6. Conclusions

6.1. Key Findings

This report analyzed the connectivity of neighborhoods in nine cities in the SRP service territory to a variety of destinations, including employment, education, retail, and recreation. Connectivity is modeled here in terms of directness and impedance of available bike routes, ignoring the effect of the distance to destinations, which is not in the control of bike infrastructure planners. Impedance is modeled here in terms of safety and desirability of various types of roads, paths, lanes, and street crossings.

The overall landscape of connectivity reveals two main results. First, averaging over the various destination types, the connectivity by bicycle from most neighborhoods is fairly good: very few neighborhoods have average RDI scores below 50, meaning half as good as a straight-line route via a residential street, if one existed. On the other hand, there are some clear areas of consistently poor connectivity caused by major barriers that force riders to go around them and ride on major arterials with or without bike lanes. These barriers include freeways, freight railroads, Grand Ave., large industrial facilities, Sky Harbor Airport, the Salt River, and—yes—even SRP canals.

The canals are a "double-edged sword" in terms of connectivity. They often provide excellent connectivity in a parallel direction, yet create an easily visible barrier on our maps for neighborhoods on the "wrong" side of them. Their potential for connecting origins and destinations across the Valley along diagonal routes that cut across the gridded street system, is matched by few other cities in the US.

These results are promising for the prospect of improving cycling connectivity in the Valley because it is clear where many of these barriers lie and, for many of them, how to cross them. The cities have a great opportunity if they successfully address the railroad and freeway crossings, where significant gains in connectivity can be achieved by finding a safe and affordable way to get from one side to the other. Part of the challenge is clearly the budget for bicycle infrastructure, especially when it comes to freeway crossings. The need for working closely with the Union Pacific railroad to find solutions to the railroad barrier is another key conclusion of this report.

For the SRP canals, three main methods of improving connectivity could yield large benefits. First and foremost, our base maps show that the barrier effect of canals is real and significant. This is an issue that SRP can solve mainly on its own, without major hurdles in dealing with municipalities or railroads. It can do so by building bridges to cross the canals where poor connectivity exists on one side and a canal path and a connection to the path into a neighborhood exists on the other side. This can be accomplished at a far lower cost than crossing a freeway, and with far fewer institutional and liability concerns than crossing a railroad. Second, SRP should continue to work with the cities to maximize the potential of the canal paths as bicycle corridors. This can be accomplished by improving the safety of the paths where they cross arterial streets, either by signage, painting, or installation of traffic signals. Third, access to the canals from neighborhoods can be improved in certain areas where housing or walls block access to the canals. The lack of safe arterial crossings and lack of canal access points, however, have less of an obvious effect on the RDI maps than the barrier effect of the canals. Thus, our analysis suggests that mid-block bridging over the canals could be an affordable and effective strategy for improving bicycling connectivity and would provide a valuable service to communities.

A second set of results in this report relate to potential future improvements of bicycle infrastructure. One set of improvements was suggested by the cities of Phoenix, Tempe, and Scottsdale, along with some improvements for Mesa suggested by our team. Another set of improvements were provided by ASU graduate students in Urban and Environmental Planning, who were asked to suggest solutions to connectivity problems at certain light-rail stations. These analyses clearly demonstrated the potential for Valley bike planners and SRP to use ViaCity to assess particular projects. The connectivity benefits of new infrastructure, in terms of percentage change of RDI values, were clearly visible on the maps. RDI scores averaged across all destinations improved by as much as 15% in some neighborhoods. Improvements targeted at better connectivity to light rail stations improved directness and reduced impedance to stations by as much as 50%. Another key finding was that the connectivity benefits often radiated out from the actual site of the improvement by 5-7 miles. As any bicyclist would affirm, bike travel can be impeded relatively far from home by barriers to safe and direct connectivity.

Our third set of results focused specifically on SRP facilities—both canals and employment sites. RDI maps highlighted neighborhoods with good and poor connectivity to points midway between arterial streets on the canals. These mid-points were analyzed because we would like to see residents—especially those with small children—able to get on the canal paths without having to detour out of their neighborhoods to an arterial street and then have to ride on a more dangerous arterial street (possibly the wrong way on the sidewalk) to reach the canal path. In addition, we analyzed connectivity from neighborhoods to their closest SRP facility to identify areas from which it might be difficult for SRP employees to bike to work. Numerous areas were highlighted where canals (as well as railroads and freeways) created barriers for SRP employees to bike to work. The canal barriers would seem to be within SRP's power to address internally by adding more bridges across the canals. Finally, we analyzed the potential to ride safely and directly between SRP facilities as a substitute for driving from one facility to another. Certain facilities, such as the Power Operations Center, are ideally situated for biking to other facilities via direct, low-impedance connections, while others such as in central Phoenix are poorly connected despite their central location.

6.2. Strengths and Limitations of the Analysis

ViaCity is a powerful tool for analyzing connectivity to destinations by bicycle, but it has certain limitations that must be recognized in interpreting its results. Its strengths lie in the simplicity of the RDI ratio, the flexibility for setting impedances and choosing origins and destinations, its ability to model bicycling at an extreme level of geographic detail, its focus on network connectivity independent of distance, and its computational power to do these things automatically for a huge number of arcs, nodes, origins, and destinations.

Its limitations in a sense are the flip side of the strengths. Due its simple ratio formulation, it can give misleading results for origins very close to the destination. For these very short trips, a small detour can lead to an exaggerated, disproportionally low RDI score because the numerator (the Euclidean distance) is so small. The fact that a 50%+ detour doesn't matter much to someone going "around the corner" is not taken into account in the RDI score. For short trips, the exact placement of each origin polygon's centroid determines where on the network trips from that polygon ostensibly begin. This can also affect RDI scores to nearby destinations more than to farther destinations. For these two reasons, the RDI maps for any particular type of destination need to be interpreted with caution. Composite maps showing the average RDI for many types of destinations at various distances and in various directions provide a more complete and consistent picture of the polygon's connectivity, and are a reliable indication that bicyclists from that neighborhood often have to take an indirect route or ride on high-impedance roads.

Finally, ViaCity's RDI results are only as good as the input data. This is a classic case of "garbage in, garbage out," or GIGO. ViaCity includes some powerful tools that help the user build the node-arc-node network topology essential for calculating shortest paths, and for checking the connectivity of the network. Specifically, its Quality Check feature highlights vertices with 1, 2, or 3 arcs connecting to it. As Section 3 explained, a large portion of the work-hours put into this project were spent on manual editing and visually inspecting the network to make sure that roads, bike lanes, and paths were properly connected. If what looks like a 3-way or 4-way intersection is highlighted as a 1-arc or 2-arc vertex, it indicates that some of the arcs coming into that intersection do not connect properly to the others. This occurs frequently because many of the GIS bicycle networks were created originally for map display purposes, not for network modeling purposes. For instance, sometimes paths were drawn in GIS to the edge of the sidewalk rather than to the street centerlines. The road network acquired from MAG was in much better shape because it was created for network modeling purposes, but some inaccuracies s were found and additional problems were introduced when merging the street network with the bike infrastructure network. In this project, the central areas of the study area were extensively checked and cleaned, but we did not have enough time or funding to systematically check and clean all areas.

6.3. Future Work

The GIS bike network created through this project could be a valuable resource to many agencies in systematically evaluating the connectivity benefits of proposed bicycle infrastructure projects. We argue that resources should be committed to complete the editing of the study area, complete the remainder of the MAG territory, and maintain the GIS network into the future. Cities, counties, and SRP will continue to build new roads and new bike infrastructure, which will require regular updating of the bicycle network to keep it current.

This project showed that while the Valley has come a long way and has a lot to be proud of in terms of its bikeability, small improvements in the network can produce significant connectivity improvements for many riders. What more, this project shows that with a reasonable effort, we can evaluate actual project proposals for their impacts on connectivity with rigor.

Two other dimensions that are essential in the planning process could then be added – cost and the populations affected. We could easily cross-tabulate specific connectivity improvements with the number of current or potential bike riders, for example, using census data (for current bike commuting numbers) or ASU enrollment (for potential bike riders). This would allow us to rank the network improvement for its potential benefit relative to other proposed improvements.

Further, we could then add cost information and, combined with benefit estimates, develop a cost-to-benefit ratio for each project. These four pieces of information—total benefits, total costs, populations affected, and cost to benefit ratios, would empower planners and policymakers to evaluate and rank projects as part of their short- and long-range planning and budgeting process. It would also provide a clear, visual communication tool for planners and policymakers to use with their communities regarding the benefits that would be generated by proposed improvements and where those benefits would accrue. For example, if traffic patterns are changed (say an automobile traffic lane is removed to make way for a bike lane, or a new bike crossing is added), policy makers and bicycle advocates can point to the neighborhoods and populations benefiting from the intervention.

It is the goal of this project team to identify future funding such that planners and policymakers can make the most-effective planning and budgeting decisions and residents of the Valley of the Sun can enjoy further significant improvements to bicycling as a viable alternative mode of transportation for multiple travel purposes.