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ROADS, RAILS, AND RUNNING SHOES: DEVELOPING MULTI-MODAL SIGNAL TIMING FOR A NEW LIGHT RAIL CORRIDOR IN AURORA, COLORADO

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ABSTRACT

The Aurora Line/I-225 Rail is one of the upcoming additions to the Regional Transportation District's (RTD) extensive FasTracks program in Metro Denver, with service slated to start in Winter 2016. Along the 10.5-mile route, there are 19 at-grade crossings in some of the busiest areas of Aurora, including a large retail hub and multiple regional medical centers on a shared campus. Programming and installation of signalized at-grade rail crossings is rarely easy. Computer models and simulations can do only so much when it comes to replicating field conditions, and field testing, while necessary, can be a lengthy and frustrating process while bugs are worked out. Because this light rail line runs through such vehicular-, pedestrian-, and cyclist-heavy areas, staff of the City of Aurora, RTD, and the Colorado Public Utilities Commission (PUC) want to ensure that field testing is as efficient as possible. Over the last year, the City of Aurora, RTD, PUC staff, and Stantec have worked together to develop comprehensive signal timing plans for all of the at-grade crossings and some of the adjacent intersections, from initial Synchro models to full peak-hour Vissim simulations. The project team has even taken a further step, beyond simple timing plans to "bench testing"—testing the signal operations in a controlled environment using the actual controllers that will be installed in the field. The groundwork that has been completed should streamline the installation and testing process and ultimately lead to signal operations that will be favorable for all modes of traffic, including drivers, pedestrians, cyclists, and trains.

INTRODUCTION

RTD's expansive FasTracks program in Metro Denver is in the middle of a banner year, with four new commuter rail or light rail lines opening in 2016. The Aurora Line/I-225 Rail, located on the eastern edge of the system, is currently under construction and is expected to open in Winter 2016. This new light rail line generally parallels I-225 from I-25 on the south end to I-70 on the north end through the City of Aurora. It will provide a critical link for residents in the area to access the commuter rail line between Union Station in downtown Denver and Denver International Airport via the shared light rail / commuter rail station at Peoria Street.

The complete project area includes 10.5-miles of new track and 19 at-grade crossings in some of the busiest areas of Aurora. The scope for this retiming project includes evaluation of 15 of these at-grade crossings, which are divided into three distinct subareas, known as Area B: Aurora City Center, Area E: Fitzsimons, and Area G: Peoria. All three of these subareas consistently see heavy vehicular, cyclist, and pedestrian traffic throughout the week due to their proximity to some of the principal arterials and destinations in Aurora. The new timing plans for the signalized intersections abutting the new route are therefore aimed at serving all modes as efficiently as possible to avoid delays to trains, drivers, pedestrians, and cyclists.

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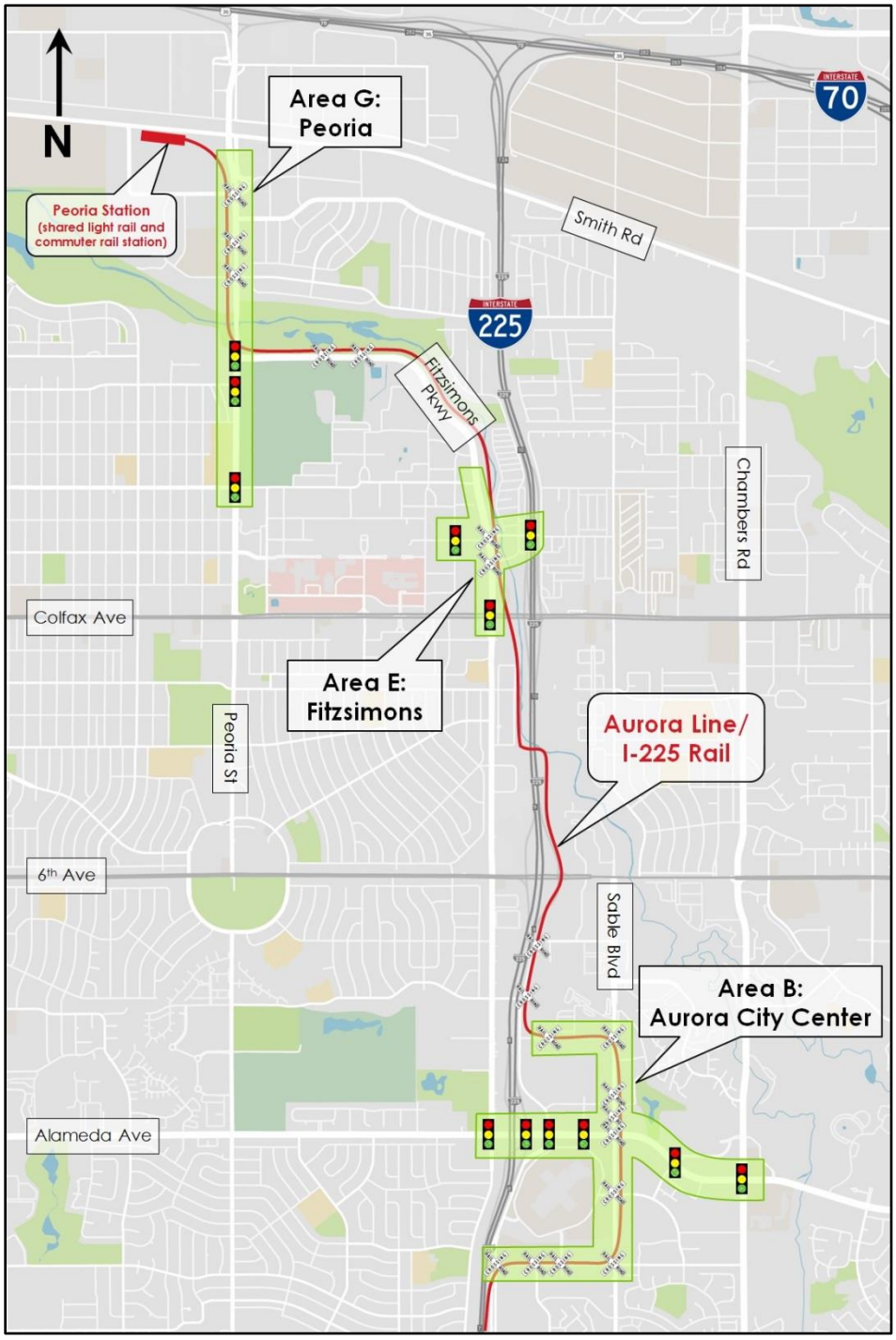
Within each subarea, certain additional signals not immediately adjacent to the tracks were also chosen to be included in the retiming process based on their distance from the light rail and the City of Aurora's established coordination corridors. Area B, which encompasses the Town Center at Aurora and Aurora City Place shopping centers, is comprised of ten at-grade crossings and six additional signals along Alameda Avenue. Area E borders the Anschutz Medical Campus/Fitzsimons Redevelopment Area and includes two at-grade crossings as well as three other signals, including the I-225 interchange at 17th Place. Area G includes three at-grade crossings and three additional signals, all on Peoria Street at the north end of the project area.

Figure 1 – Aurora Line Signal Retiming Project Area and Subareas



In this map, at-grade crossings (whether at signalized or unsignalized intersections) are marked with crossbucks. Additional signals that were included in the retiming scope for coordination purposes are marked with signal heads.

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The City of Aurora currently maintains timing plans for five different times of day. These include the standard AM Peak and PM Peak periods, as well as Weekday Off-Peak, including the middle of the day and the late evening; Weekend, all day on Saturdays and Sundays; and Overnight, seven days a week. Almost all signals in Aurora are free-running during the Overnight plan. Because trains on the Aurora Line are expected to operate from early morning until after midnight every day, all five of the signal timing plans for each intersection, not just those for the peak hours, need to be designed to work in conjunction with the light rail operations.

INITIAL MODEL DEVELOPMENT: PEAK HOURS

The first step in developing signal timing plans for the different areas was to determine parameters such as the level of priority that could be granted to the trains at each crossing, the types of priority that could be used, and the locations where trains could or could not be permitted to stop outside of stations. RTD, City of Aurora, and PUC staff worked together to establish a preliminary concept of operations for each of the three areas, outlining on paper how trains were expected to travel through each segment.

Due to concerns from the City over potential impacts to existing signal coordination and traffic operations, the initial concept of operations designated Transit Signal Priority (TSP) to be used at most of the signalized crossings. The closely spaced crossings in Area B along Sable Boulevard, from Alameda Avenue to Ellsworth Avenue, were elected to be "linked" together using TSP to minimize disturbance to the non-train traffic at each intersection. This strategy called for trains to wait at holding signals on either end of the segment until being released at the appropriate time to cross Alameda Avenue concurrently with the northbound and southbound traffic on Sable Boulevard. Timeline diagrams were created using Synchro and Excel to show how the traffic signal phasing, necessary track clearances, and gate operations at the linked crossings would overlap so that, once released from the holding signals at either end, trains could pass through the entire section without stopping. The crossings in Area E and in Area G were also linked together in this way, each with their own timelines outlining how train and traffic operations would interact.

The installation of the Aurora Line is anticipated to substantially increase pedestrian and cyclist activity in areas that already see frequent foot traffic. As such, City of Aurora and RTD staff agreed to accommodate pedestrian crossing times within the regular cycle length at almost every signal. This helped to ensure there will be good progression for drivers and trains along these corridors, without disruption to the coordinated operations every time a side street pedestrian phase is called. The possible cycle lengths that could therefore be considered for implementation were increased because many of these intersections have long crossing distances and thus long pedestrian phases. Additionally, the project team agreed not to allow skipping of any pedestrian phases in the TSP settings, in order to curtail potential unsafe pedestrian or cyclist crossings due to skipped phases during train operations.

With these considerations in place, the functionality of the proposed concept of operations could be tested using PTV Vissim micro-simulation software. Initial timing plans for the AM and PM peak hours, designed for non-train traffic in Synchro, were input into Vissim models of the anticipated Opening Day 2016 conditions for each area and then amended for train operations as needed. Vissim was selected as the software of choice for this process because, while still only

approximating real-world conditions, it could model train operations in a multi-modal environment—with automobiles, pedestrians, and cyclists—much better than Synchro alone. The ability to create videos of the simulation meant that the project team could observe signal operations in real time, rather than simply relying on reported results to verify the effectiveness of the concept of operations.

Figure 2 – Vissim Simulation

This screenshot, captured during a simulation run of the Area B PM Peak Vissim model, shows two trains crossing Alameda Avenue in parallel with the vehicles on northbound and southbound Sable Avenue. The linked crossings at the Commercial Access and Bayaud Avenue are visible in the background.

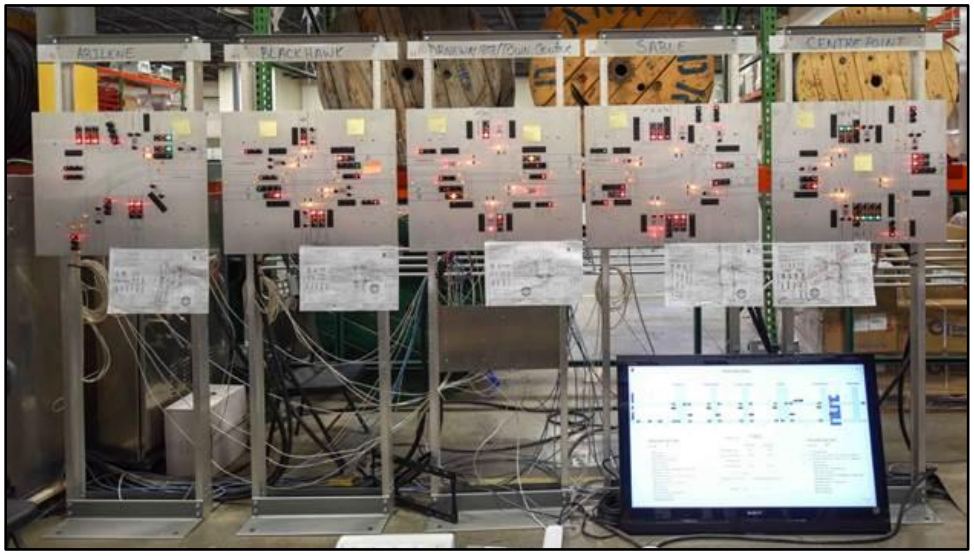
OPERATIONAL REFINEMENT: BENCH TESTING

As the Aurora Line will be operating in some of the most active regions of Aurora, there justifiably have been some concerns about the efficiency of field testing once the tracks are completed and trains begin running regularly later this year. While field testing is unquestionably necessary, City of Aurora, RTD, and PUC staff are keen to make the procedure work as smoothly as possible for all parties involved.

To that end, the City, RTD, and PUC staff have employed an additional step known as "bench testing" as a key required element to further the line construction. This innovative technique acts as an intermediate stage between pure computer simulations and full field operations. The City of Aurora routinely uses this process before installing new or improved signal technology in the field. With help from Kiewit, the design-build contractor for the Aurora Line, and Mass. Electric Construction Co. (MEC), the project team has been able to create a much more elaborate bench test than usual. The actual signal controllers that will be installed for the traffic and train signals along the Aurora Line have been set up in a controlled environment off-site and connected to a series of light boards that can display signal states for each intersection in real time. An external computer simulation transmits detailed information relating to the trains, such as location, speed, headways, and travel times, while the controllers respond and change the light boards accordingly to represent actual signal operations. This process allows the traffic and train operations to be observed in a more accurate reproduction of reality than in Vissim, but without the safety risks

that can arise unexpectedly during field testing, and with the ability to make changes to the timing inputs much more responsively than in the field.

Figure 3 – Area B Bench Test



The first part of bench testing for Area B focused on the five crossings between the Florida and Aurora Metro Center stations. The light boards for each crossing are each hooked up to a separate signal controller, while the screen at the bottom displays the status of trains during each test.

By utilizing bench testing, the timing parameters for the AM and PM peak hours were able to be transferred into the signal controllers and observed in real time, well before field installation. As a result, certain shortcomings that were not previously discernible within the limited capabilities of the Vissim models were brought to light.

Fortunately, the bench testing process allows such adjustments to be identified and tested without major impacts to the project schedule. For instance, three of the signals on Exposition Avenue in Area B, which had been coordinated with trains given partial TSP in the preliminary concept of operations, were found to operate more effectively for all modes when fully actuated with full priority allotted to the trains. The proposed "linked" sections in all three areas were similarly revised, with some of the previously interconnected signals changing to full TSP or even preemption to help reduce delays. Two of the busiest crossings retained the original concept, with trains being released from holding signals at the appropriate times to cross with the parallel vehicle phases without disrupting the signal timing—Alameda Avenue & Sable Boulevard (Area B) and Peoria Street & 33rd Avenue (Area G). Without bench testing, modifications such as these would have taken much more time and effort in the field to isolate and implement. With the results of the bench tests in hand, field installation and testing later this year should be a more efficient process.

FINE-TUNING: OFF-PEAK HOURS

Once the concept of operations was refined in the bench test for the peak hours, Stantec could proceed with creating plans for the off-peak periods. Developing optimized Weekday Off-Peak, Weekend, and Overnight timing plans for each of the three subareas is essential to ensuring acceptable service for all modes at all times of day.

After all of the effort that was put into the AM and PM peak hour timing plans, the interactions between non-train traffic and trains did not require any further investigation for the three off-peak periods. As such, the timing plans could be developed now using Synchro, rather than returning to Vissim. Without the need to focus on parameters relating to train operations, Synchro was the more effective tool to optimize the timing and offsets of each area.

In order to create the best possible timing plans for the off-peak hours, accurate volume projections were necessary. The City of Aurora and RTD provided existing 2008 and 2012 traffic counts, but there were some significant gaps in the available weekday off-peak and weekend data. In order to fill in these gaps and forecast the necessary weekday off-peak and weekend volumes for Opening Day 2016, Stantec compared the AM and PM volumes, which were available for every intersection in the scope, to those few intersections where weekday off-peak and weekend counts had been collected in 2008. The resulting ratios allowed volumes for the rest of the intersections to be estimated for 2008 and then projected using the established growth rates into 2016. The final projected volumes were balanced and then entered into Synchro to produce the optimal Weekday Off-Peak and Weekend timing plans.

For the overnight period, even less data was readily available – only a series of 24-hour tube counts gathered at a few of the busier intersections in 2012; turning movement counts were not available at all. Because all of the signals within the scope of this project are meant to run free, i.e., non-coordinated, and fully-actuated in the Overnight timing plan, and only a simple assessment of the existing volume-density controls was required, Stantec determined that detailed turning movement projections were not necessary. Instead, efforts focused on estimating maximum link volumes for each approach at each intersection based on the available 24-hour tube counts. A similar comparison between the measured overnight link volumes and back-calculated AM peak hour link volumes was established to estimate approach link volumes for all intersections without existing overnight data. After projecting these new overnight link volumes into 2016, they were compared to the projected weekday off-peak values. In every case, the overnight volumes were found to be close to or below the weekday off-peak numbers. Stantec determined that the basic timing parameters used for the Weekday Off-Peak plans would suffice to control traffic in the free-running Overnight plans as well.

NEXT STEPS

Now that the preliminary timing plans for all times of day have been completed, RTD, Kiewit, the City, and PUC staff will proceed with more bench testing. Each timing plan will be assessed and refined to attempt to work out as many bugs as possible in a controlled setting. While additional fine tuning will still occur when field testing begins in the next few months, overall, the process should be faster and smoother thanks to all the work that has already been completed. If all goes according to plan, the Aurora Line will be ready to operate on time!