Use of GIS to Identify a Possible New Freight Rail Route

Joshua Chlapek

A Course Project for

Dr. Minhe Ji
Intermediate GIS
University of North Texas
I. Introduction

In most countries around the world, the process of developing and implementing passenger rail systems, particularly commuter rail, essentially begins and ends within government. Many countries have publicly-owned rail systems, and government agencies can work together to institute passenger rail over public trackage to serve the populations of bustling metropolitan areas.

In the United States, however, private ownership of the primary rail lines complicates what would otherwise be an exercise in public bureaucracy. Corporations such as Union Pacific and Burlington Northern-Santa Fe own tens of thousands of miles of trackage, the rails of which are plied by freight trains carrying the commerce of the nation. Many large metropolitan areas, such as Chicago and New York City, have public rail transportation systems which use some private or semi-private rail lines, and many other cities, such as Dallas, have been able to purchase abandoned or little-used rail lines for conversion into commuter rail usage.

In the case of Austin, Texas, however, the most desirable route for a commuter rail line would require the use of an increasingly busy main line of the Union Pacific Railroad. Acquisition is out of the question, and sharing the right-of-way would require either sharing the existing track or adding additional tracks, with the former solution being the most desirable. A recent article in the *Austin American-Statesman* examined this possibility, but suggested that Union Pacific’s ultimate cooperation would be more likely if the city would construct a bypass for freight traffic around Austin, using both existing and new rail lines. The construction of the new portion of this line is the focus of this project.

In addition to the line from San Antonio through Austin and Round Rock to Taylor and beyond (the “Austin Subdivision”), Union Pacific owns a rail line running south from Taylor to Smithville (part of the “Waco Subdivision,” which continues north from Taylor through Temple to Waco), and another running west from Smithville to Ajax, near San Marcos (the “Lockhart Subdivision”), where it becomes a “second main track” for the line extending from San Marcos on southward to San Antonio. The lines radiating outward from Smithville have hosted through freight trains in and out of San Antonio in the past, but to create a fast and efficient bypass around the Austin line the total distance on this alternate route would have to be shortened by “cutting the corner” around Smithville. The purpose of this project, then, would be to examine a possible route for a new rail line running roughly from Bastrop to Red Rock, Texas, tying into the existing Union Pacific main lines on either end.

Rail line construction is not cheap, and many factors must be examined to maximize the usefulness of the new route while minimizing the cost and human/environmental impact. Elevation is one factor that must be considered, both to minimize the number of fills, cuts, and bridges needed as well as to minimize fuel consumption for train traffic. Should there need to be a gradient, it would be preferable for the line to slope downward towards the northeast, as the majority of the freight traffic on the current line through Austin is headed is northbound according to the “directional running” in Union Pacific’s operating plan. Related to this consideration is the examination of waterways, to minimize the number of new bridges required as well as to minimize the possible environmental impact. Smithville-Taylor line already crosses the Colorado River immediately south of Bastrop, so it was originally thought to be likely that any new alignment would begin south of this bridge so as to prevent the need for a second one. Highway and road crossings are also an issue, and grade separation may be a consideration for intersections with busier roadways. Finally, land use would need to be considered, as Bastrop
County is rapidly becoming a suburban extension of the Austin-San Marcos area, with new housing developments appearing at a quickening pace. It is likely that the new line would need to be buffered, wherever possible, to be at least a quarter of a mile from any significant housing developments.

During the production of this project, the *Austin American-Statesman* carried an article (March 23, 2004) featuring a discussion of Union Pacific’s plan for these corridors. The article discussed many of the points of interest to all of the parties involved in the project, while also delineating a more precise view of what would be done should the plan be carried out. The plan published in the *Statesman* reflected some differing thoughts than those of the author of this project, and it was at that point that it was decided to modify the scope and plan of the project to take these new developments into account. The scope remains to examine a possible new rail route in Bastrop County, but now the central focus will be to choose between two alternatives—Union Pacific’s plan, and a route resembling the original project plan. Care will still be taken to keep the new routes outside of buffered areas, and to check on elevation issues, but the main focus now is to examine the relative merits of two possible routes using GIS.

II. Literature Review

Because of the technical nature of this project, related to an industry that keeps many of the details of its large-scale work projects private, there are surprisingly few technical documents readily available discussing this sort of undertaking. Some of the best documentation found so far, however, deals with noise mitigation and planning for the Powder River Basin extension of the Dakota, Minnesota & Eastern Railway Company. Precise routings of these planned lines must be filed with the Surface Transportation Board, the successor to the Interstate Commerce Commission, and several on-line communities have raised issues primarily concerned with safety and noise-mitigation issues. While the safety concerns are generally dismissed (since the new and re-vamped mainline would be more physically sound than the existing right-of-way), the noise mitigation issues are much more of a focal point of discussion. Noise-mitigating walls are often presented as a solution, isolating the noise pollution of the rail corridor from surrounding areas. It is hoped that, by planning the line in this project to be a certain distance away from residential areas, the noise pollution impact would not be an immediate concern. Nevertheless, it is likely that local town meetings would need to be held to allow for citizens along the right-of-way to voice their concerns, and to attempt to settle them as effectively and as diplomatically as possible. Private landowners outside of incorporated areas may also express misgivings about a planned right-of-way through their lands, but for the sake of this project we will assume that such protests ultimately would be rendered moot by eminent domain powers.

No literature review of this project could be complete without a mention of the *Austin American-Statesman*, for it was an article in this paper that first inspired this project, and another article in this paper that resulted in changes to its structure and plan. Further information about the railroad operations in the area in general were obtained either through personal observation over several years of growing up near the area, as well as from the “Railspot” list at [www.yahoogroups.com](http://www.yahoogroups.com).

III. Methodology
Essentially, the study area for this project is Bastrop County, Texas, as the newest alignment of trackage should be contained entirely within the county. A basic map of the county is depicted on the following map (from http://www.texasfun.com/bstrpmap.htm).

![Fig. 1 – Bastrop County, Texas](image)

While this map does not include rail lines, the two existing lines in question are roughly delineated by the Elgin-Bastrop-Smithville axis (“Waco Subdivision”) and the Smithville-Rosanky and points west axis (“Lockhart Subdivision”). Red Rock, the proposed southern end of the new line, is located roughly where the emblem for Farm-to-Market Road 20 is on the map southwest of Rockne. The precise northern end of the line was originally thought likely to be south of the Colorado River, south of Bastrop proper, but the revisions necessitated by the recent American-Statesman article have also suggested a line bypassing Bastrop to the west and re-connecting to the Waco Subdivision north of the city might be preferable.

Required data layers (following the change in focus) are as follows:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railroad Lines</td>
<td>Line</td>
</tr>
<tr>
<td>Residential Lands – Bastrop County, TX</td>
<td>Polygon Shapefile. It was found that a shapefile of City Limits would likely be the best available determinant of organized housing developments, and would also represent areas least likely to support the use of Eminent Domain powers.</td>
</tr>
<tr>
<td>Waterways</td>
<td>Line (possibly Polygon for the Colorado River)</td>
</tr>
<tr>
<td>Elevation</td>
<td>Raster/Grid – DEM files, to be converted to TIN for elevation analysis</td>
</tr>
<tr>
<td>Roadways</td>
<td>Line</td>
</tr>
</tbody>
</table>

Table 1 – Required Data Layers
The progression of the project resembled the following flowchart—

![Flowchart Image]

Chart 1 – Project Flowchart

Downloaded DEM layers are converted into TINs, to represent land contours in greater detail, for the purposes of this analysis. Using the new plan of comparing two possible route alternatives, the beginning and end-points, after their determination, would then have a line interpolated across the TINs from start to finish. The line would skirt city limits by at least half a mile (due to the use of city limits to delineate settled areas, rather than land use); this increase in buffer also represents a larger safety concern for areas that would be located near what is planned to be more-or-less a “high-speed” rail corridor. In the creation of the route lines, because multiple TINs had to be traversed to cover the length of both routes, the lines had to be created “piecemeal” with one part for each segment within a given TIN. After interpolating a line (lines), ArcGIS allows for the creation of an elevation graph that can be exported and examined. (Again, due to the “piecemeal” progression between separate TINs, one graph for each TIN containing part of a route had to be created.) With elevation graphs created, evaluation can proceed based on the elevation data as well as on the anticipated monetary and societal costs of each alternative.

IV. Scientific Merits

The principal merit of this exercise will be in examining how GIS can use data from several different sources, representing several different factors, to plan appropriately for a new rail line. Future commuter rail projects and rail-line relocations will need to examine similar problems and find effective solutions; this project represents a small step in the direction of finding workable solutions. The inclusion of the buffering plan also takes into account recent issues involving noise pollution, such as those involving “quiet zones” at railroad crossings and the construction of sound-barrier walls along rail lines. If a new line is planned to be away from residential areas as much as possible ahead of time, then it is less likely that citizen uproar and the so-called “Not in My Backyard” condition will cause excessive friction against the fulfillment of the construction project.

Even with GIS to show us the way, the raw data must still be interpreted to consider possible problems that are difficult to represent in a GIS-based model. Some of these problems were not considered in the original project definition, such as the nature of the tight curvature of trackage in downtown Bastrop, where tracks bisect the campus of the local high school. If a line relocation is to be built in the area anyway, would it not be reasonable to include alleviating this bottleneck (and “lawsuit-waiting-to-happen”) in the same plan? These questions led to the revision of the project plan to consider the possibilities of two different alternatives, rather than
simply designing one bypass and not considering other issues that might lie just beyond the construction limits.

V. Time Schedule

The priority for this project was planned to be in accordance with additional assignments taken while in the Intermediate GIS class (and additional Geography classes) at the University of North Texas. Because of the overlapping of time, it was paramount that this project receives some prioritized time within the months remaining in the semester.

Data collection occurred over several weeks of the project, with different data sources evaluated for their merits and usability. The choice to use city-limit shapefiles rose in part from this stage, when it became difficult to obtain land-use data for Bastrop County that would be in a useful or convertible format. Beginning analysis followed, as did the revision of the plan when the newest American-Statesman article revealed new ideas and insight into the full scope of the real-life project. Analysis continued, now using two possible routes, with May 3 being the final due date and targeted completion date.

VII. Results and Discussion

Based on the new information from the Austin American-Statesman article of March 23, 2004, combined with the general route considered in the original project plan, the new routes resemble those presented below.

“Route 1” represents the newest suggested alignment, originating from a diagram and description presented in the March 23, 2004 Austin American-Statesman article, “Railroad's price for move: $500 million.” It originates just outside of Bastrop, south of Phelan Siding on the Waco Subdivision, and skirts around the city of Bastrop, generally charting a southwesterly course towards the Lockhart Subdivision at Red Rock. “Route 2” represents the original route being considered in the original project plan for this assignment, moving almost completely in a straight line from a curve along the Waco Subdivision just south of the Colorado River bridge south of Bastrop towards a junction with the Lockhart Subdivision at Red Rock. Also indicated on the map are primary Federal and State Highways, as well as other trackage such as the Smithville Subdivision (extending eastward out of Smithville) and part of the Austin Area Terminal Railroad, in the northwest corner of the map. (This line crosses the Waco Subdivision at Elgin.)

At first glance, Route 2 appears to be the lower-monetary-cost alternative. It is shorter, and would not require a new span over the Colorado River to construct, nor would it need to cross busy State Highways 21 and 71 (combined) west of Bastrop, which is used as a primary commute route in and out of Austin for this area. However, this is apparently not the route favored by Union Pacific, and that will become clearer later in the discussion.
The elevation profiles for the routes were created piecemeal due to the use of separate TINs for each DEM layer traversed by the new alignment. The separate TINs can be seen in a square-grid pattern in Figure 2, where different display ranges for each TIN would make the colors appear to not “line up” at TIN borders. An analysis of the elevation profiles for the two routes will show some interesting results:
Because the profiles were created using north-to-south lines, it is important to remember that what appears to be a run up-grade from left to right on these profiles would actually be a down-grade run for the prevailing traffic pattern, as this new line would be used primarily for northbound traffic in Union Pacific’s directional running plan. With this in mind, the first segment would be seen as an upgrade “pull” out of the immediate Colorado River valley, while the second segment would represent a gentle down slope towards what would be a new Colorado River bridge. The third segment begins at roughly the same elevation at which it ends, with a couple of small valleys (primarily for creek crossings) in between. These “valleys” will essentially be unavoidable because of the presence of waterways, but the construction of fills and cuts, along with some sturdy bridges to support higher-speed traffic, should allow for trains to pass through this area with little difficulty. The final segment would represent a small “hogback” ridge for trains to roll over as they begin to traverse the new alignment from Red Rock.
The profiles for Route 2 were created in three segments:

<table>
<thead>
<tr>
<th>Route 2 Piecemeal Profiles (North to South, meters elevation)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="chart.png" alt="Profile Chart" /></td>
</tr>
</tbody>
</table>

As can be seen, this route uses a gentler profile on the whole, also appearing to give it an advantage. The north end of the new route begins at the edge of the immediate Colorado River valley, and then has one ridge before another valley for a creek crossing, and a hill following that. With a creek bridge and cuts, this grade could be reduced to a gentle descent for northbounds approaching the river bridge. As it is, the second segment represents another downgrade alignment for northbounds, and the final segment would represent a similar “hogback” arrangement to the first alternative, albeit with perhaps gentler grades.

Again it seems that the original planned route for this project would be the “winner” between the alternatives—the only major highway crossing required would be that of State Highway 304, a two-lane thoroughfare that sees significantly less use than busy, four-lane Highways 21 and 71. An overpass here would be cheaper as well due to the fewer highway lanes required. However, the geographic analysis thus far fails to tell the entire story.

The *Statesman* article of March 23 identified the stretch of trackage through Bastrop as a potentially troublesome stretch of track—not only does it contain sharp curves that slow the passage of trains, but the trackage also slices through the middle of the campus of Bastrop High School! Without expensive line improvements and noise abatements within the city itself, not to mention some sort of pedestrian overpass or underpass to allow for schoolchildren to cross the
tracks safely at all times, this stretch of line would almost certainly fail to support the increase in train traffic that would come with the planned line adjustment.

Speed is a pivotal element in the development of this line adjustment as well, something that knocks the existing Bastrop trackage down in stature. As seen in Figure 3, this new line must fit seamlessly into Union Pacific’s plan for directional operation in the area.

Fig. 3 – Directional Operation in South Central Texas

The existing Smithville and Lockhart Subdivisions exist primarily as a westbound “funnel” taking southbound traffic off of the Giddings Subdivision at a new connection at West Point (west of Smithville) and carrying it over to the Austin Subdivision at San Marcos. The Austin Subdivision north of San Marcos is a well-maintained mainline that makes a relatively “straight shot” through Austin and Round Rock to Taylor. The new alignment of the south end of the Waco Subdivision, then, must be able to handle trains expeditiously and efficiently to compensate for the fact that it will be significantly longer than the current route via Austin and San Marcos. For this reason, “Route 1” in the project’s consideration pulls ahead on merit.

It is also important to consider the fact that this project will largely be funded from public funds. If Union Pacific can have the route bypass built without spending much of its own money to do so, then it is to its advantage to get the best route possible. The $500 million price tag mentioned in the article refers to not only building a new alignment for the southern end of the Waco Subdivision, but also a bypass around Elgin, Texas, as well as new track in some areas to help flatten grades and straighten curves. The entire segment from San Marcos to Taylor (via
this new alignment) would also be double-tracked, allowing for the line to handle more trains more efficiently by having expedited trains pass slower-moving trains without stopping by using the parallel trackage. (For this reason it is assumed that the new alignment for “Route 1” would begin south of Phelan siding, north of Bastrop, as Phelan represents a track segment of almost two miles that already has double track installed.) The double track would also be a virtual necessity west of Red Rock, where the Lockhart Subdivision would be handling heavy rail traffic in both directions. To reiterate, if public funds will be the primary support for the project, then Union Pacific has a significant advantage in getting a straighter, flatter, double-tracked route that bypasses the downtowns of Elgin and Bastrop, also meaning that many railroad crossings at-grade in those cities would be eliminated in the process. Noise mitigation also becomes less of an issue if the new mainline will bypass the denser populations of the cities.

VIII. Conclusion and Notes

For these reasons, it makes sense to conclude that, with money being virtually a non-factor, the alignment of “Route 1” is superior. If this route is to replace the Austin Subdivision for through traffic, it needs to bypass the downtown Bastrop trackage, as well as needing a new second track on any bridge across the Colorado River anyway. With municipal, state, and federal funds behind the project, it will probably be only a matter of time before land is acquired and earth is moved to start building this new rail alignment, taking care to install fills and cuts as necessary to make the grades as gentle as possible. In an interesting reversal from similar projects in this nation’s past, this unique rail realignment project perhaps represents a new convergence of public and private thinking on how to deal with aligning the nation’s rail network to benefit both sectors.

* * * *

As an aside, it is interesting to note that the segment of the Waco Subdivision between Smithville and Bastrop would supposedly be abandoned according to the realignment plan discussed by Union Pacific. A second connection is being installed at West Point to handle traffic to and from the eastern end of the Smithville Subdivision, including the coal-fired Fayette Power Project power plant at Halsted, east of La Grange. The existing alignment of the Smithville Subdivision south of Bastrop is currently the primary means of sending coal trains to and from this power plant, and I would think it would be wise to include some provision for sending coal trains down the Waco Subdivision in case the Giddings Subdivision were ever severed due to a derailment, washout, or attack. In any event, a preserved connection to the Waco Subdivision would allow for northbound coal empties to travel “with the current” of the directional flow all the way out of south-central Texas, instead of having to travel “against the current” north of West Point. This would also preserve a shorter route for both Union Pacific and Burlington Northern-Santa Fe rock trains (the latter using trackage rights to operate on Union Pacific’s tracks) to serve customers in western Houston from quarries near Georgetown. If the Waco Subdivision trackage out of Smithville is not preserved, then perhaps a second connection (forming a “wye,” as railroaders call it—a Y-shaped track arrangement where trains on any one track can go to either of the others) serving the same purpose could be installed at Red Rock, where the Lockhart Subdivision would meet the new alignment.
IV. References

- General -

“Railspot” mailing list: http://groups.yahoo.com/group/railspot/
(“Railspot” is an informal email-list discussion group involving current and former railroad employees and executives, railroad historians, and other rail enthusiasts with a coverage area of Texas and the surrounding states.)

(Map resources available under the “General Public” section.)


-Dataset Sources-

GIS Data Depot. www.gisdatadepot.com
(DEMs for Bastrop County locations.)

(Texas highways, railroads, cities, and hydrological features)