MEMO

TO: David Patman

FROM: Grantley King

SUBJECT: **Eastern Corridor Study – AHP Methodology**

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The weighting of the refined criteria was undertaken using an 'Analytic Hierarchical Process' (AHP) as the technique for group decision making. The goal of this exercise was to weight the Criteria Categories (the goals for the project) and the Category Specific Criteria (sub goals specific to each category) which had been reviewed and refined by the project team based on technical and public input. The resulting weights are to be used in evaluation of the route segments that have proceeded through the 'Fatal Flaw Analysis'.

AHP was identified by the City as a process that had previously been successfully used to set priorities for Public Works projects in the past. Based on this recommendation, the project team proceeded with preparing an AHP exercise to set the weighting for the proposed criteria categories and the sub criteria within each category.

Analytical Hierarchal Process (AHP)

AHP is a technique used to analyze or organize a complex set of decisions that provides a structure and method to organize and track the decisions that are being made. It was developed by Thomas L. Saaty in the 1970s and is used for a wide variety of decision making process where numerous options need to be compared to each other.

Pairwise comparisons are used to derive scores (weightings) for different options or considerations that relate to a decision. For example, AHP could be used to identify and quantify an individual's preferences between different transportation modes. For this project it was used to identify the relative importance of the identified criteria.

Criteria and Goals

In order to answer the central question for the project 'What is the best route to connect Downtown with Eastern Winnipeg (Transcona) with a bus rapid transit route?', the priorities for the project must be identified and weighted. This process began by proposing six high level Criteria Categories that supported the stated goals for the project. These Criteria Categories were based on the technical team's input and were presented to the public in May 2017. Both the technical team and the public had an opportunity to suggest refinements and express how important they felt each category was relative to the others.

These criteria were established at the outset of the project to ensure that the criteria was not developed with bias towards a particular alignment. They were developed to reflect the goals and priorities for the project as articulated by the City, City Policy, expert input, and public input

There are six categories proposed. Each of these high level categories is supported by a goal statement. They are as follows:

Connectivity	Connects people and places with a variety of viable transportation options (transit, bicycle, walk, and automobile).
Performance	Increases transit and active transportation ridership by developing a modern, high-quality, reliable rapid transit system that mitigates impacts on other modes.
City Building	Helps build and re-invigorate neighborhoods and enhance livability by building complete communities.
Cost	Affordable to build, maintain and operate.
Social Equity	Supports equitable access to housing, employment and other destinations regardless of income, household type, ability, age, etc.
Environmental Impacts	Minimizes impacts on climate, air, water and the surrounding community.

Each of these categories is further supported by two to five sub goals:

Connectivity	
C1	Provides transit system connections to the existing transit system, including bus routes, transit transfer centers, park-and-ride lots, etc. and future planned transitways.
C2	Eliminate gaps in the pedestrian and cycling network.
C3	Facilitates connections to rapid transit stations / alignment using pedestrian and bicycling facilities.
C4	Minimizes physical barriers to connectivity (i.e. street crossings, etc.).

Performance	
P1	Optimizes transit ridership and meets transit demand. Note: Ridership will be measured using a computer model that will represent and simulate the various feasible alternatives.
P2	Reduces transit travel times. Note: Travel time will be measured using a computer model that will represent and simulate the various feasible alternatives
P3	Improves transit system reliability (on-time performance).
P4	Mitigate negative impacts on the City's transportation network

City Building	
CB1	Optimizes and strengthens connections between and within neighbourhoods, and to frequently accessed destinations, community assets and places that generate (or are expected to generate) high transit ridership.
CB2	Aligns with the City's Vision and policy direction as articulated in the City's Development Plan, OurWinnipeg, the supporting direction strategies, and secondary plans.
CB3	Supports community improvement and economic growth by encouraging infill developments of underutilized land, and creating opportunities in areas anticipated to experience growth and change.
CB4	Optimizes placemaking opportunities, creating dynamic, high-quality places and spaces that leverage local assets, creativity and vision to enhance community vitality, quality of life, happiness and well-being.

Cost	
CE1	Minimizes construction and other capital costs, such as land acquisition, etc.
CE2	Right-of-Way Requirements & Convertability
CE3	Optimizes financial feasibility.
CE4	Minimizes system operating and maintenance costs.

Social Equity	
SE1	Improves transit access for under-represented populations particularly to provide improved access to jobs and services.
SE2	Improves transit access in neighbourhoods that are currently not well-served by transit.
SE3	Supports and complements reinvestment strategies that mitigate displacement, access and affordability challenges.
SE4	Minimizes construction-related impacts to neighbouring businesses.
SE5	Minimizes construction-related impacts to neighbouring residences.

Environmental Impact	
EI1	Reduces greenhouse gas emissions.
EI2	Minimizes risk of significant impacts to environmental resources (wetlands, waterways, historic facilities, hazardous sites, etc.).

Each potential rapid transit alignment will be evaluated against all of the sub-goals using quantitative and qualitative measures.

Weighting Exercise

Weighting the Goals and Sub Goals allows for the evaluation process to determine whether or not certain priorities are more important than others and to what degree. In order to identify this for the Eastern Corridor Study, the technical team used the AHP in a workshop setting to come to a group consensus on the recommended weightings.

To prepare for the group weighting exercise the City and Consultant technical teams reviewed the goals and sub-goals along with the prepared worksheets and the instructions for the exercise. Participants came together prepared to represent their respective technical disciplines. Each of the technical disciplines were represented along with representatives from the public engagement team who advocated for public's perspective, as heard in the public engagement.

The group worked through each of the pairwise comparisons for seven sets of goals, one for the overall goals and one for each set of sub goals. The worksheets, the scale, and a summary of the results are attached.

As a starting point, the consulting team proposed an entry for each pairwise comparison and each discipline representative was asked to indicate if they agreed or felt the proposed should be adjusted. Through a group discussion the technical team came to an agreement on a value and proceeded to the next pair. In most cases there were disagreements about the appropriate value. When this was the case each discipline had an opportunity to explain their rational for why they felt their proposal was appropriate and to indicate how much they would be willing to adjust their initial position. The processes recognizes that there are many different priorities that are often at odds with one another and the consensus achieved does not mean that everyone agrees with the outcome but rather that everyone understands the reasons for the outcome and can accept them.

Sample AHP Process

Using the sub goals for the Connectivity the following will provide a step by step example of how the weights for the individuals sub goals was derived.

1. The goals were presented in pairs on a prepared worksheet. Between each pair is a drop down list of the possible options that describe the level of importance between the pairs. Figure 1 shows the completed worksheet for the Connectivity sub goals.

Eastern Corridor Connectivity AHP Worksheet

C1	Provides transit system connections to the existing transit system, including bus routes, transit transfer centers, park-and-ride lots, etc. and future planned transitways.
C2	Eliminate gaps in the pedestrian and cycling network.
C3	Facilitates connections to rapid transit stations / alignment using pedestrian and bicycling facilities.
C4	Minimizes physical barriers to connectivity (i.e. street crossings, etc.).

C1	c) is Much More Important than	C2
C1	f) is Slightly Less Important than	C3
C1	f) is Slightly Less Important than	C4
C2	g) is Way Less Important than	C3
C2	h) is Far Less Important than	C4
C3	f) is Slightly Less Important than	C4

Figure 1

2. Each phrase within the worksheet corresponds to a numeric value automatically populated in the Connectivity matrix. The decisions made in the worksheet automatically populate the upper/right half of the matrix, the lower left is automatically populated with the reciprocal values. The connectivity matrix is shown in Figure 2.

		C1	C2	C3	C4
Provides transit system connections to the existing transit system, including bus routes, transit transfer centers, park-and-ride lots, etc. and future planned transitways.	C1	1	5	1/3	1/3
Eliminate gaps in the pedestrian and cycling network.	C2	1/5	1	1/5	1/7
Facilitates connections to rapid transit stations / alignment using pedestrian and bicycling facilities.	C3	3	5	1	1/3
Minimizes physical barriers to connectivity (i.e. street crossings, etc.).	C4	3	7	3	1

Figure 2

3. The values are then normalized and summed for each of the sub goals.
4. The geometric mean is then calculated based on the normalized sum. Geometric mean, rather than arithmetic mean, is used to preserve the ratios and maintain reciprocity.
5. The geometric means were then adjusted so that the sum of the weights equals 100 by dividing the geometric mean for each criteria by the sum of the geometric means.

Scale

Previously a simplified five level scale was created by removing the even values. The even values were replaced and a nine level scale was used to allow for the minor adjustments.

Review and Consistency

The AHP process, similar to any decision process or model, is a tool that can result in illogical results that benefits from an expert review to ensure that the results are logical and applicable. There is also a risk when looking at pairs of criteria in isolation that the responses are inconsistent with other responses provided. To address both of these issues review mechanisms were included in the weighting process.

Consistency

To ensure that the issues related to consistency of responses were identified and addressed a mathematical test of consistency was used. Where inconsistencies were identified small adjustments were made to remove the inconsistency.

Public Input

The Public has been involved in the identification of priorities, criteria and the goals through the public engagement Process.

- Public Engagement May – July, 2017
  - The public was asked to provide their input on the proposed criteria, suggest modifications, additions and/or deletions.
  - The public was also asked to articulate their priorities by distributing a fixed number tickets to each of the criteria categories (more tickets for higher priority).

The results from Round 3 have been provided to the City in a report.

- Public Engagement November – December, 2017
  - The public was asked to provide their input on the revised criteria and sub criteria.
  - The public was asked to provide input on whether they agree or disagree with the criteria weightings. If they disagreed, they were asked to indicate whether the weighting should be higher or lower than proposed.

A summary of the results from this engagement have been provided in Appendix B.

Review

Expert Judgement was used to make minor refinements to the weightings in the context of public input and final technical review of the criteria. The weightings were refined to ensure that they reflect the realities of selecting a route that will be successful. The results of this review were determined with input from the City, and small adjustments to the AHP categories and pairwise comparison have been made as follows:

- **Criteria Categories**:
    - Connectivity and Performance weighting decreased slightly, from 33% each to 28% each. While maintaining importance over the remaining categories, the reduction was required to allow for minor adjustments amongst the other criteria categories.
    - City Building weighting increased slightly from 15% to 18%.
    - Cost weighting increased slightly from 10% to 13%.
    - Social Equity weighting increased slightly from 5% to 7%.
    - Environmental weighting increased slightly from 4% to 6%.

All of the adjustments were a maximum of two positions on the scale.

- **Connectivity:** C2 *"Eliminate gaps in the pedestrian and cycling network"* increased slightly in importance using the nine level scale. This increase was facilitated by lowering the importance of C1 *"Provides transit system connections to the existing transit system, including bus routes, transit transfer centers, park-and-ride lots, etc. and future planned transitways"* and C4 *"Minimizes physical barriers to connectivity (i.e. street crossings, etc.)"*.
- **Performance:** adjustments of one position on the scale were made between each pair of sub-criteria and the weightings remained relatively stable.
- **City Building:** CB3 *"Supports community improvement and economic growth by encouraging infill developments of underutilized land, and creating opportunities in areas anticipated to experience growth and change"* and CB4 *"Optimizes placemaking opportunities, creating dynamic, high-quality places and spaces that leverage local assets, creativity and vision to enhance community vitality, quality of life, happiness and well-being"* increased slightly in equal importance. CB1 *"Optimizes and strengthens connections between and within neighbourhoods, and to frequently accessed destinations, community assets and places that generate (or are expected to generate) high transit ridership"* and CB2 *"Aligns with the City's Vision and policy direction as articulated in the City's Development Plan, OurWinnipeg, the supporting direction strategies, and secondary plans"* dropped slightly in importance to allow the increase of CB3 and CB4.
- **Cost:** CE1 *"Minimizes construction and other capital costs, such as land acquisition"* and CE2 *"Right-of-Way Requirements and Convertability"* increased slightly in importance. CE3 *"Optimizes financial feasibility"* and CE4 *"Minimizes system operating and maintenance costs"* dropped slightly in equal importance to allow the increase to occur.
- **Social Equity:** a significant drop in importance in SE1 *"Improves transit access for under-represented populations particularly to provide improved access to jobs and services"* have allowed for slight increases in importance in SE3 *"Supports and complements reinvestment strategies that mitigate displacement, access and affordability challenges"*, SE4 *"Minimizes construction-related impacts*

to neighbouring businesses" and SE5 *"Minimizes construction-related impacts to neighbouring residences"*. SE2 *"Improves transit access in neighbourhoods that are currently not well-served by transit"* remained unchanged.

- **Environmental Impacts:** a significant drop in importance in EI1 *"Reduces greenhouse gas emissions"* allowed for a significant increase in importance in EI2 *"Minimizes risk of significant impacts to environmental resources"*.

All of the adjustments were a maximum of two positions on the scale.

Proposed Criteria Weighting

The revised criteria weighting is provided in full in Appendix A.

Weighting of Evaluation Criteria –Overview

The primary functions of transportation investments are to connect places and serve users; without these elements, funding the proposed improvement is difficult to justify. Cost and Performance are fundamental aspects of a worthwhile and effective transportation program. As such, the categories of Connectivity and Performance are weighted much more heavily, at 33% each than the other factors of City Building (15%), Cost (10%), Social Equity (5%) and Environmental Impacts (4%) for the evaluation of alternatives for the proposed Eastern Corridor BRT system. The rationale for this weighting is explained below:

Connectivity and performance are critical elements required for a successful transit system. These two factors are key determinants of ridership, which is typically one of the most significant measures of success for transit systems. Without good connectivity and performance, the investment in transit infrastructure will not be worthwhile.

What is Connectivity and why does it matter? Connectivity measures the ease with which people can get from origin to destination easily, directly and with few transfers or change of travel mode. For transit, being able to get to the desired destinations, without extensive walking and/or transfers, is a significant determinant in generating ridership.

What is Performance and why does it matter? Transit system performance is typically evaluated based on several factors, including reliability (Does the bus arrive on schedule?), service frequency (How long do I have to wait for a bus?), travel time (How long will it take me to get to my destination? Is it a lot longer than driving a car?), safety, and clean and courteous service. Each of these sub-areas of performance will impact ridership and the overall success of a transit system.

Consideration of other evaluation factors:

City Building: By its very nature, the presence of a successful transit system will re-invigorate the neighborhoods that are served by that system. As such, it is important to consider the location and impact potential for each alternative but again, the transit system must be successful to stimulate city building, which circles back to the importance of system Connectivity and Performance.

Cost: Cost and being cost-effective are always important considerations, including operating costs as well as capital costs associated with construction. Financial investments will also be viewed through the lens of the transit system and its effectiveness as a travel mode, which again relates to Connectivity and Performances.

Social Equity: If a transit alignment alternative provides good Connectivity and Performance, it will also address Social Equity concerns, since disadvantaged groups are key components within a transit market. Although Social Equity is interrelated to the primary factors for a successful transit system, it is included as a separate factor to ensure and document that specific, identified Social Equity concerns are addressed.

Environmental Impacts: By its very nature, an effective transit system will fundamentally transform the development pattern along the transit corridor, reducing the need for auto travel and improving sustainability and resiliency. Although effective transit will reduce automobile use, this benefit is often not well-captured by an assessment of environmental impacts, which are typically more effective in assessing environmental impacts associated with roadway projects (i.e., impacts to right-of-way, environmentally sensitive areas, etc.). As such, although it is recognized as an important criterion, it is not assigned a high relative weight.

Next Steps

EPC review and endorsement of the criteria and proposed weighting.

Eastern Corridor Study

Connectivity (28%)
Connects people and places with a variety of viable transportation options (transit, bicycle, walk, and automobile).

- Provides transit system connections to the existing transit system, including bus routes, transit transfer centres, park-and-ride lots, etc. and future planned transitways. (16%)
- Eliminate gaps in the pedestrian and cycling network. (8%)
- Facilitates connections to rapid transit stations / alignment using pedestrian and cycling facilities. (27%)
- Minimizes physical barriers to connectivity (i.e., street crossings, roads, rivers, etc.). (49%)

Performance (28%)
Increases transit and active ridership by developing a modern, high-quality, reliable rapid transit system that mitigates impacts on other modes.

- Optimizes transit ridership and meets transit demand. (49%)
- Reduces transit travel times. (22%)
- Improves transit system reliability (on-time performance). (22%)
- Mitigates negative impacts on the City's transportation network. (7%)

City Building (18%)
Helps build and re-invigorate neighborhoods and enhance livability by building complete communities.

- Optimizes and strengthens connections between and within neighbourhoods, and to frequently accessed destinations, community assets and places that generate (or are expected to generate) high transit ridership. (31%)
- Aligns with the City's vision and policy direction as articulated in the City's development plan, OurWinnipeg, the supporting direction strategies, and secondary plans. (43%)
- Supports community improvement and economic growth by encouraging infill developments of underutilized land, and creating opportunities in areas anticipated to experience growth and change. (13%)
- Optimizes placemaking opportunities, creating dynamic, high-quality places and spaces that leverage local assets, creativity and vision to enhance community vitality, quality of life, happiness and well-being. (13%)

Cost (13%)
Affordable to build, maintain and operate.

- Minimizes construction and other capital costs, such as land acquisition, etc. (22%)
- Right-of-Way requirements and convertibility to LRT. (12%)
- Optimizes financial feasibility. (33%)
- Minimizes system operating and maintenance costs. (33%)

Social Equity (7%)
Supports equitable access to housing, employment and other destinations regardless of income, household type, ability, age, etc.

- Improves transit access for under-represented populations particularly to provide improved access to jobs and services. (41%)
- Improves transit access in neighbourhoods that are currently not well-served by transit. (27%)
- Supports and complements reinvestment strategies that mitigate displacement, access and affordability challenges. (19%)
- Minimizes construction-related impacts to neighbouring residences. (8%)
- Minimizes construction-related impacts to neighbouring businesses. (5%)

Environmental Impacts (6%)
Minimizes impacts on climate, air, water and the surrounding community.

- Reduces greenhouse gas emissions. (75%)
- Minimizes risk of significant impacts to environmental resources (wetlands, waterways, historic facilities, hazardous sites, etc.). (25%)

APPENDIX B

November 2017 Workshops – Criteria Input

Six drop-in workshops were held from November 27 – 30, 2017. At these workshops, the public had an opportunity to learn about the study, provide input, and share their ideas. The **Criteria Station** provided an opportunity for the public to see the recommended criteria and weighting and provide feedback on the weighting. Approximately 230 people attended the workshops.

A digital workshop was launched on November 15, 2017 and was available online until December 15, 2017. The online **Criteria Activity** provided an opportunity for the public to complete a Criteria Workbook survey where they could see the recommended criteria and provide feedback on the weighting. Eleven surveys were completed online as of December 7, 2017.

Participants at the workshops and online were asked to provide input on whether they **agree** or **disagree** with the criteria weightings. If they disagreed, they were asked to indicate whether the weighting should be **higher** or **lower** than proposed.

Below is a summary of the input received both in-person and online. Note: These numbers do not represent a statistically significant sample.

Do you agree with how the criteria categories have been weighted?						
Category	**Connectivity**	**Performance**	**City Building**	**Cost**	**Social Equity**	**Environmental**
Weighting	**33%**	**33%**	**15%**	**10%**	**5%**	**4%**
Agree	19	17	14	19	20	17
Disagree	9	7	9	4	3	3
Higher	1	2	3	5	4	8
No Change	8	6	8	7	10	7
Lower	6	7	4	3	1	0

Generally, participants indicated support for the proposed criteria and weighting. Some participants suggested that cost and environmental impacts should be weighted higher

Connectivity	Provides transit system connections to the existing transit system, including bus routes, transit transfer centres, park-and-ride lots, etc. and future planned transitways.	Eliminate gaps in the pedestrian and cycling network.	Facilitates connections to rapid transit stations / alignment using pedestrian and cycling facilities.	Minimizes physical barriers to connectivity (i.e., street crossings, roads, rivers, etc.).
Weighting	18%	5%	27%	50%
Agree	31	18	20	23
Disagree	4	8	7	3
Higher	12	7	5	1
No Change	4	9	5	5
Lower	0	0	6	10

Generally, participants indicated support for the proposed criteria and weighting. Some participants suggested transit connectivity should be increased as the study should prioritize transit infrastructure, while others indicated that pedestrian and cycling connectivity is equally important.

Performance	Optimizes transit ridership and meets transit demand.	Reduces transit travel times.	Improves transit system reliability (on-time performance).	Mitigates negative impacts on the City's transportation network.
Weighting	50%	22%	22%	6%
Agree	20	23	27	12
Disagree	3	1	1	5
Higher	3	7	7	4
No Change	2	2	3	4
Lower	6	2	1	3

Generally, participants indicated support for the proposed criteria and weighting. Some participants suggested that transit performance should be considered higher than vehicle performance. Some suggested that transit corridors should be separated from other traffic and street crossings for optimal performance.

City Building	Optimizes and strengthens connections between and within neighbourhoods, and to frequently accessed destinations, community assets and places that generate (or are expected to generate) high transit ridership.	Aligns with the City's vision and policy direction as articulated in the City's development plan, *OurWinnipeg*, the supporting direction strategies, and secondary plans.	Supports community improvement and economic growth by encouraging infill developments of underutilized land, and creating opportunities in areas anticipated to experience growth and change.	Optimizes placemaking opportunities, creating dynamic, high-quality places and spaces that leverage local assets, creativity and vision to enhance community vitality, quality of life, happiness and well-being.
Weighting	35%	45%	10%	10%
Agree	19	11	15	11
Disagree	3	7	5	1
Higher	3	0	5	3
No Change	3	1	3	4
Lower	2	7	0	1

Generally, participants indicated support for the proposed criteria and weighting. Some participants suggested prioritizing infill and higher densities near transit and stations.

Cost	Minimizes construction and other capital costs, such as land acquisition, etc.	Right-of-Way requirements and convertibility to LRT.	Optimizes financial feasibility.	Minimizes system operating and maintenance costs.
Weighting	18%	10%	36%	36%
Agree	17	13	12	18
Disagree	4	1	2	1
Higher	4	6	0	2
No Change	3	2	2	0
Lower	1	0	6	6

Generally, participants indicated support for the proposed criteria and weighting, with a few comments about mitigating fuel costs in the future and considering LRT over BRT.

Social Equity	Improves transit access for under-represented populations particularly to provide improved access to jobs and services.	Improves transit access in neighbourhoods that are currently not well-served by transit.	Supports and complements reinvestment strategies that mitigate displacement, access and affordability challenges.	Minimizes construction-related impacts to neighbouring residences.	Minimizes construction-related impacts to neighbouring businesses.
Weighting	48%	27%	16%	6%	3%
Agree	18	18	11	10	12
Disagree	0	0	1	1	2
Higher	1	3	4	1	1
No Change	3	3	3	6	7
Lower	4	2	1	1	0

Generally, participants indicated support for the proposed criteria and weighting. Some participants suggested that prioritizing access in area with higher densities is more important than trying to provide more coverage to all neighbourhoods.

Environmental Impacts	Reduces greenhouse gas emissions.	Minimizes risk of significant impacts to environmental resources (wetlands, waterways, historic facilities, hazardous sites, etc.).
Weighting	83%	17%
Agree	24	15
Disagree	3	5
Higher	0	6
No Change	2	2
Lower	6	0

Generally, participants indicated support for the proposed criteria and weighting. Some participants suggested the use of electric vehicles, and to increase the weighting to environmental resource impacts criteria.