAX, phone, or email to arrange to purchase this version. When you have completed your purchase, you will be provided with an authorization code by FAX. Entering this authorization code while running the installation process lets you to complete the installation of **TNTmips 7.0**.

The prices for upgrading from earlier versions of **TNTmips** are outlined below. Please remember that new features have been added to **TNTmips** with each new release.

Thus, the older your version of **TNTmips** relative to **RV7.0**, the higher your upgrade cost will be.

Within the NAFTA point-of-use area (Canada, U.S., and Mexico) and with shipping by UPS ground. (+150/each means US$150 for each additional upgrade increment.)

TNTmips Product	Price to upgrade from **TNTmips**:				**V6.4**	
	V6.9	**V6.8**	**V6.7**	**V6.6**	**V6.5** and earlier	
Windows/Mac/LINUX	US$500	750	950	1100	1250	+150/each
for 1-user floating	US$600	900	1140	1320	1500	+180/each
UNIX for 1-fixed license	US$800	1250	1650	2000	2250	+200/each
for 1-user floating	US$960	1500	1980	2400	2700	+240/each

For a point-of-use in all other nations with shipping by air express. (+150/each means US$150 for each additional upgrade increment.)

TNTmips Product	Price to upgrade from **TNTmips**:				**V6.4**	
	V6.9	**V6.8**	**V6.7**	**V6.6**	**V6.5** and earlier	
Windows/Mac/LINUX	US$600	900	1150	1400	1600	+150/each
for 1-user floating	US$720	1080	1380	1680	1920	+180/each
UNIX for 1-fixed license	US$900	1400	1850	2200	2500	+200/each
for 1-user floating	US$1080	1680	2220	2640	3000	+240/each

Internationalization and Localization

Localization Editor.

Translating the help messages is an optional requirement. A toggle has been added to exclude these help messages if they are not to be translated.

Note! If your language is missing for **RV7.0** and earlier, please contact MicroImages if you wish to discuss becoming its official technical translator.

MicroImages Authorized Resellers

The following 5 new Resellers were authorized to sell MicroImages' products since **RV6.9** shipped.

AUSTRALIA.

Melbourne

Geo-Ed Consulting

David S. Gamble voice: (6139)482-7753
24 Mark Street FAX: (6139)429-2044
North Fitzroy, VIC 3068 email: dgamble1@bigpond.net.au
Australia

BOLIVIA.

Santa Cruz

Industrial Consulting Services Ltd. (ICS)

Rafael Arias voice: (5913)339-1000

Av. Busch #520   FAX: (5913)339-1000
Edificio Equanta, Piso 2   email: arias.ics@scbbs.net
Santa Cruz de la Sierra
Bolivia

INDIA.

Calcutta

OPSIS System

Balen Basu   voice: (9133)2631-8058
Keota Shibtala   FAX: (9133)2355-9712
PO Sahagani   email: opsiset@yahoo.com
Hooghly District, West Bengal
India

SOUTH AFRICA.

Cape Town

Umvoto Africa

Andiswa Mlisa   voice: (2721)788-8031
No. 5 Hillcrest Road   FAX: (2721)788-6742
Muizenberg   email: andiswa@umvoto.com
South Africa   web: www.umvoto.com

CHINA.

Beijing

Beijing Digital View Technology Co., Ltd.

Keming Wu   voice: (8610)8489-5822
8ᵗʰ Floor, Jin Meng Building   FAX: (8610)8489-5819
17 Xiaoying Road   email: tntmips@tom.com
Chaoyang District, Beijing   web: www.dview.com.cn
China 100101

Discontinued Resellers

The following resellers are no longer authorized to sell MicroImages' products. This list is longer than usual as some of these locations were omitted from previous MEMOs. Please do not contact these former resellers regarding support, service, or information. Please contact MicroImages directly or one of the other MicroImages Authorized Resellers.

MicroImages is pleased to provide new resellers the opportunity to use, learn, and resell the **TNT** products. However, professional geospatial analysis is a complex undertaking. MicroImages discontinues resellers for various reasons. Foremost among these is that it is not in our interest, your interest, or the interest of prospective new clients to be put in contact with a reseller who makes little or no effort to use and understand the **TNT** products. As a result, they can not help design or participate in projects, contribute input to MicroImages product improvement and development, or effectively promote the **TNT** products.

Canada.

GlobalPoint Technologies. [Steven Ge] located in Richmond is discontinued.

China.

Spatial Port Network Technologies (SPNT) Ltd. [Guowei Wang] located in Beijing is discontinued.

Egypt.

iTarget. [Sherif Khattab] located in Cairo is discontinued.

Germany.

geo-konzept GmbH. [Thomas Muhr] located in Adelschlag is discontinued.

Ghana.

Dei Consult. [Alfred Dei] located in Cape Coast is discontinued.

Guatemala.

SAESA. [Eddie Alveno] located in Guatemala City is discontinued.

Mexico.

Caddland. [Salvador Silva] located in Guanjuarto is discontinued.

Netherlands.

eXQte. [Hans van der Maarel] located in Klundert is discontinued.

Pakistan.

Digitek. [Hassan Mian] located in Lahore is discontinued.

Poland.

EKO-GIS Services [Marek Kamieniecki] in Szczecin is discontinued.

Russia.

RACURS Co. [Dmitry Kochergin] located in Moscow is discontinued.

ESTI MAP Ltd. [Alexei Prossianov] located in Moscow is discontinued.

Serbia and Montenegro.

PrimaRes d.o.o. [Jasmin Babic] located in Belgrade is discontinued.

Spain.

URBITEC NETWORKS, S.L. [Marina Emelianova] located in Madrid is discontinued.

Switzerland.

GeoMatics. [Isabella Pacchiani] located in Geneva is discontinued.

USA, Florida.

Satellite Imaging Group. [Sean Morrissey] located in Coconut Creek is discontinued.

USA, Colorado

ALPI Services Inc. [Pieter Viljoen] located in Longmont is discontinued.

United Arab Emirates.

Global Environmental Solutions. [Saleh Al-Bashir] located in Abu Dhabi is discontinued.

Appendix: Abbreviations

For simplicity, the following abbreviations were used in this MEMO.

RV7.0 = the official and first release of **RV7.0** of the **TNT** products matching the version on the CDs distributed.

PV7.0 = any version of the **TNT** products created subsequent to **RV7.0** to which patches have been applied to update **RV7.0** or a **PV7.0**.

DV7.1 = The partially complete development version of the **TNT** products which will eventually be officially released as **RV7.1** when complete.

W95 = Microsoft Windows 95.

W98 = Microsoft Windows 98.

WME = Windows Millennium Edition.

NT or NT4 = Microsoft NT 4.0 (the **TNT** products require the use of NT4.0 and its subsequent Service Packs). NT4 now has a Service Pack 6a available. Windows 2000 now has Service Pack 2, which is recommended if you are working with large files.

W2000 = Microsoft Windows 2000.

XP = Microsoft Windows XP.

Mac 10.3.5 = Apple Macintosh using Mac OS X version 10.3.2.

MI/X = MicroImages' X Server for Mac and PC microcomputer platforms and operating systems.

GRE = MicroImages' Geospatial Rendering Engine, that is at the heart of most MicroImages products. The current **GRE** will respond and render requests from either X/LessTif or Windows.

VB = Microsoft Visual Basic

MB = megabyte (1,000,000 bytes)

GB = gigabyte (1000 megabytes) or 10^9 bytes

TB = terabyte (1000 gigabytes) or 10^{12} bytes