

Automated Three Dimensional Planning and Visualization Tool for Urban Environments

Terry Kinsman
KTUA

Background: The Centre City Development Corporation (CCDC) is a public agency that oversees development within the community planning area for downtown San Diego. In 2001 CCDC began the process of updating their downtown community plan. For the first phase of the project, KTUA was contracted to:

1. Provide services to guide data collection/development and;
2. Develop a planning tool incorporating a three dimensional modeling environment. The tool required the ability to create, summarize, and visualize potential development in downtown San Diego.

The second phase of the project was performed by an additional firm to update the community plan for the downtown area. The firm was to use a custom tool developed by KTUA to generate planning scenarios. These scenarios would then be the basis of recommendations for changes to the current community plan. After generating scenarios resulting in preliminary building models and planning data, the firm was to visually enhance the basic volumetric models of potential projects by using additional software packages for presentation within the community plan update. Final presentations were to utilize technology that was unavailable to ArcGIS 8.x software such as advanced texture mapping and shadow casting. Advanced articulations to potential building models was out of scope with the goals of the software customizations, so any additional advanced articulations were to also be performed with alternative software packages.

Tasks:

1. Develop data that would be used as a baseline for visual models. The baseline data would consist of a terrain model. Terrain model would include surface breaklines and 1 foot contours. Building features were digitized separately. These features, both the digital terrain model and the buildings were created from true color orthophotography flown at an altitude of 2400 feet. The images were scanned in at a resolution of 1 pixel = 6 inches. Control Photo was contracted to perform image capture and photogrammetric processing of the imagery and feature creation.
2. Develop a tool to allow planners to generate hypothetical development scenarios for the downtown area. The tool will generate planning related data, and have the ability to visualize projects in a three dimensional environment. Basic development regulations were to be incorporated into the tool so that potential projects would conform with the major development restrictions pertaining to height, bulk (setbacks/vertical setbacks), and floor area ratios. The three dimensional environment was to contain the models of proposed projects with current existing buildings so that the potential projects could be compared with existing environment in size and location.

Data Creation Summary (task1)

1. Fly CCDC Area at 2400 feet. Scan to create true color orthophoto imagery at 1 foot = 1 pixel. (Control Photo)
2. Digitize terrain model and buildings in microstation. (Control Photo)
3. Convert microstation files into gis data. (KTUA)
 - create digital terrain model – TIN
 - create existing buildings – 3D shapefile (roofs)
4. Obtain select CAD drawings of existing buildings, planned construction and buildings currently under construction from La Jolla Group. (LaJolla Group, KTUA)
5. Interpret current zoning code to create gis files of setbacks, setbacks. (KTUA)
6. Consult CCDC staff to develop attribute data regarding redevelopment feasibility.

7. Create macros to automate geoprocessing tasks for buildings and data collection/compilation tasks. (KTUA)
8. Use scenario builder macros activated from project toolbar to create development scenarios. Run reports to generate scenario data summaries for planning purposes. (Dyett and Bhatia)
9. Use scenario analysis as a basis for alternatives in Community Plan Update. Modify scenario building data by conversion into to software format for enhancement and final presentation. (Dyett and Bhatia)

Application Customization (task 2)

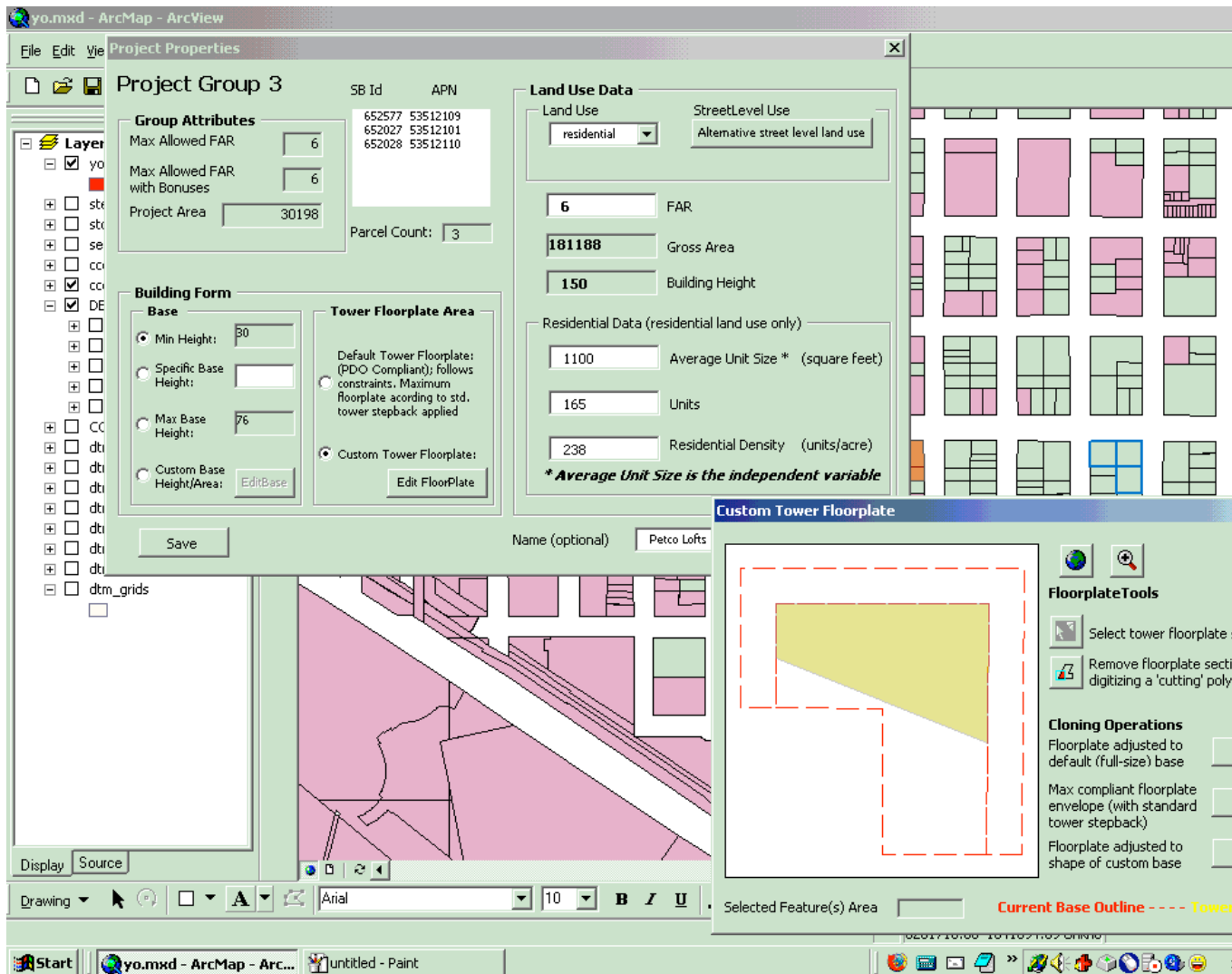
Two ESRI applications and one application extension were utilized in the customization of two ArcGIS documents for the purposes of the project. ArcMap 8.x was customized for planning and project scenario development while ArcScene 8.x/3D analyst extension was used to model the scenario in a three dimensional environment. Macros were inserted into the application documents and activated thorough a menu based toolbar(ArcMap) and document startup events(ArcScene). These macros automated standard geoprocessing techniques(ArcMap) to create the building models/project data and standard rendering environments(ArcScene) to visualize the 3D scene. The only customization within the 3D visualization environment consisted of startup scripts to render the scene in a standard fashion. Custom VBA forms let the user of the application interact with the virtual projects and alter the project's attributes(spatial and non-spatial).

All of the data created for scenario builder was specific to downtown San Diego. Many uncertainties associated with data presence did not have to be addressed. Customization was fairly straightforward as data and schemas were known. This same logic that scenario builder utilizes to construct virtual projects could be expanded upon so that different entities could use the tool with their own data. The software would need to be re-engineered and packaged as a third party extension or loadable Dynamic Link Library(.dll) to accommodate varied data sources, possible incorporation of different types of analysis/development constraints, and different formats of reporting and calculating statistics. A possible object model framework would have to be created and standard planning methods agreed upon for universal use.

Example creation of Virtual Project

Scenario builder's methodology is based on taking multiple parcels and combining them to create a virtual development project. The macros dissolve the feature(s) into a single shape. That base is then combined with constraints that were taken from portions of the city development code. Not all development constraints could be incorporated into the projects logic. Most important were those affecting height and bulk. These constraints were built into various GIS layers where they are geoprocessed as inputs with the project data. The physical constraints to project development consisted of ground-level setbacks, vertical setbacks at various elevations, view corridors and height restrictions. These variables ultimately influence the bulk of the virtual projects and thus the total amount of space that a virtual project may occupy. The program was designed to do large scale scenarios of multiple projects within an area. Default volumetric development restrictions constantly operate. Attributes from the project user form affects the result of planning reports and also help determine 3D rendering characteristics of the projects so that they may be seen in relation to other buildings. Among the project attributes, some may be edited by the program, others may not. Modifiable project attributes are Floor Area Ratio (FAR), number of units(residential development), building shape and land use. Building height is a byproduct of a project's shape and density. As FAR or total number of units is modified by the user in the project user form, changes to unit size will be updated to reflect the modification. As the user is constructing a virtual project, the form will flag instances where the project exceeds height or density limits based on existing code. The user may construct the project if it does not conform to development code, but it will be flagged as illegal.

The purpose of creating the software customizations is such that given current development restrictions, planners can see what is possible in terms of what can realistically be developed. If a study is performed and if it discovered that certain goals are not met, then development codes may be changed so that targets can be met. Market conditions are not taken into account and the planner must use their intuition when manipulating the variables of the virtual project. Scenario Builder is an example of a lightweight application made in-house by employing VBA macros. The same application could be developed using Python in a ArcToolbox context.



Project and Tower Floorplate forms



Scenario Builder Toolbar that activates VBA macros after virtual project parcels have been selected



User created Scenarios rendered in 3D through ArcScene (red and yellow projects are proposed and under construction CAD models, green and blue are virtual projects)

CCDC Totals

Totals in square feet

Potential Gross Developable Area	2,624,246
Current Gross Developed Area	2,517,180
Current Projects Gross Development Potential	107,066
Remaining Developable Area	63,329,832

Non Transient Residence Totals

Permanent Residential Units Created	1,529
Average Residential Unit Size (<i>square feet</i>)	1,115
Residential Density (<i>units per acre for residential projects within the CCDC Area</i>)	291

Land Use Detail

Land Use	Primary Use Area	Street Use Area	Total Area	Units
residential	1,704,440	0	1,704,440	1,529
retail	0	29,836	29,836	0
office	782,904	0	782,904	0
hotel	0	0	0	0
open space	0	0	0	0
structured parking	0	0	0	0
other	0	0	0	0
	2,487,344	29,836	2,517,180	1,529

Sample output of report generated through Scenario Builder