Date: November 7, 2018

To: Central City in Motion Project Management Team

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Subject: Central Eastside Industrial District Freight Compatibility Memorandum

P17156-000

This memorandum reviews Central City in Motion (CCIM) projects and presents findings and recommendations relevant to the function of freight movement within the Central Eastside Industrial District (CEID).

Key Findings and Recommendations

The most important takeaways from this report are as follows:

1. The CCIM planning process, including facility selection, included a detailed understanding of freight access and loading points in the CEID as detailed in the CEID Existing Conditions Map (see Figure 12).
2. CCIM projects include new freight and transit access lanes. Staff will coordinate with the freight community to develop a permit system and/or operational guidelines for how this new dedicated infrastructure should operate.
3. Traffic modeling analysis indicates that, on a system level, there is little change to overall network performance and that average travel speeds throughout the CEID during the PM peak period remain largely unchanged with the addition of CCIM projects compared to the 2035 base model.
4. The CEID features a well-connected grid network that provides direct routes through the district. Although the street grid is limited at its exterior edges due to river and rail crossings that channel drivers to specific streets, the intersection capacity at these locations is generally not being reduced.
5. If fully implemented, CCIM projects will dedicate an additional 2% of Central City right-of-way to bicycle and transit/freight lanes. Overall, bicycle and transit/freight lanes will account for a total of 6% of Central City right-of-way.
6. Overall, most CCIM projects avoid areas of the CEID with the highest concentrations of loading facilities. Loading zone impacts are primarily limited to SE 7th Avenue. CCIM staff should work with individual businesses to mitigate loading zone impacts.
7. Proposed widening of travel lanes on SE 11th and SE 12th Avenues provide easier access to loading zones and facilitate movement for larger vehicles on these constrained corridors.
8. In locations where protected intersections (see Figure 9) are recommended, mountable truck aprons and/or stop bar setbacks should be used to give more room for freight vehicles.
9. Further design work should undertake to separate freight and vulnerable road users' movements with traffic signal phasing in locations where protected intersections are not possible.

Introduction

Portland's Central City, including downtown and nine core neighborhoods, seen below in Figure 1, currently supports 130,000 jobs, thousands of businesses, dozens of important institutions, and is home to 32,000 people. This area is also expected to accommodate 30% of Portland's growth despite being only 3% of the city's land area. This equates to an expected increase in 51,000 jobs and 38,000 new households in the Central City by 2035. These new jobs and households will depend on freight transportation to ensure continued access to goods and services. Businesses need freight access to provide goods and services to consumers, residents expect fast and frequent delivery of goods or groceries purchased online, and new growth will continue to be supported by freight transportation.

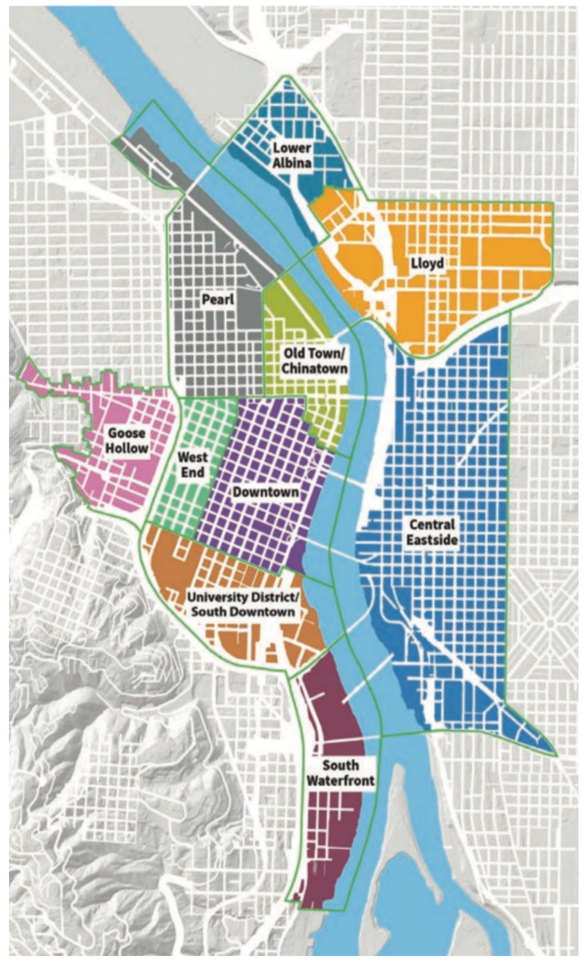

Figure 1 Portland's Central City

The movement of freight is especially critical in one particular part of the Central City: the CEID, located east of the Willamette River and south of I-84. Historically, many industrial businesses have operated in the CEID, and all streets in the CEID are designated by PBOT as freight district streets, meaning all streets should be designed to facilitate truck movements as practicable. Investments in transit, pedestrian, or cycling infrastructure create dedicated road space for people walking, biking, and taking transit. If well designed, these changes will make all users more visible and predictable, making it easier for freight traffic to navigate difficult urban streets.

The CCIM project is an initiative from the Portland Bureau of Transportation to guide and prioritize multimodal transportation investments within the Central City. These investments will be coordinated with the Green Loop and Enhanced Transit Corridor projects to create a cohesive strategy for developing the pedestrian, bicycle, and transit facilities throughout the Central City. The anticipated benefits and consequences of CCIM projects on freight movement in the CEID is documented below along with recommended solutions to ensure compatibility with freight uses within the CEID.

Central City in Motion Goals

PBOT established CCIM with the following goals:

- Prioritize Safety: Our Central City transportation system should be designed to prioritize safety first and eliminate traffic-related fatalities and serious injuries (Vision Zero).

- Enable Efficiency: Our Central City transportation system should enable the movement of people and freight reliably and predictably.
- Promote Equity: Our Central City transportation system should ensure affordable and convenient travel options for everyone, including people who want or need to travel without a car.
- Improve Sustainability: Our Central City transportation system should help residents and businesses reduce carbon emissions (Portland's Climate Action Plan).

As part of the CCIM goal to enable efficiency, investments in bicycle and transit facilities on the CEID will be coordinated to ensure that critical roadways maintain their freight accessibility. Both the benefits and impacts of CCIM projects for freight transportation are outlined below.

Central City in Motion Planning Process

CCIM projects are designed to provide protected, low-stress bicycle facilities, enhanced pedestrian crossings, and transit and freight improvements as part of the Enhanced Transit Corridors project. CCIM projects were identified using an iterative planning process that involved establishing planning principles and urban design strategies, documenting project opportunities and constraints, identifying and organizing projects into groups, evaluating projects, designing concepts for each project, and prioritizing project implementation. CCIM projects were identified in collaboration with stakeholder groups and community members throughout the planning process. Public involvement activities included a Sounding Board, Technical Advisory Committee, in-person and online open houses, and targeted outreach which were used to refine projects and ensure community needs are addressed. The final project list is designed to provide the most multimodal benefits within the next 5-10 years.

Figure 2: CEID freight uses and access points

Projects were removed from consideration if they relied on the design of a regional project (*e.g.* Southwest Corridor), required significant changes to sidewalk/structures to meet low-stress bikeway standards, or required removal of traffic lanes and/or parking in a manner that is not supported by the City's Transportation System Plan (TSP) in the near term.

The Central Eastside Industrial Council's Transportation and Parking Advisory Committee (TPAC) was an early project partner and assisted CCIM staff in conceiving and developing this freight study and report. In addition, CCIM staff regularly attended the TPAC's monthly meetings and provided regular project updates. Feedback from the TPAC helped improve staff's understanding on key freight considerations in the district, leading to improved project proposals.

In the CEID, the planning process foundation was also built upon a detailed understanding of the districts' freight usage. One of the CCIM's first work products included a map detailing every loading zone and bay, portal streets, and major freight access points and roadways (see Figure 2) in the Central Eastside. That foundation allowed project staff a clear understanding of how potential projects could impact freight and work to improve streets with significant freight activity. The CCIM project team also held three workshops with area stakeholders to focus more closely on CEID-specific needs and concerns for freight accommodation. CCIM project staff also held individual meetings with freight operators to better understand potential issues and changed project proposals to reflect freight needs. For example, a proposed bikeway on NE Davis Street from NE 12^{th} Avenue to NE 3^{rd} Avenue was modified after working with operations staff from the Franz headquarters in the district.

Figure 3: Example freight function in the CEID

Proposed Central City in Motion Improvements

The proposed low-stress bike facilities map within the Central City is shown in Figure 5. These routes were identified through a collaborative planning process to create a cohesive, direct, safe, and comfortable bicycle network throughout the central city. Additional consideration was also given to the existing bicycle facilities and projects identified from the TSP, especially those identified as priorities for the near term.

At the same time, CCIM is also investing in auto, freight, and transit facilities to ensure the system continues to function well for all users. A map of the proposed auto, freight, and transit improvements is provided in Figure 6. For example, converting a travel lane to a bike lane on the SE 11^{th} Street/SE 12^{th} Street couplet, seen in Figure 4, will also allow for restriping that widens travel lanes and increase maneuverability for auto and freight traffic along the corridor. Similarly, transit improvements, including dedicated bus lanes along the SE Martin Luther King Jr. Boulevard/SE Grand Avenue couplet, will be open to freight traffic, increasing reliability for travel along these corridors. These are just a few examples of how investments in multimodal transportation infrastructure can also improve freight transportation.

Key Finding #1: CCIM planning process was based on a detailed understanding of freight access and loading points in the CEID.

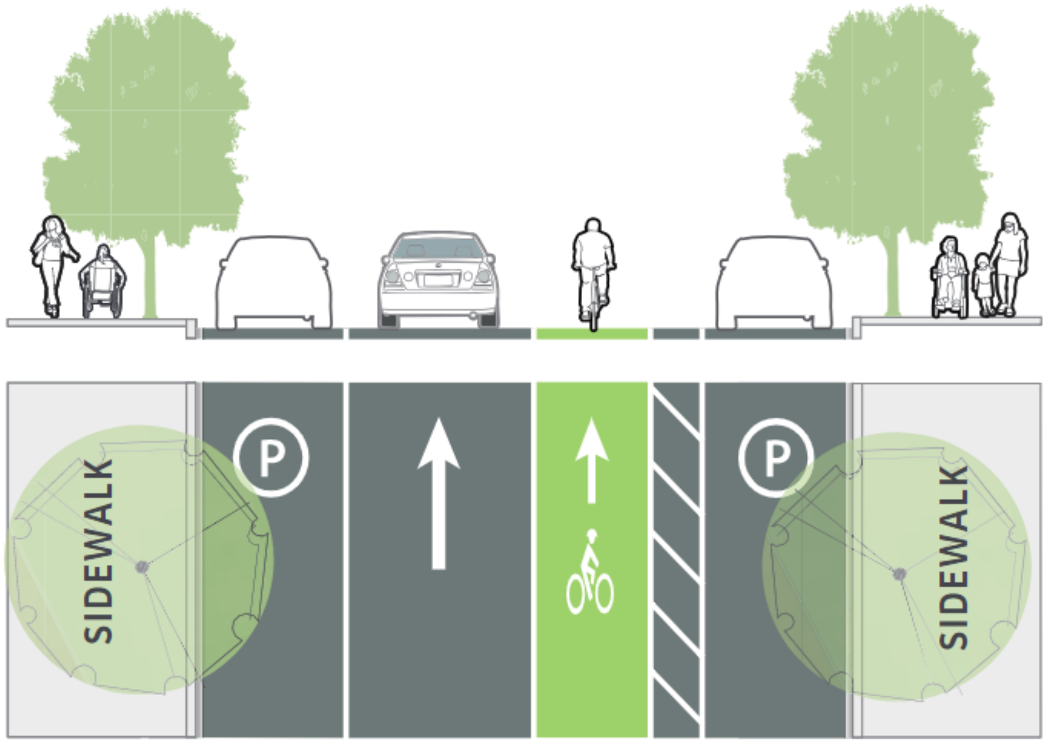

Figure 4: Potential enhancements on SE 11th Avenue/SE 12th Avenue

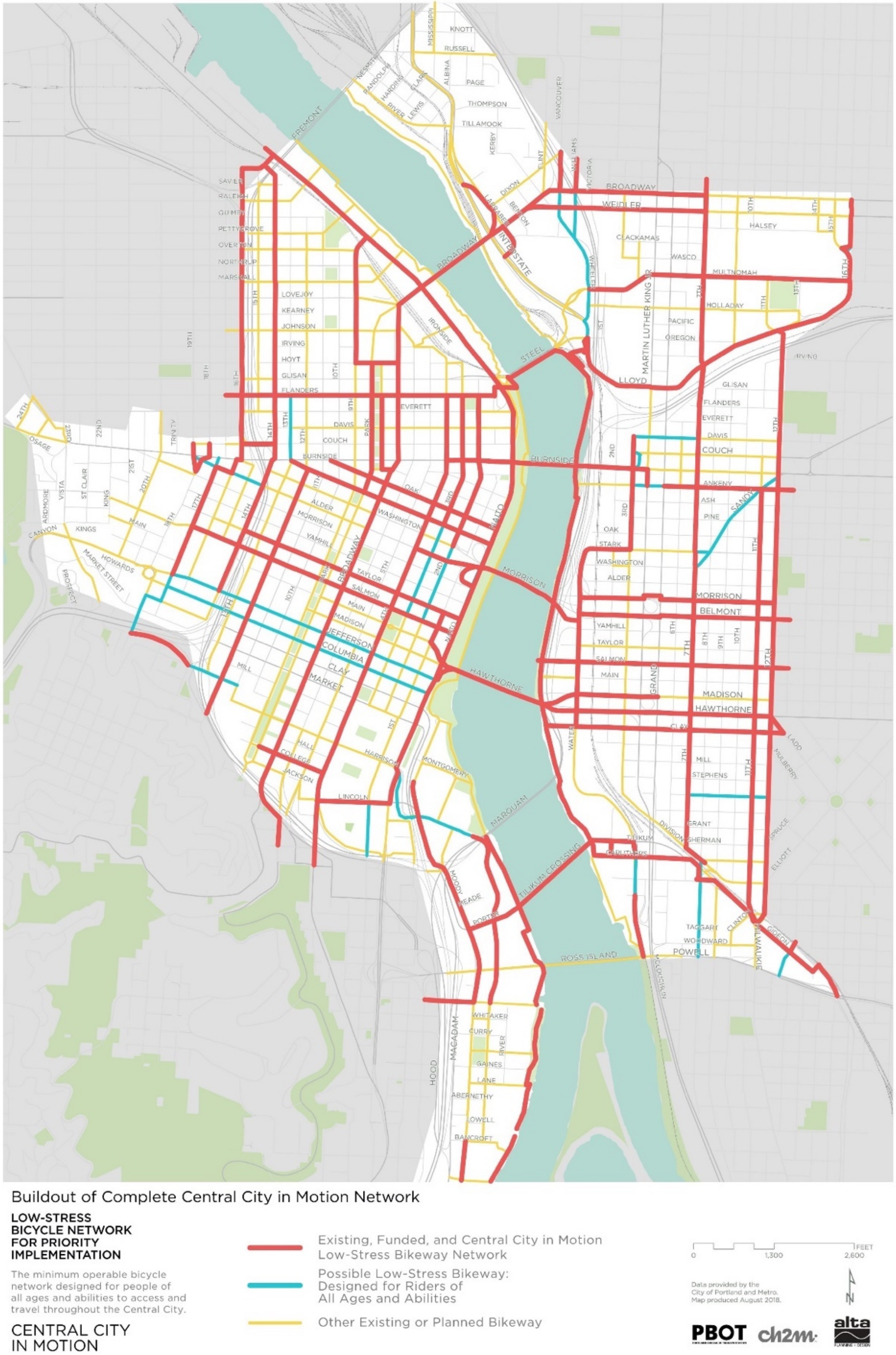

Figure 5 Central City in Motion Low-Stress Bicycle Network

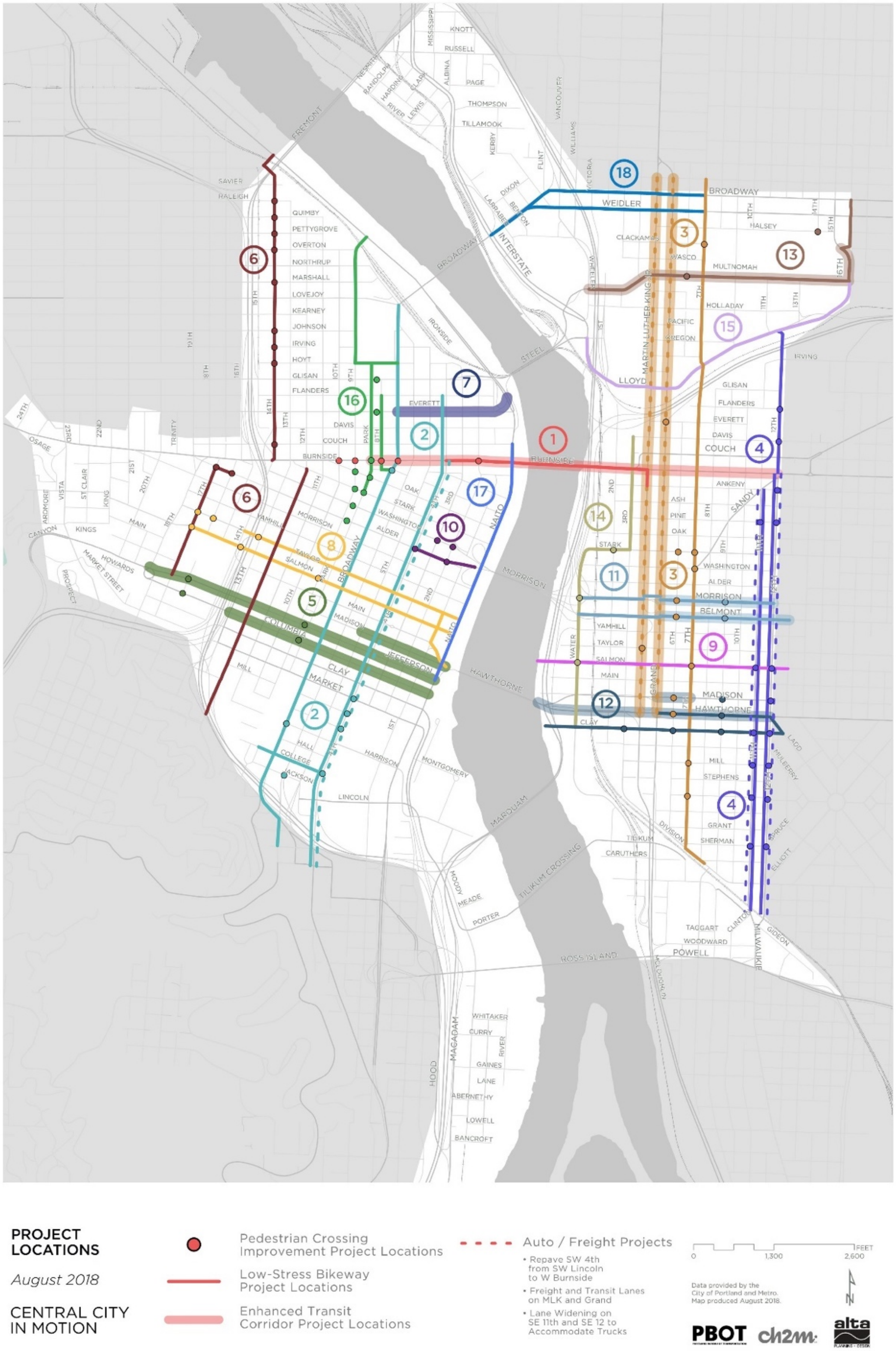

Figure 6 Central City in Motion Auto, Freight, and Transit Projects

Candidate Locations for Intersection Improvements

Each proposed CCIM bicycle project is designed to be used by cyclists of all ages and abilities, meaning that all users, including small children, recreational cyclists, and users with impaired mobility should feel safe and comfortable using the facility. Improving safety at intersections is a critical step towards developing an all ages and abilities bicycle network since intersections often include several conflict points between turning vehicles and bicyclists. Vehicles turning right or left could potentially cross paths with a person biking straight through an intersection. These movements are risky for both drivers and cyclists. Furthermore, the higher speed of people biking, relative to people walking, also makes it easy for drivers to miss cyclists who are occluded from view by other cars queued at an intersection or who might suddenly appear at an intersection.

As the level of protection, through either physical or temporal separation, for bicyclists at intersections is increased, the number of conflict points between different modes is decreased, as shown in Figure 7 below. Physical protection at intersection also helps to dedicate roadway space to different transportation modes and increase visibility of vulnerable road users, like people biking. These treatments enhance the predictability of an intersection and reduce the likelihood of unexpected behaviors that could result in a collision. Improving the predictability of intersection operations will particularly benefit freight operators by reducing the potential for crashes which decreases stress for drivers. All roadway users will benefit from clearly defining roadway space.

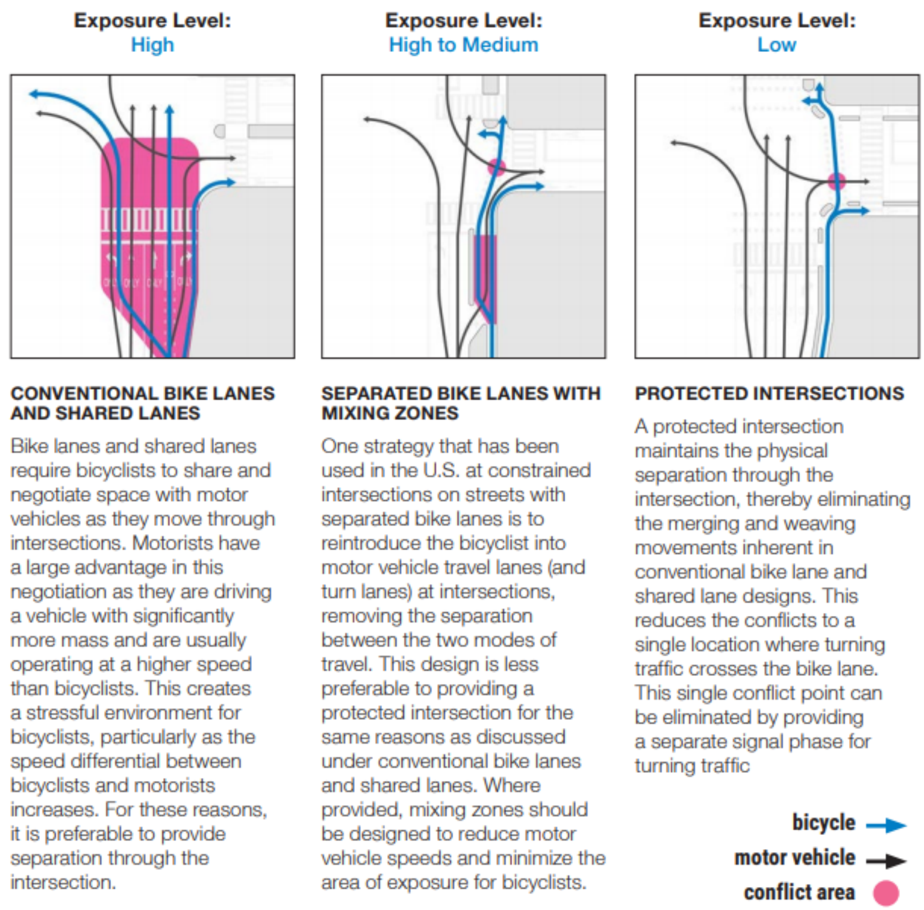

Figure 7 Bicycle Exposure Level at Different Intersection Types[i]

The appropriate intersection treatments varies by the context of the intersection. Particular attention is given to locations with the highest potential conflict between bicycles and other road users. Through collaboration with PBOT, the design team identified a critical threshold of 150 vehicle turning movements per hour to trigger intersection improvements. This turning movement threshold was applied at each intersection within the study area.

Turning movement counts have been collected at some study intersections by PBOT. If turning movement counts were available, these counts were used to identify critical turning movements that exceed the 150 vehicles per hour threshold. These intersections were also used to identify common intersection characteristics that were used to screen the remaining intersections for which turning movement counts were not available. Generally, intersections that exceed the critical 150 vehicles per hour threshold are turning movements that connect to freeway or river bridge crossings, turning movements that are required because the road converts to a one-way street (depending on traffic volumes), proximity to major attractions like the Lloyd Center Mall, and turning movements between major roadways in the study area (*e.g.* turning from SE Hawthorne Boulevard to other major N/S arterials like SE Martin Luther King Jr. Boulevard or SE Grand Avenue).

Turning movements were not included if they were to or from a minor street since they have low volume and therefore cannot meet the critical threshold during the peak hour. These movements include turns from major streets or bridge connections to minor streets, turns from a minor street to a major street, or turns from minor streets to minor streets. After identifying locations with critical turning movements, these movements were also evaluated for their potential conflict with the proposed low-stress bike network, based on preliminary design, and potential conflicts with freight facilities. These criteria were used to identify a refined list of priority intersection locations for the low-stress bike network, seen below in Figure 8. These intersections are the candidate locations for protected intersection treatments including separate bike phases, leading bicycle and/or pedestrian intervals, or geometric improvements to increase the visibility of vulnerable road users.

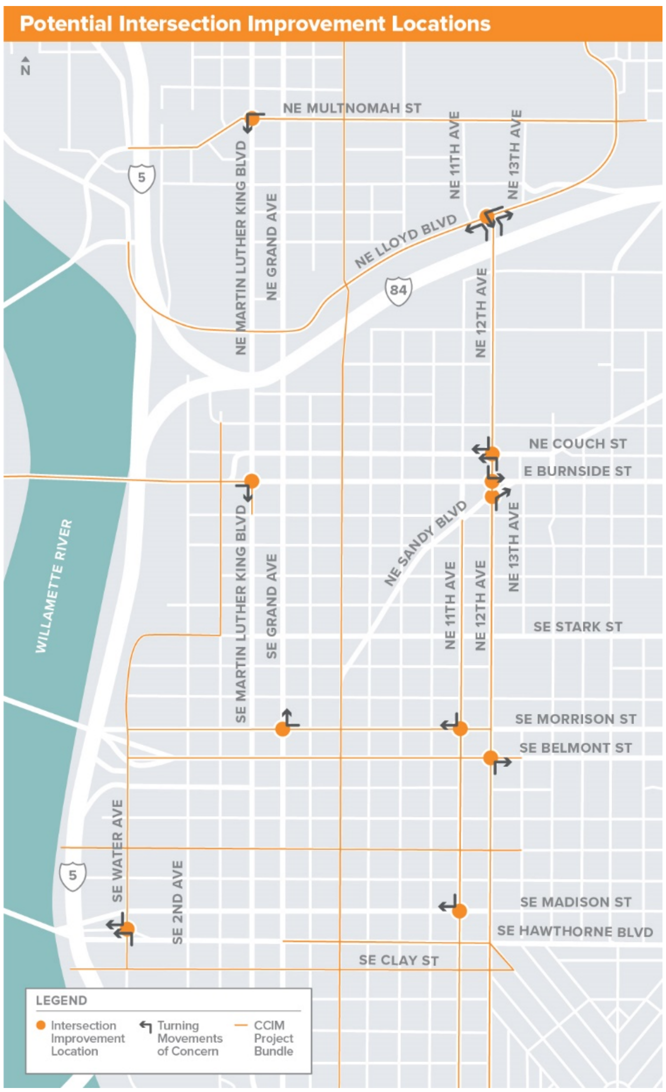

Figure 8 Priority Intersection Improvement Locations

Potential Intersection Improvements

As part of CCIM, the project team prepared a primer for the design and construction of protected bike facilities throughout Portland, which includes a discussion of intersection treatments.[ii] The design primer illustrates potential protected bike facilities based on existing best practices to introduce the public to possible improvements. The primer does not show recommended designs for specific location; rather, all final designs will be prepared in coordination with community stakeholders, including the freight community of the CEID. A range of intersection treatments is available to designers depending on documented needs at each intersection, including protected intersections, mixing zones, bicycle signals, and leading bicycle and pedestrian intervals. The specific treatments at each priority intersection location will be determined during future design phases.

Elements of protected intersections, illustrated in Figure 9, could impact roadway geometry and turning movements for freight vehicles. Protected intersections often include buffers between bicycle lanes and vehicle lanes at intersections, and corner islands which reduce the effective area of the intersection. While these features shorten pedestrian and bicycle crossings, in addition to increasing their visibility, they also reduce the available space for freight vehicles and can tighten turning radii, making it more difficult for freight to navigate through the

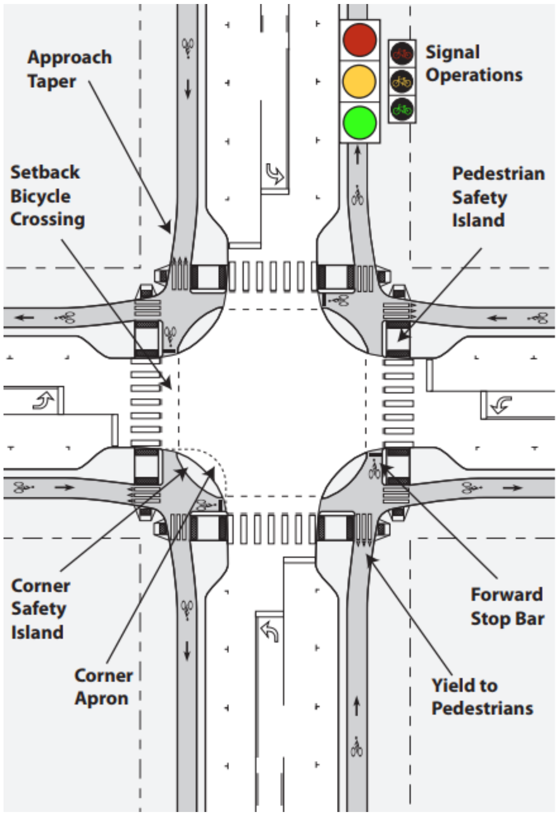

Figure 9: Protected Intersection Design Elements

intersection. In locations where protected intersections are recommended in the CEID, mountable truck aprons or stop bar setbacks should be used to give more room for freight vehicles while still achieving benefits for bicyclists. Stop bar setbacks should be coordinated with signal timing changes to ensure that freight vehicles will have enough green time to clear the intersection.[iii]

In a mixing zone design, shown in Figure 10, turning vehicles and bicyclists share a traffic lane at the intersection. This design can be implemented within the existing right of way and is not expected to have adverse impacts on freight accessibility. However, mixing zones are only recommended for intersection locations with turning movement volumes between 50 and 150 vehicles per hour which is exceeded at the candidate intersection locations.[iv]

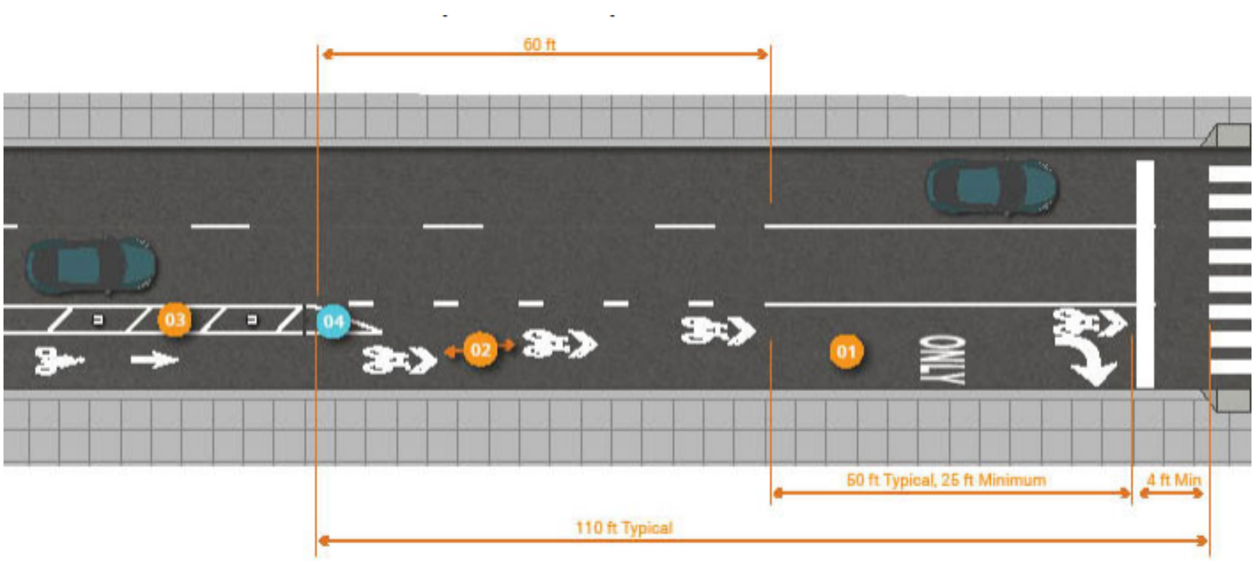

Figure 10 Mixing Zone Intersection Design[iv]

For locations where a full protected intersection is impractical due to geometric constraints, bicycle signals should be implemented to provided separate movements for cyclists and vehicles. While this option is not expected to impact freight accessibility, adding a separate signal phase for cyclists could increase delay and congestion for all road users.

Anticipated Project Impacts

System Impacts

As changes are made to the road network, including increases or decreases in motor vehicle capacity, travelers change their behavior to use the network more effectively and reduce their total travel time. These changes can be modelled using assumptions for the roadway capacity, free flow speed, and origin/destination patterns to identify network-level outcomes in the future. System level impacts for CCIM projects were analyzed using the City of Portland's travel demand model, which is a refinement of Metro's regional model. This model is maintained in coordination with long-term system planning efforts to identify system deficiencies and assess the benefits of funded capacity projects expected to be completed by the plan horizon year. The model uses a horizon year of 2035 to be consistent with its most recent transportation system plan and provides system-level insight into changes in transportation system performance. Changes in congestion and speed were compared for the 2035 base model and the 2035 CCIM model, which modifies the base model to include all CCIM projects.

The model does not include the full street network, but rather is composed of roadway segments classified as a collector or higher. The base model includes all funded Regional Transportation Plan projects scheduled to be complete by 2035, and the CCIM model starts with the same base model and includes CCIM project changes (i.e., changes to motor vehicle capacity) for comparison purposes. The CCIM model assumes the same number of auto trips as the base model; no assumptions about mode shifts were made for this analysis, even though it is anticipated that a connected network of all ages and abilities facilities will lead to more bike trips. The model provides analysis for the PM peak hour.

Analysis shows that average travel speeds throughout the CEID remain largely unchanged with the addition of CCIM projects. The average speed across all modelled roadway segments is consistent for both models. CCIM projects decrease the average speed district-wide by only one mile per hour, and this effect is consistent for roadway segments with both higher and lower free flow speeds (i.e., posted speed limits).

In both the base and CCIM future scenarios, average speeds are expected to be lower than free flow travel speed. This is an expected outcome in the 2035 PM peak hour regardless of CCIM improvements. Base 2035 model analysis forecasts that 38% of roadway segments in the CEID will operate within 5 mph of their free flow speed, and 68% of segments to operate within 10 mph. With CCIM projects included, 32% and 61% of segments are expected to operate within 5 mph and 10 mph of their free flow speed, respectively. These differences are summarized below in Table 1.

Key Finding #3: Modeling results show little change to traffic speeds and congestion conditions with CCIM projects included in the 2035 PM peak hour network.

Table 1 Expected Speed Changes (2035 PM Peak Hour)

Variable	Change with CCIM
Average Speed throughout CEID	-1.0 mph
Percent of CEID Lane-Miles within 5 mph of Free Flow Speed	-6%
Percent of CEID Lane-Miles within 10 mph of Free Flow Speed	-7%

Link capacity and congestion are measured in terms of the volume to capacity (v/c) ratio. V/C ratio quantifies how much traffic a roadway segment is expected to carry compared to the theoretical capacity of the roadway segment. This ratio can be used to identify changes in expected congestion levels with or without the CCIM projects for the future year of 2035.

- A v/c ratio greater than 1 indicates that a segment carries more traffic than its theoretical capacity which leads to congestion and delay for drivers since all traffic cannot be served and the system is vulnerable to breakdowns.
- When the v/c ratio is between 0.85 and 1, the segment is near capacity. A roadway with a v/c ratio in this range may experience delay and congestion and is vulnerable to breakdown, but generally can serve the amount of traffic in an efficient and reliable manner.
- If a roadway v/c ratio is less than 0.85, there is sufficient capacity to serve traffic demand, and fluctuations in travel demand will have minimal system impacts.

Figure 11 illustrates a conceptual example of how traffic compares at different v/c levels, and Table 2 highlights the expected percentage of CEID streets operating with different congestion levels with and without CCIM projects.

Figure 11: Congestion Level Examples

Table 2 Expected Changes in Congestion from CCIM Projects (PM Peak Hour)

Variable	2035 Base Model	2035CCIM Model
Percent of Segments Under Capacity (0.85 ≥ v/c > 0)	85%	85%
Percent of Segments Near Capacity (1 ≥ v/c > 0.85)	8%	7%
Percent of Segments Over Capacity (v/c > 1)	7%	8%

As shown in Table 2, 85% of modeled roadway segments in the CEID have sufficient capacity and contribute little to overall system congestion in both future scenarios. The other 15% of segments experience near or over capacity conditions, which tend to spill back and impact upstream segments that have otherwise sufficient capacity. The results indicate that, on a system level, there is little change to overall network performance with CCIM improvements in place. The CEID features a well-connected grid network that provides alternate routes, and although the grid is limited at its exterior edges due to river and rail crossings that channel drivers to specific streets, the intersection capacity at these locations is generally not being reduced. In both scenarios, about 15% of segments will operate near or over capacity with and without CCIM projects, with just 1% more segments operating over capacity in the CCIM scenario.

Access to and from major freight portals within the CEID remain unchanged or improved as a result of CCIM projects. Freight access to I-84 will be improved due to new freight and transit lanes along NE Grand Avenue. Access to I-5 remains unchanged due to CCIM projects, as roadway capacity is not being altered at the ramp terminals in the vicinity of SE Morrison Street. SE Powell Boulevard (US 26) will also not see capacity changes from CCIM projects. Freight access to SE Powell Boulevard will be improved via the freight and transit lanes on SE Grand Avenue/SE Martin Luther King Jr. Boulevard.

The traffic analysis work presented in this report has already helped inform the project. Several project proposals were modified when their impact to modeled traffic speeds or v/c ratios suggested a substantial risk to freight reliability. For example, the SE Hawthorne Boulevard and SE Belmont Street projects were both revised to mitigate modeled traffic impacts.

Parking Impacts

To incorporate improved multimodal facilities across the CEID, existing road space must be reallocated by either repurposing a vehicle travel lane or reallocating on-street parking facilities. Currently design concepts show removing parking along one side of SE 7th Avenue, SE Clay Street from SE Water Avenue to SE Grand Avenue, and the along the west side of SE Water Avenue. Parking would also be removed in small sections along SE Clay Street between SE Grand Avenue and SE Ladd Avenue and at the intersections of SE Hawthorne Boulevard with SE 7th Avenue and SE 12th Avenue to allow for bus queue jump lanes. Parking reallocation is also being considered along SE Belmont Street and SE Morrison Street. For additional information on the anticipated parking impacts related to CCIM projects, please refer to the Parking Mitigation Strategy.

Loading Zone Impacts

Loading zones and loading docks are clustered throughout the CEID to serve businesses within the area, detailed below in Figure 12. Generally, care was taken to locate CCIM projects on existing streets with relatively few loading zones or docks. Loading zone impacts are expected to be concentrated along SE 7th Avenue where there is a higher concentration of loading zones and on-street parking that would be removed for future facilities. Loading zones and loading bays could be impacted from increased bicycle traffic on SE Salmon Street and SE 3rd Avenue, north of SE Stark Street, but no loading zones or parking changes will occur on these streets. Overall, most CCIM facilities are already located away from areas of the CEID with the highest concentration of loading facilities to reduce potential conflicts between freight and bicycle facilities.

Some of the anticipated loading zone impacts along SE 7th Avenue can be mitigated through removing parking from the side of the street that impacts the fewest loading zones or relocating existing loading zones to the opposite side of the street if they will be eliminated under the design. Moving existing loading zones could still be challenging if delivery access was needed for businesses, however, crosswalk improvements or relocating impacted loading zones to side-streets near the business could make it easier for deliveries. Similar strategies should be applied to existing loading zones on SE 11th Avenue or SE 12th Avenue and SE Salmon Street if they are impacted through CCIM projects, although there are generally fewer loading zones along these facilities. Additionally, widening travel lanes on SE 11th Avenue and SE 12th Avenue could make it easier for delivery drivers to access loading zones and navigate their vehicles along the corridor, improving overall freight access in this corridor.

Loading bays, as an off-street facility, will likely face minimal impact. However, by placing “sharrows” along SE Salmon Street and SE 3rd Avenue north of SE Stark Street, drivers utilizing the loading bays in this area could face a more challenging driving environment from a greater number of cyclists. This discomfort should be mitigated by providing greater visibility, such as mirrors or other detection, to help drivers know when they should expect bicyclists. For loading bays with high utilization, additional measures should be considered to ensure safety along these corridors.

Figure 12 Loading Zone and Loading Bay Locations in the CEID

Roadway Geometry Impacts

CCIM could result in geometric changes to several corridors within the CEID. However, some projects in the CEID will expand road space for freight vehicles, making it easier to navigate for traffic and improving reliability along these corridors. For example, narrow two-lane streets on SE 11th Avenue and SE 12th Avenue include proposals to convert the corridor to a wider one-lane street and include a bike facility. Widening this facility will increase navigability for heavy and oversize vehicles along a key north-south corridor. Additionally, freight vehicles should have access to dedicated bus and turn lanes along SE Martin Luther King Jr. Boulevard and SE Grand Avenue that could speed travel times along these corridors through dedicated road space. By restricting lane use, both freight and transit should experience improved reliability of travel time along major north-south corridors in the CEID.

On other streets within the CEID, such as SE 7th Avenue, providing protected bike facilities will reduce stress for drivers. Existing narrow bike lanes next to on-street parking create a dangerous environment for cyclists and increase stress for drivers visiting SE 7th Avenue. Eliminating on-street parking along SE 7th Avenue reduces the possibility of "dooring," where a driver unexpectedly opens a door into a bicycle lane which can result in severe injuries for a person biking. These crashes can be particularly problematic in areas with high parking turnover, including locations with many loading zones. Providing physical separation between bicyclists and drivers through protected bike lanes also reduces the likelihood of sideswipe collisions between bicyclists and vehicles. Additionally, protected bike facilities will enhance the visibility of cyclists for drivers, making the roadway environment more predictable for all users. Freight drivers will especially benefit from these changes since their vehicle's large blind spots and high mass increase the probability of severe crashes. These enhancements will reduce driver stress navigating this corridor and improve safety for all modes.

Roadway geometry is also expected to change at key intersections throughout the CEID to provide for protected bike facilities at these locations. Potential geometric improvements are illustrated above in Figure 9 and Figure 10. Intersection concepts will be developed in future design phases, and as design proceeds, freight movement and accessibility will be considered at these sites. Protected intersection features will not simply include tightening turn radii to make it more difficult for vehicles to turn, but also include other intersection design standards that ensure both bicyclists and freight vehicles can comfortably move through an intersection. These designs will be implemented based on existing best practices and the neighborhood context. For more information on possible roadway geometry and freight accommodation for protected bike facilities refer to Portland's Central City in Motion Design Primer, Volume 2.[ii]

Potential Solutions or Alternatives

Figure 13: SE MLK Jr. Blvd. and SE Grand Ave. at SE Stark Street looking north

Implementing CCIM projects bring both challenges and opportunities for the freight community in the CEID. CCIM projects will have benefits for the freight community. Expanding lane widths on SE 11th Avenue and SE 12th Avenue will make these key corridors more navigable for larger vehicles, and other projects will provide freight vehicles with access to shared, dedicated lane space, including developing freight and transit lanes on the Martin Luther King Jr. Boulevard and Grand Avenue corridors (see Figures 13 and 14). As these lanes are developed, PBOT should coordinate with the freight community to establish guidelines for use, based on criteria like vehicle classification, commercial designation, time of day, or other measures.

These projects will make it easier for freight traffic to navigate in the CEID. Other CCIM projects are not designed to limit freight traffic on the CEID, and the following accommodations should be employed to ensure freight accessibility.

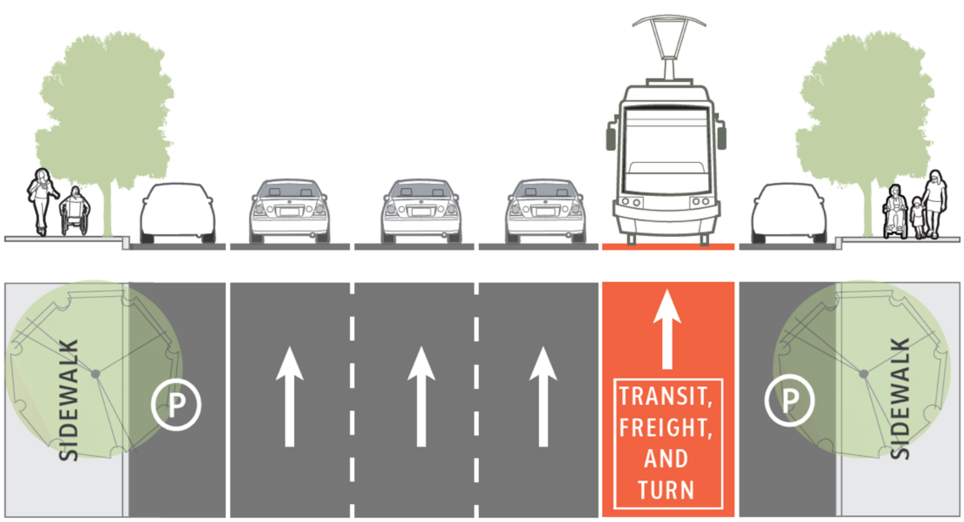

Figure 14: SE Grand Avenue Cross Section (SE Hawthorne Boulevard to I-84) looking north

Intersection Geometry Accommodations

For locations where geometric changes for protected intersections are recommended, existing reference materials that support the Central City in Motion Design Primer provide design techniques that will accommodate freight or larger delivery vehicles while also improving bicycle and pedestrian safety. Both the 2015 MassDOT Separated Bike Lane Planning and Design Guide and the 2015 Evolution of the Protected Intersection White Paper provide detailed guidance on accommodating heavy vehicles at protected intersections.

The 2015 MassDOT Design Guide identifies several protected intersection treatments which can be used to accommodate trucks or larger vehicles.[i] At intersections, the smallest feasible corner radius should be used to slow motorists which can improve yielding behavior and reduce needed stopping distance. These features make it more comfortable for bicyclists, but they also make it more difficult for larger vehicles to navigate. To mitigate freight impacts, compound curves, recessed stop lines, and mountable truck aprons may all be used to accommodate large vehicles while still slowing passenger car turning to movements to under 10 mph.

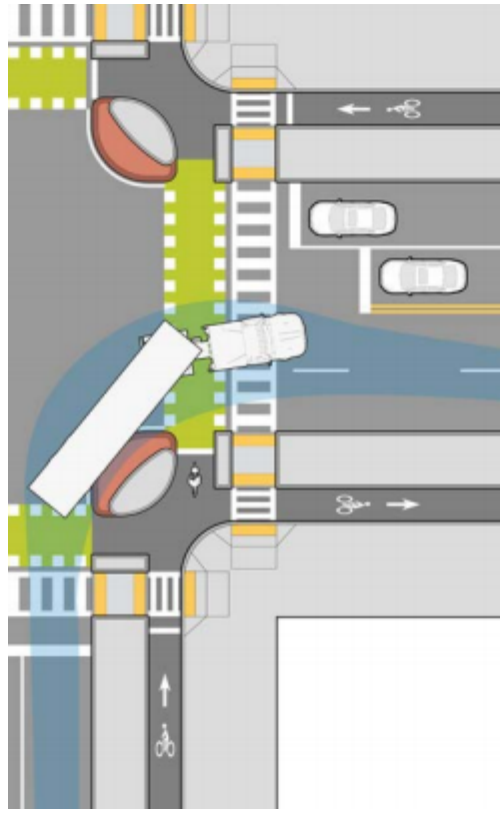

Figure 15 Recessed Stop Line Design to Accommodate Trucks[i]

Recessed stop lines, seen in Figure 15, allow larger vehicles to encroach on additional lanes to make their turn, effectively increasing the turning radius for larger vehicles. When encroachment is not desirable, compound curves can be used instead to reduce the effective turn radius. Mountable truck aprons, seen in Figure 16, should also be used to accommodate a larger turning radius for heavy vehicles while tightening turn radii for passenger vehicles, and they should be considered when the design vehicle exceeds an SU-30 (30' box truck). The design of mountable trucks aprons should discourage pedestrian or bicycle refuge to protect their safety, and the mountable surface should be visually different from surrounding roadway features. Mountable truck aprons should be no higher than 3 inches above the travel lane to accommodate lowboy trailers. Raised crosswalks and bike crossings should also be considered on minor street approaches to further alert drivers to the presence of bicyclists and pedestrians.[i]

Signal Phasing Accommodations

If geometric strategies are not feasible at a particular location due to right of way constraints or other limitations, protected bike facilities should be achieved through signal phasing. Different phasing operations[iii] include:

- Protected but Concurrent Phasing: Bicycle and vehicle through traffic occur simultaneously while vehicle turn movements, including right turn on red, are restricted.

- Protected Left Turn Phasing: Bicycle and vehicle through and right turn traffic occur simultaneously. Right turn traffic during the green phase must yield to bicyclists while left turns and right turns on red are restricted.
- Permissive Only Signal Phasing: Bicycle and all vehicle movements occur simultaneously. Turning traffic must yield to other vehicles and cyclists.
- Exclusive/All-Way Bicycle/Pedestrian Phasing: All bicycle and pedestrian movements are allowed during one signal phase, separate from all vehicle movements. This phasing operations is not currently allowed by the FHWA.
- Leading Bicycle Interval: Bicycle and pedestrian phase begins ahead of concurrent traffic phase to increase their visibility. This phasing operation is not currently allowed by the FHWA.

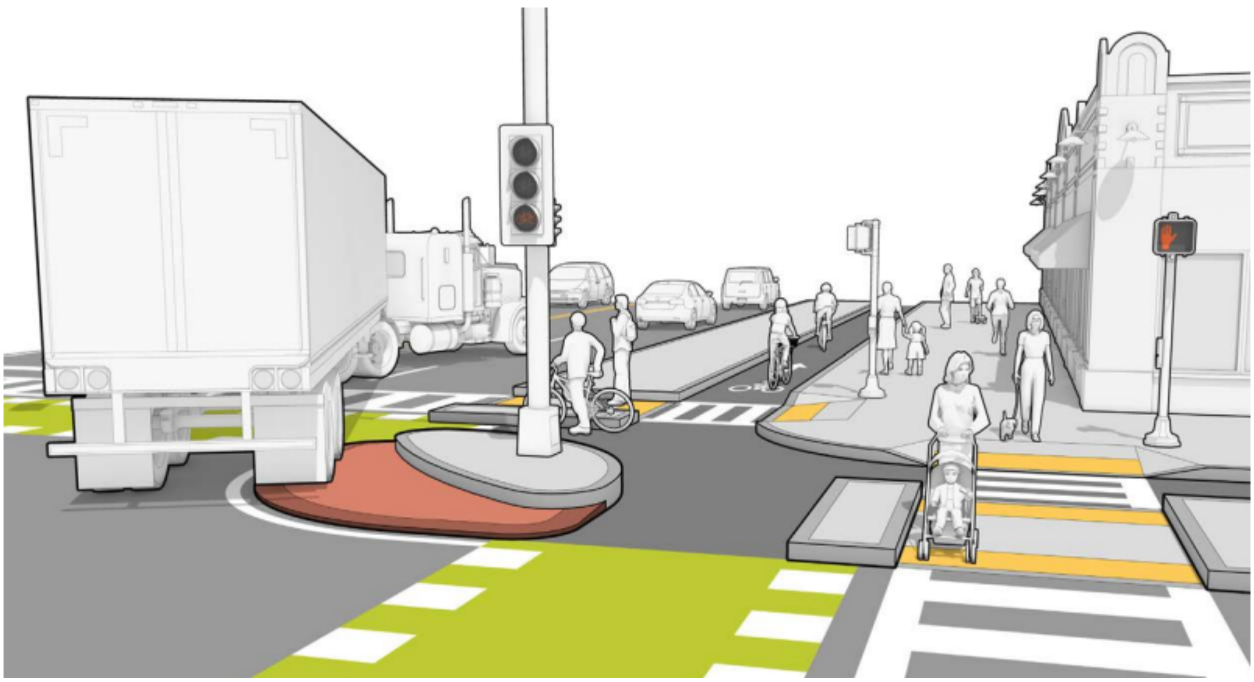

Figure 16 Mountable Truck Aprons at Protected Intersections[i]

Network Level Accommodations

Key Finding #5: Implementing all CCIM project means reallocating just 2% of Central City right-of-way.

Each travel mode within the central city has its preferred route depending on a user's origin and destination, facility characteristics, and other user considerations. Not every central city street should be designed to accommodate every travel mode. By clearly designating routes for freight and routes for bicycles or other vulnerable road users, each road user will have their designated roadway space which will enhance predictability and improve operations for all road users. While there will necessarily be some overlap of these facilities at locations like bridges, establishing a road network which functions to support certain modes on specific streets provides predictable operations across the road network. In locations where there is overlap between these projects, including throughout the CEID, CCIM projects improve the visibility of cyclists and increase predictability for all roadway users, making it easier for drivers to navigate these corridors. Furthermore, establishing a tiered roadway network which supports different users on different links ensures each user has access to the roadway network.

CCIM projects will contribute to a tiered roadway network through increasing roadway space allocation for bicyclists, freight, and transit on certain corridors. Within the Central City today, one percent of roadway space is currently dedicated to transit and three percent of roadway space is dedicated to bikeways. Table 3, below, summarizes the changes in roadway space allocation expected as a result of CCIM projects. After CCIM projects are implemented, two percent of Central City roadway space will be dedicated to transit and four percent will be dedicated to bikeways. CCIM transit improvements will also increase the total roadway space dedicated to freight vehicles within the Central City by creating freight and transit lanes on select corridors. While CCIM projects will include reductions in general purpose lanes or parking, only two percent of the total roadway space within the Central City will be affected. These small changes, however, will result in significant benefits for transit, freight, pedestrians, and cyclists.

Table 3: Changes to Central City Right-of-Way Allocation

Central City in Motion ROW	Total Area Increase (ft^2)	Percent Increase
Bicycle	253,212	1%
Transit	338,206	1%

Conclusions and Recommendations

The Portland Bureau of Transportation is directed by City policy to improve facilities for active transportation modes through CCIM. While this project will bring changes to the CEID, PBOT is sensitive to the unique needs of the freight community in the CEID and will continue to engage with this community to ensure CCIM designs meet this policy directive while maintaining freight accessibility.

Some CCIM projects will directly enhance freight transportation within the CEID, either through providing freight access to dedicated lane space or widening existing travel lanes to improve maneuverability. Other projects will provide dedicated road space for all roadway users, increasing predictability and enabling easier navigation for drivers. As designs are finalized, freight needs will continue to be considered in facility design through either geometric enhancements that can accommodate larger trucks or alternative design strategies. PBOT will coordinate with the freight community to establish a permit system or other guidelines governing the use of shared freight and transit lanes to further dedicate space for all road users. CCIM projects will define and dedicate roadway spaces for each mode to enhance roadway operations and provide predictability for all users.

Previous work on corridors and intersections to accommodate freight and other vulnerable road users should be used by PBOT and adapted to meet freight needs specific to Portland. The CCIM Design Primer[ii] draws from established protected bikeway facility design guides that already provide recommendations for freight accommodations. Last year, ODOT also opened bike lanes on Lombard Street in North Portland, a state designated freight route.[v] Coordination with ODOT will leverage knowledge gained from this project for implementation of CCIM projects within the CEID. Global experience should also be leveraged to easily accommodate both freight vehicles and cyclists at intersections, as seen below in Figure 17.

Figure 17 Truck Interacting with Protected Intersection in the Netherlands[vi]

Implementing CCIM projects is not without challenges – limited right of way across the City of Portland means there is limited road space to accommodate all roadway users. However, by providing dedicated lane space for different roadway users, PBOT will enhance predictability for all users, making it easier to navigate Portland's central city with less conflict. As PBOT moves forward with designs for CCIM facilities, freight needs will continue to be an important design criterion, particularly in the CEID, and PBOT will continue collaborate with the freight community to ensure their concerns are met during the design process.

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[i] Massachusetts DOT. *2015 MassDOT Separated Bike Lane Planning and Design Guide, Chapter 4, Intersection Design.* 2015.
[ii] Portland Bureau of Transportation. *Central City in Motion Design Primer, Vol. 2.* 2018.
[iii] Alta Planning and Engineering. *Evolution of the Protected Intersection.* 2015.
[iv] Federal Highway Administration. *Separated Bike Lane Planning and Design Guide.* 2015.
[v] Maus, J. *First look: Buffered bike lanes on Lombard in north Portland.* https://bikeportland.org/2017/06/27/first-look-buffered-bike-lanes-on-lombard-in-north-portland-233005. 2017.
[vi] Bicycle Dutch. *A common urban intersection in the Netherlands.* https://bicycledutch.wordpress.com/2018/02/20/a-common-urban-intersection-in-the-netherlands/. 2018.