Seamless Seattle

June 2019

Seattle Wayfinding Digital Strategy

Seattle
Department of
Transportation

Seamless Seattle

This document is a part of a wider suite that has been produced as part of the development of Seamless Seattle, a pedestrian wayfinding system for the City of Seattle.

The system is being planned for wider roll-out but is initially being implemented in two downtown pilot areas at Jackson and at Westlake in late 2019.

This suite of documents captures the strategic recommendations, standards and guidance produced in order to guide the pilot implementation and support wider implementation.

Though the documents can be read individually, it is recommended that the suite is read in its entirety to benefit from a thorough understanding of the thinking and process behind the development of the project. The key documents cover the system-wide approach and recommendations while the supporting documents focus on the detailed application within the pilot areas.

The project is being delivered by a specialist wayfinding consultant team led by Applied Wayfinding with Alta Planning + Design providing local planning and design expertise, and 3 Square Blocks who specialize in engaging communities in public planning projects.
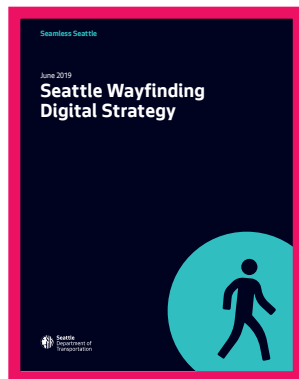
Key documents

Strategy

Summary of strategic recommendations and planning standards. Includes:

– Principles
– User scenarios
– Asset selection
– Naming
– Routing & placement
– Sign typology

Digital Strategy

Recommendations for the approach to using digital tools to deliver, manage and maintain the system beyond the pilot phase. Includes:

– Open Wayfinding Platform
– Implementation Plan
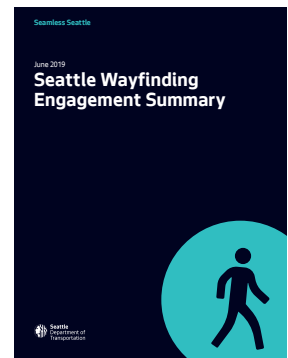– Accessibility initiatives

This document

Visual Design Standards

Design specification for the pilot elements. Includes:

– System Identity
– Sign Information Design
– Map Design
– Product Design
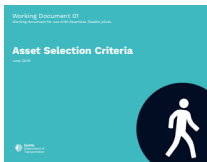– Design Intent Drawings

Engagement Summary

Summary of stakeholder and public engagement that shaped the strategy and design of the pilot program, including:

– Engagement methods
– Participants and organizations consulted
– Feedback gathered
– Full record of meetings

Supporting documents

01 Asset Selection Criteria

Explains the criteria used to determine the inclusion of assets in mapping and directional content. Includes:

– Categorization of assets
– Illustrated assets
– Master list of assets for inclusion

02 Sign Content Rational

Explains how assets identified in the Asset Selection Criteria should be applied to directional content. Includes:

– Guidance on prioritizing content
– Sign addressing
– Use of icons

03 Sign Placement and Clutter Reduction

Summary of the steps required to determine sign placement and identify street furniture for removal. Includes:
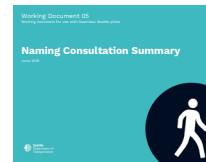
– Guidance on developing a Priority Route Network
– Overview of sign types
– Sign placement rules
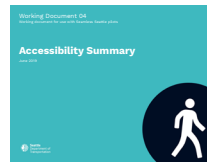
04 Accessibility Summary

Overview of the accessible components of the wayfinding system Includes:

– Map content
– Use of Braille and tactile
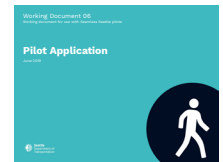– Future opportunities

05 Naming Consultation Summary

Summary of the Westlake and Jackson Pilot naming consultations. Includes:

– Neighborhood naming
– District naming
– Naming maps

06 Pilot Application

Summary of the pilot schemes to be implemented in Jackson Street and Westlake. Includes:

– Sign placement plans & quantities
– Detailed sign locations
– Sign content schedules

Contents

The following document recommends a set of approachs to using digital tools to deliver, manage and maintain the wayfinding system beyond the pilot phase.

It also recommends a set of accessibility initiatives within the digital realm that would help wayfinding in Seattle.

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wayfinding

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PLANNING + DESIGN

3 SQUARE BLOCKS

Introduction

Purpose of Document

The Seamless Seattle Digital Strategy forms part of the wider Seamless Seattle wayfinding strategy, and presents opportunities for digital as a tool to help achieve the City's wayfinding goals. The document makes two core recommendations for consideration to align with the City's goals of creating better, more accessible, wayfinding information for Seattle. This document should be read in conjunction with the Seamless Seattle Wayfinding Strategy and Pilot Phase Visual Design Standards.

Background

Digital is a fast changing industry. Cutting edge technologies can become obsolete in a short period of time.

When discussing digital innovation opportunities, one usually jumps to the end-user applications. For wayfinding, this may mean applications for personal digital devices such as smartphones, on-street information delivery systems, or the support of personal technology for specific use cases such as accessibility.

Recommendation One — Open Wayfinding Platform

The first core recommendation of this document is a focus on creating a robust digital infrastructure for the management of wayfinding data and the production of wayfinding applications. Not only will applications built by the City and its partners benefit from such infrastructure, but it will also be readily available for use by third parties. We're calling it the **Open Wayfinding Platform**.

The Open Wayfinding Platform ensures consistency of both data and core visual design, creating a coherent image of the City regardless of the end-user touchpoint or who it is developed by—a common wayfinding-language for everyone to speak. This ensures accuracy of Seattle's Wayfinding information, and allows third parties to focus on their own innovations.

The Open Wayfinding Platform is an open data project very much in the spirit of Seattle's technological roots and reputation, and it will benefit Seattle's residents and visitors alike. The conceptual model of the Open Wayfinding Platform is explained on the following pages, and discussed in further detail in the implementation plan.

Recommendation Two — Accessibility Initiatives

Digital wayfinding services have vastly improved in the last decade, mostly driven by tech companies in the private sector. However, these tech companies, despite their might, are often limited on two aspects: city-wide access to the built environment, and the pursuit of public-minded projects that are valuable but not profitable. A good example of this are applications and system infrastructure on accessibility.

As a public organization, the City of Seattle assumes certain responsibilities for city wayfinding to be inclusive and accessible. In this context, selective investments aligned with the Seamless Seattle wayfinding strategy should aim to fill the market-failure gap on accessibility initiatives.

Based on this rationale, the second core recommendation in this document outlines potential Accessibility Initiatives, such as voice-assisted street signs for the City to develop.

1   Background

1   Background

1.1   Common Problems of City Wayfinding

Without exception and regardless of size, most modern cities face common problems with regard to city wayfinding. Diverse authorities, ranging from city, boroughs, local attractions, and property owners, design and implement their own separate wayfinding systems in their pockets of jurisdiction. This, for the user, results in:

– Inconsistent units (i.e. distance displayed in blocks, yards, or minutes)

– Inconsistent visual languages (i.e. color schemes, iconography etc.)

– Inconsistent hierarchy (i.e. landmarks, routes of importance etc.)

– Inconsistent naming (i.e. place and boundaries)

– Inconsistent priorities (i.e. accessibility, tourism etc.)

All these combined, create confusion and inaccessibility across the City, leaving a bad experience for residents and visitors alike. When produced as touchpoints, these different approaches also compete for space and attention; creating visual, physical, and content clutter.

1.2   Current Landscape of Digital Wayfinding

Like most industries, developments in new technology have sparked numerous innovations and initiatives in wayfinding. In general, these efforts can be summed up as the following:

Mostly User-side Applications
The vast majority of the new innovations are focused on user-side applications—most notably digital maps and location based services.

Evolving at Fast Speed
Like any other tech sector, these applications are evolving quickly and globally.

Unreliable Data
Data driving these initiatives is often patchy, incorrect, and inconsistent. This is due to the nature of wayfinding management where data sources come from a multitude of sources.

Lack of Public-minded Evaluation
There is very little meaningful evaluation on the new digital initiatives—return on investment, public benefits, or sustainability. The majority of evaluation is for corporate valuation or revenue.

Lack of Management Systems
Off-the-shelf Sign Management Systems currently do not provide comprehensive management of city-scale wayfinding systems. Certain systems do not account for the practicalities of sign production, some have limited capabilities of managing content, and some are task-oriented, hence focus on just one or two aspects of a wayfinding system.

Static analog signs will always have their merit due to their accessibility and ease of use. Approximately 19% of all Americans and 33% of who are 50 or older did not own smartphones in 2018*.

Nevertheless, it is evident that digital tools have a growing role to play in wayfinding beyond user-side applications.

*Smartphone ownership in advanced economies
https://www.pewresearch.org/global/2019/02/05/smartphone-ownership-is-growing-rapidly-around-the-world-but-not-always-equally/

1.3   Seattle's Direction

Below are some of the goals, initiatives and programs in Seattle that are pertinent to this document.

Move Seattle
As a 10-year (2015-2024) strategic vision for SDOT, Move Seattle sets out to achieve the following:

–   Modal integration and interconnectedness

–   Data driven decisions

–   User-centric travel options

–   Openness towards third parties

–   Advancement of technology in transit

Intelligent Transportation System Strategic Plan
SDOT's Intelligent Transportation Systems (ITS) Strategic Plan, sets out to enhance mobility for all modes by employing electronics and communication technologies. This includes:

–   (Develop) future unidentified systems and services

–   Expand pedestrian and bike services

–   Enhance Traveler's information website

Seattle IT's Success Indicators
According to 2018 Open Data Plan, Seattle IT's success indicators are the following:

–   Centralized workflow

–   Automated publishing

–   Work with internal & external third party

–   Support real-time data flows

–   Support Smart City efforts

Open Data programs
Seattle, King County, Sound Transit and King County Metro all run Open Data programs with similar goals — managed datasets to work across platforms for better wayfinding. The City of Seattle in particular, has been ranked sixth in the US for Open Data by the Code for America Open Data Census; and was also awarded Citizen Engagement Project of the Year by the Governing Institute.

Access to Open Data
Data collection efforts are undertaken by Seattle GIS Open Data Portal, King County GIS Open Data, Sound Transit, local initiatives, and Puget Sound Regional Council.

We have learned that the these portals and programs provide a variety of options for accessing data related to transportation, business, land, safety among others.

Signing into the portal with a Socrata or Seattle ID provides additional datasets or options. Furthermore, data is also available through an ArcGIS platform. The data available on these sites is available for free download. In addition to individual datasets, the City has also made available several predefined digital maps.

Data
SDOT has several data systems that serve as the systems of record. Below are the 3 main ones:

Hansen 8/Infor
–   Main data repository for Asset Management and Work Management

–   Most data is joined with GIS spatial data and available as GIS datasets

–   Able to export to Open Data Program, but is not connected per se

–   Infor has since updated it program to 'Infor CloudSuite Public Sector'

GIS
–   Main data repository for Spatial Data

–   ESRI-based technology

–   Most SDOT GIS datasets are available through the Open Data Program

Accela
–   Main data repository for Permit Data

–   SDOT is currently converting all permit data from the Hansen 7 system into Accela

–   Most data is joined with GIS spatial data and available as GIS datasets

1.4   Seamless Seattle Wayfinding Strategy

The wider Seamless Seattle Wayfinding Strategy introduces two perspectives of wayfinding—theoretical and user-centric. Digital tools can be utilized to augment and sustain this strategy.

Two Approaches to Wayfinding
The wider Seamless Seattle Wayfinding Strategy introduces two approaches to wayfinding:

> Figure 1 — Elements, Rules, and Applications
> One set of common rules and elements are applied to multiple applications. This ensures consistency for the wayfinding user.

> Figure 2 — User-centric
> A user-centric approach of wayfinding information pieces catering to different needs throughout their journey.
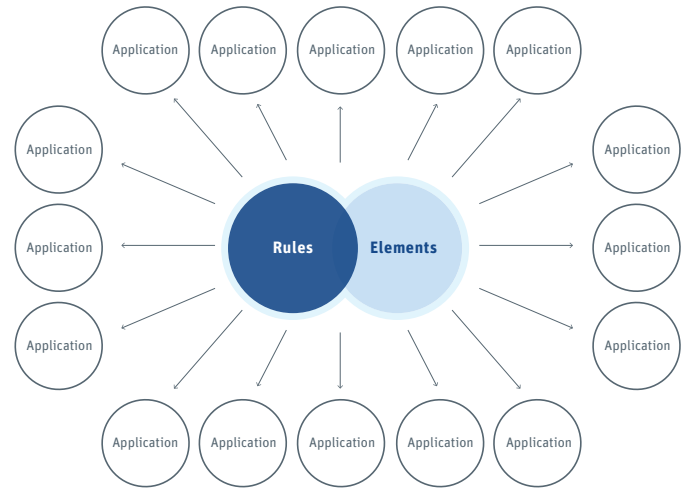
One Philosophy of Seamless Wayfinding
The two models shown above, in essence, are the same. It is a systematic, coherent approach to wayfinding, only shown from different perspectives of theoretical and user-centric view. There is, however, one more perspective that needs to be taken into consideration—the management perspective.

Management Perspective
In order to sustain seamless wayfinding, a systematic approach to management is needed. City officials, transit agency partners, and third party innovators all need a reliable source of data and production methods to sustain a seamless wayfinding system.

Figure 1
Elements, Rules, and Applications[1]
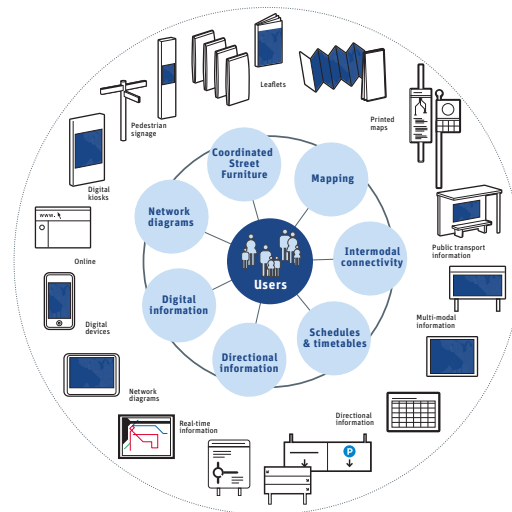
Figure 2
User-centric[2]

1.5   Case Studies

Industry leading wayfinding applications
Industry leading wayfinding applications are Google Maps and Citymapper. They both provide multi-modal journey planning and digital mapping services. Citymapper uses open data, user-generated data, and its own collected data. Google Maps, perhaps one of the most used mobile apps, runs on purchased local map data or leased copyrighted data.

OpenStreetMap is also widely used because of its royalty-free crowdsourced data. It provides service in 93 languages with an open-source journey planning feature.

These industry leading applications, however, are all global projects and thus have an inherent problem with local management and care of data.

This leads to inconsistencies for the user, illustrated in the images on the right:

1. Inconsistent representation of road structure

2. Omission of label 'Bush Hotel'

3. (Google Maps shows this label only at the last level of zoom.)

4. Western half of Hing Hay Park is represented differently

5. Omission of 'Chinese Grand Pavilion' label on Google Maps

6. 'Vital T Leaf' on Google Maps, but 'Vital Tea Lounge' on OpenStreetMap
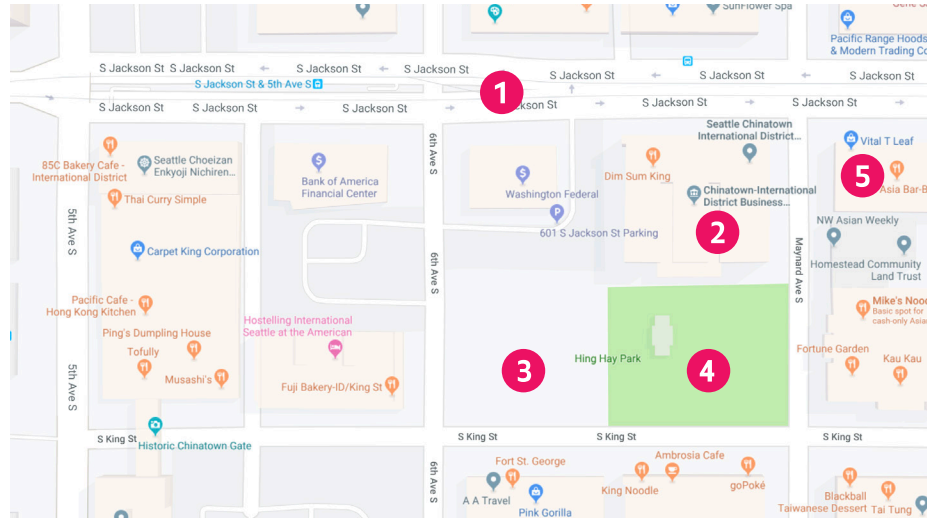
Google Maps' data for the Hing Hay Park area[3]

OpenStreetMap's data for the same area[4]

Integration with Open Data Programs

Third party applications such as Transitscreen* shown above are fed from public open data programs using open standards including GTFS (General Transit Feeds Specification), GTFS-realtime, and GBFS (General Bikeshare Feed Specification).

Although it is too early to determine the efficacy of this particular application, this is a good example of innovative third party activity.

*Transitscreen
https://transitscreen.com/

Transitscreen[5]

New Physical Technologies

New hardware technologies such as e-ink screens are being deployed to assist wayfinding in cities, including Boston*, Singapore, and Sydney. E-ink screens cost less than other screen technologies, use less power, and can be solar powered. Outdoor signs with partial e-ink displays are a useful tool to distill complex information—only displaying what is important to the user at that moment, rather than a full listing.

*MBTA e-Ink Project Page
https://www.mbta.com/projects/solar-powered-e-ink-signs

MBTA e-Ink Project[6]

Accessibility Driven Applications

Accessibility driven applications such as Wayfindr* shown above, use Bluetooth beacons to assist users with audio directions. As well as creating an Open Standard for such protocols, Wayfindr aims to expand into other non-wayfinding environments such as museums where audio guides can be provided with the same set of infrastructure.

*Wayfindr
https://www.wayfindr.net/
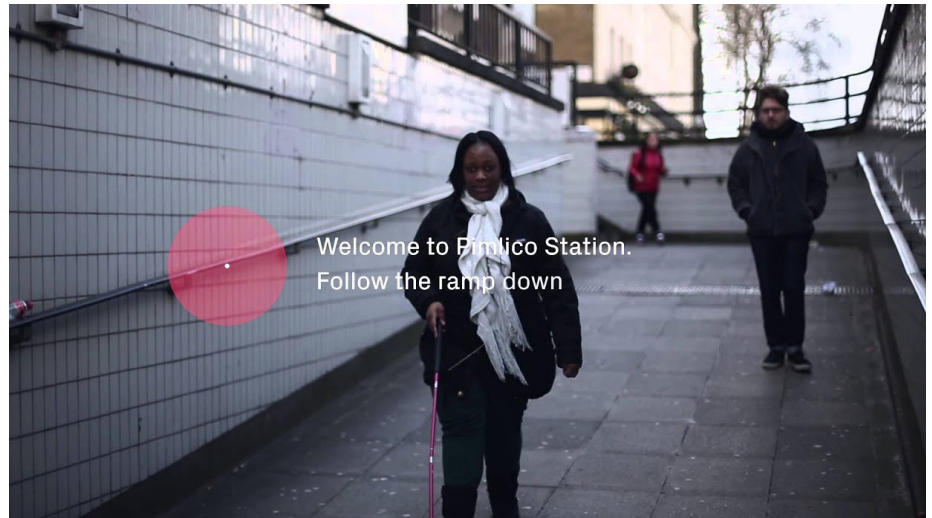
Wayfindr[7]

Curated Content

Although the trend of wayfinding applications is certainly that of an 'open' system — where users query certain variables and the application display solutions based on algorithms — one should not disregard the top-down & curated approach. Go Jauntly* shown above, provides selected walking routes based on themes. (Users can create their own walk routes too.)

This top-down & curated approach is especially pertinent to the public sector, where city governments hold authority on the content they create and provide.

*Go Jauntly
https://www.gojauntly.com/
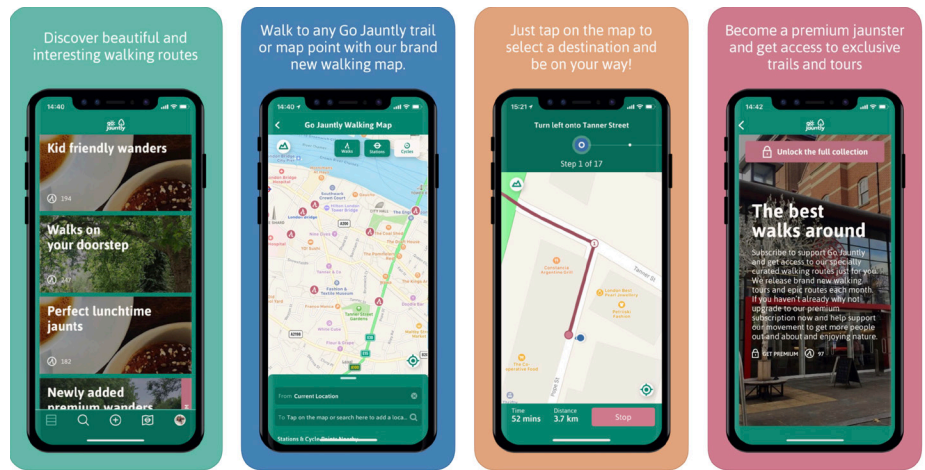
Go Jauntly[8]

On-Street Applications
Best known example of an on-street application is LinkNYC*. With over 900 products serving New York City as a free WiFi spot, its expansive features include:

– High-definition displays
– Android tablet computers
– USB charging
– A phone allowing free calls
– A button to call 911

Passpoint (Hotspot 2.0) which makes LinkNYC work like a cell tower, requiring the user to login only once to the free WiFi.

However, these early attempts are not perfect. Public abuse caused NYC to shut down certain functions of these kiosks, while privacy and security concerns still remain.

*LinkNYC
https://www.link.nyc/

LinkNYC[9]

Open Beacon Network
Amsterdam's Open Beacon Network* invites app developers to explore use-cases for a city-wide beacon network. Currently there are 200 beacons installed on bus and tram stops in the inner city. The project was initiated by Gemeente Amsterdam, Amsterdam Smart City, and Google. It uses the Google Beacon Platform*.

*Amsterdam Open Beacon Network
https://amsterdamsmartcity.com/projects/amsterdam-open-beacon-network

*Google Beacon Platform
https://developers.google.com/beacons/overview
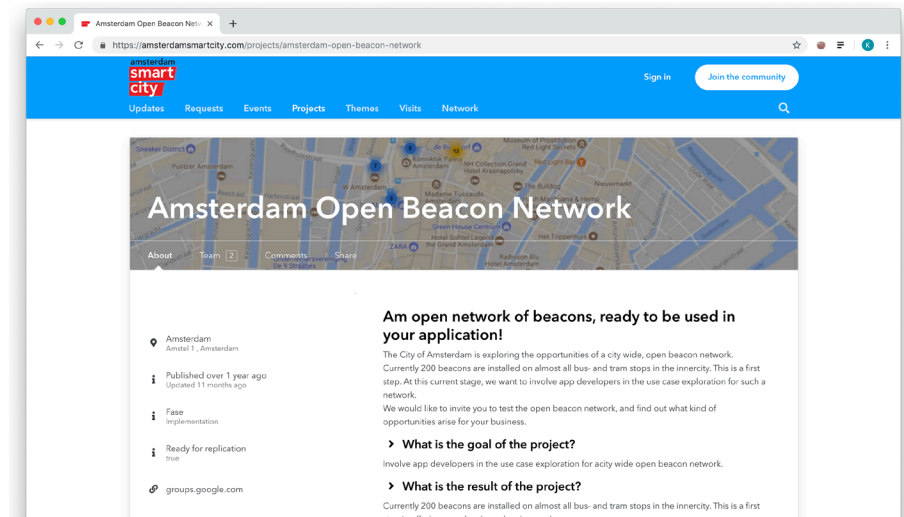
Amsterdam Open Beacon Network[10]

Other Experiments

Hello Lamp Post* is a project where users can 'talk' to street furniture. Using the objects unique asset management code, users can use their phones to text questions to the objects. Its purpose can be used for community engagement, storytelling, and public consultation.

*Hello Lamp Post
https://www.hellolamppost.co.uk

Hello Lamp Post[11]

Advertising & Financing

As technology advances, it does so hand in hand with advertising opportunities. The aforementioned LinkNYC is funded by advertising. Traditional outdoor advertising companies like ClearChannel and JC Decaux* are partnering with communication providers to offer new zero-cost packages in exchange for advertising rights that include WiFi hotspots, digital kiosks, cell integrated furniture for cell relays, and context-driven messages using Bluetooth beacons.

*JC Decaux
https://www.jcdecaux.com/partners/improving-connectivity
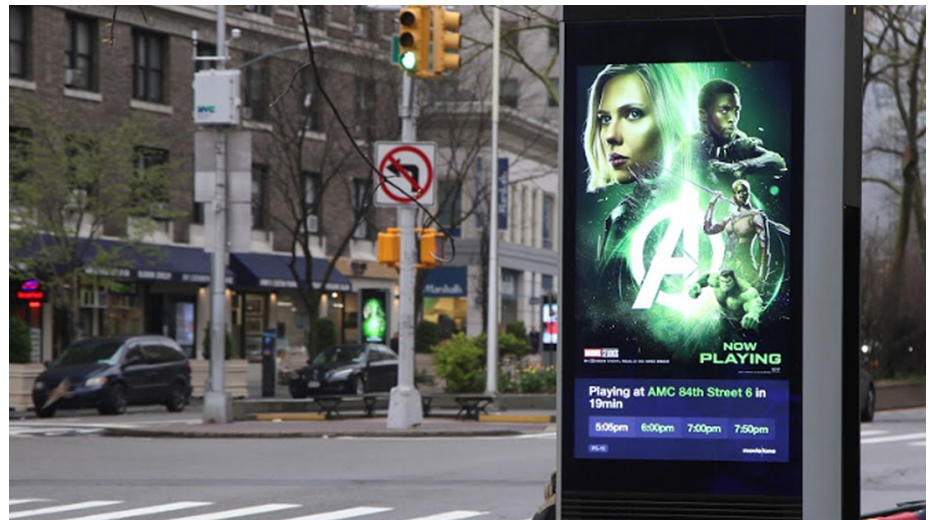
LinkNYC[12]

2   Recommendations

Digital is a fast changing industry. Cutting edge technologies can become obsolete in a short period of time.

When discussing digital innovation opportunities, one usually jumps to end-user applications. For wayfinding, this may mean applications for personal digital devices such as smartphones, on-street information delivery systems, or the support of personal technology for specific use cases such as accessibility.

The private sector has a wealth of companies already targeting end-user applications—from small independent developers creating innovative apps and technologies such as Wayfindr, to the world's largest tech companies producing ubiquitous software such as Google Maps. These companies are better positioned to invest in emerging technologies and absorb the failures along with the successes.

It is recommended that the City does not try to compete with these private sector initiatives, as in-doing-so the City would be left with the maintenance of potentially fleeting technologies, where the uptake of any such applications may struggle against well established rivals.

But if the City were to leave wayfinding to the free market, Seattle would be left with gaps in its system – especially with respect to accessibility and inclusivity – and prevailing inconsistencies in content across different platforms, as highlighted in the previous section. This leads to two core recommendations for digital wayfinding, summarized opposite and explained in further detail in this section.

Recommendation One — Open Wayfinding Platform

The first core recommendation of this document is a focus on creating a robust digital infrastructure for the management of wayfinding data and the production of wayfinding applications. Not only will this platform enable applications to be built by the City and its partners, it will be published as open data for use by third parties. We're calling this infrastructure the Open Wayfinding Platform.

Recommendation Two — Accessibility Initiatives

Increasing accessibility and inclusivity through wayfinding is a key City goal, but are too easily and often neglected by the private sector. As such we have included five ideas for accessibility initiatives – a mixture of wayfinding applications and infrastructure projects – that could help improve accessibility and inclusivity across the City.

2.1   **Open Wayfinding Platform:**
              Overview

Function & Purpose
The core function and purposes of the Open Wayfinding Platform are:

Centralize the management of Seattle's wayfinding content to ensure accuracy and consistency across all city wayfinding applications;

Produce publicly-available middleware that allows third parties to develop digital wayfinding applications using Seattle's centralized wayfinding content

Enable the production of static wayfinding artwork for maps and signs from the centralized content

Benefits
The Open Wayfinding Platform ensures consistency of both data and core visual design, creating a coherent image of the City regardless of the end-user touchpoint or who it is developed by—a common wayfinding language for everyone to speak. This ensures accuracy of Seattle's wayfinding information, and allows third parties to focus on their own innovations.

The Open Wayfinding Platform is an open data project very much in the spirit of Seattle's technological roots and reputation, and it will benefit Seattle's residents and visitors alike. The conceptual model of the Open Wayfinding Platform is explained on the following pages, and discussed in further detail in the implementation plan.

Structure
A simplified structure can be illustrated as the following:
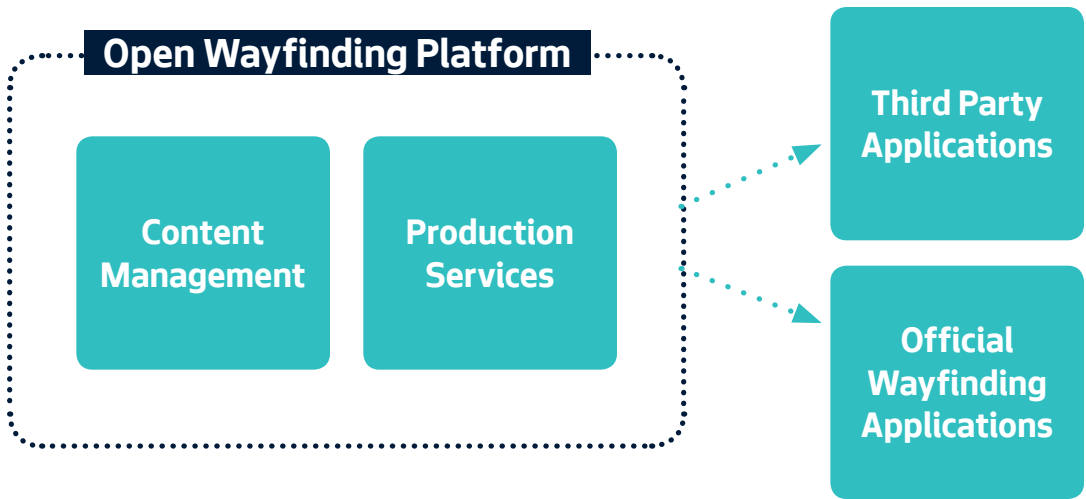
The Open Wayfinding Platform consists of two sections—Content Management and Production Services. A detailed structure can be illustrated as the following:
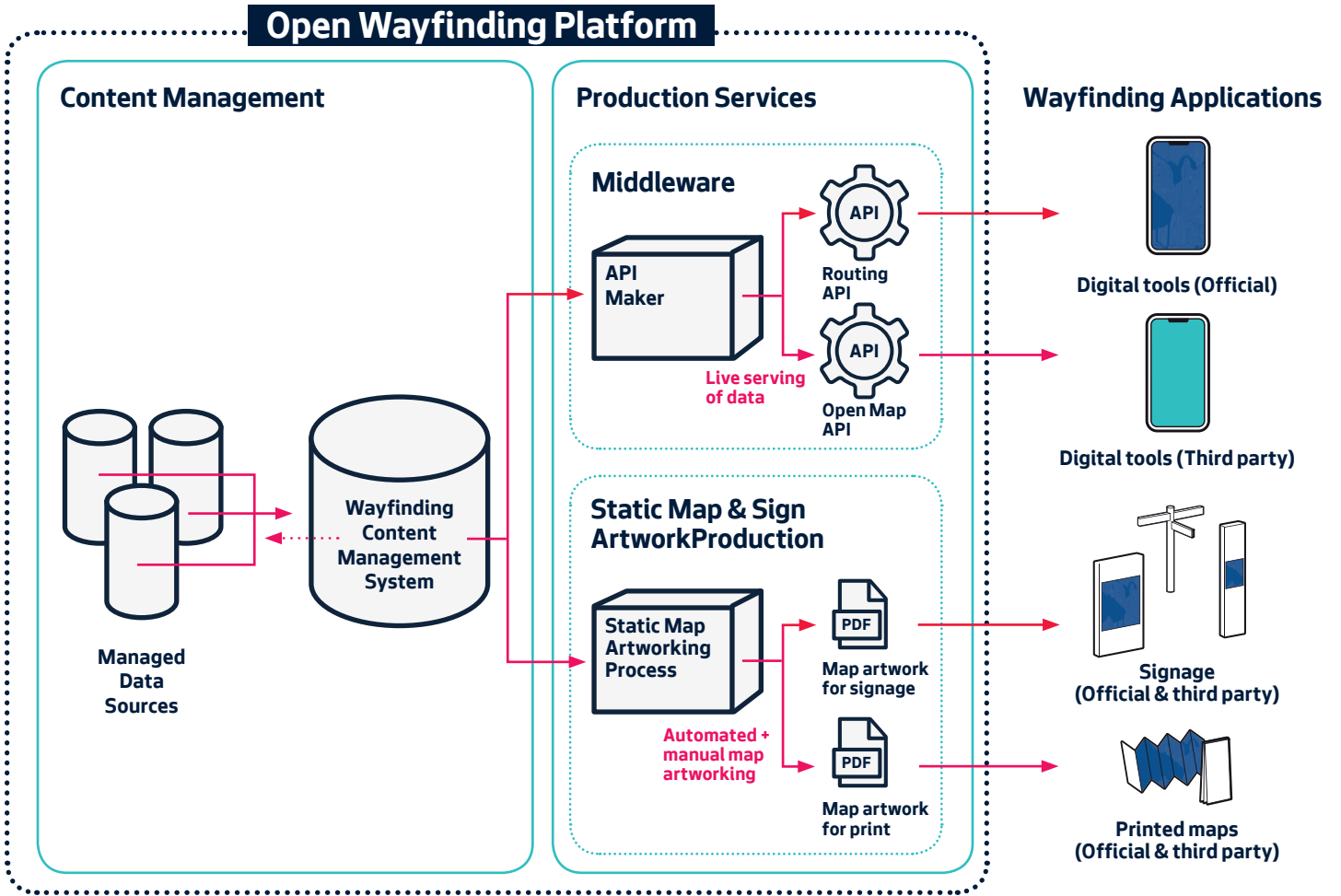
2.1.2 Content Management Overview

Content Management is the key to the success of the Open Wayfinding Platform. Its mission is to gather, verify, and format diverse datasets needed to sustain the platform's backbone. It enables the consistency of wayfinding data across all wayfinding applications, and provides mechanisms to maintain this data accurately and easily. Examples of datasets that can be utilized by the Wayfinding Content Management System include:

–   Seattle's Open Data program

–   Seattle & King County transit agencies' real time data feeds

–   Seamless Seattle's wayfinding enhancements

–   (defined on the following pages)

Wayfinding content is largely defined by the Design Standard, and is mostly map-based, but may include content relating to signage, and non-map-based APIs. While core pieces of data may be required for many of the wayfinding applications, different content is likely to required for the different wayfinding applications.

The Wayfinding Content Management System allows all of this data to be stored in one place, and can filter the content as required to feed the production services of different outputs. It allows data to come from various data sources, and turn it into useful content for wayfinding purposes. Data may need to be added to these managed data sets at source so that it can be translated between systems correctly, and ideally in an automated way.

The Wayfinding Content Management System has the potential to manage more than just wayfinding content, and can be utilized to help run the system. For example, it can be used to keep track of the installed signs within the system, giving them unique identifications and recording their content, electricity/power availability, condition, land owner, and tagging signs for future updates.

Content Management

Managed Data Sources

Wayfinding Content Management System
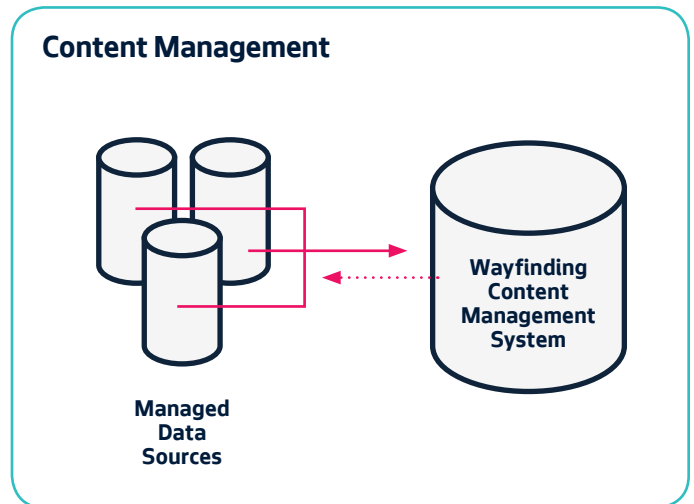
2.1.3   Core Wayfinding Content for Mapping and Signage

There are certain datasets that are essential to build a wayfinding system. The majority of these datasets should be kept and maintained by the City. This is to ensure rigidity and consistency in basic wayfinding content, for digital maps and other forms of information. Some datasets need to be sourced from transit agencies and third parties. The following is a list of these essential datasets.

Paths:
- General road structure shapes
- Road names
- Sidewalk shapes
- Pedestrianized route shape
- Stair locations
- Elevator locations

Edges and Districts:
- General topography shapes
- Administrative boundary shapes
- Colloquial boundary shapes
- Feature based district shapes
  (shopping or finance districts)
- Barrier shapes
- Gradient
- Entrances locations
  (to landmarks and stations)

Nodes and Landmarks:
- General place names or address
- Landmark location and names
- Tourist attraction locations
- Parks and other natural feature locations
- Open public space locations
  (maintained by City & third party)
- Transit station, stop, or hub locations
  (maintained by City & transit agency)
- Toilet locations
  (maintained by City, transit agency & third party)
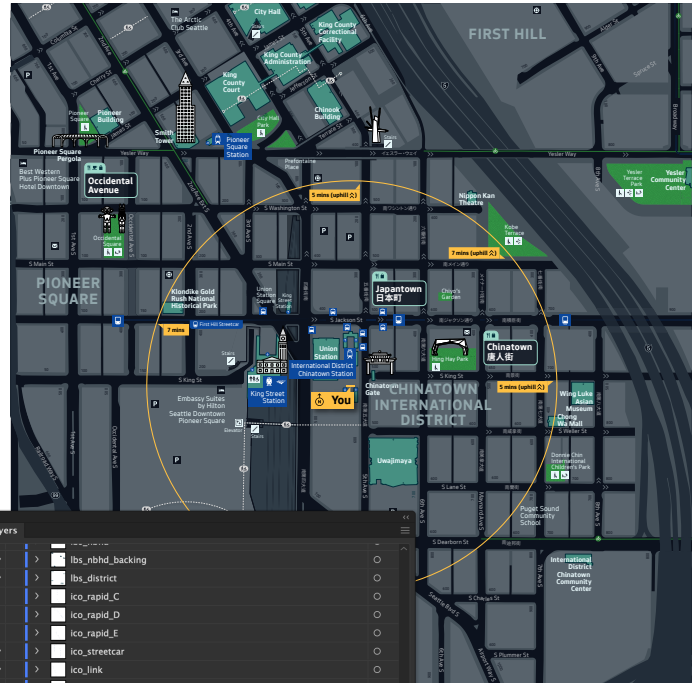
Typical set of data layers involved in creating a user centric map

2.1.4   **Additional Wayfinding Content for Mapping and
Signage**

To enhance the Open Wayfinding Platform, we recommend that the
City coordinate with data stakeholders to connect these following
datasets. Please note that enhancing accessibility and inclusivity does
not come in 'one accessibility dataset'—it can be realized with many
datasets in different areas, from drop curbs to languages.

1. Timely or Temporary Data (disruption or promotion):

>   Major event information
>   Scheduled events that result in diversion or increase in
>   traffic affect routing and trip planning.

>   Construction information
>   Both long term and short term construction result in
>   diversion and inaccessibility for wayfinding.

2. Live Feeds:

>   Real-time information and/or General Transit Feed
>   Specification (GTFS)
>   This will enable the wayfinding user to quickly make
>   decisions based on the information provided, especially at
>   transit facilities.

3. Built Environment Detail:

>   Surface conditions
>   Paved or unpaved conditions can have an influence on
>   users' trip planning, especially for wheelchair users.

>   Lighting
>   Street lighting is relevant to the safety of pedestrians
>   walking at night. Hence this too can affect trip planning
>   for the pedestrian.

4. Other:

>   Different languages
>   Wayfinding content prepared in different languages can
>   be beneficial to non-English speaking users.

2.1.5   Wayfinding Enhancements

As part of Seattle's Open Data program, many cartographic-quality datasets already exist. Additionally, the City maintains other datasets that may be of use to wayfinding. In order to allow these datasets to be used for wayfinding, they may need slight modifications to add additional information or create hierarchies within the data that did not previously exist. We call these Wayfinding Enhancements.

These enhancements may include, but are not limited to:

– Emphasizing landmarks

– Prioritizing routes

– Developing routing algorithms

– Integrating real-time data

– Defining information hierarchy

– Planning progressive disclosure of content

– Defining map scales

– Creating visual identity

– Customizing for different demographics

2.1.6   **Transit Agency Integration**

Partnerships and integration with local transit agencies is imperative to the success of the Open Wayfinding Platform.

User journeys take on multiple modes at a time. These journeys include multiple wayfinding touchpoints that range from analog to digital, from on-street signs to maps on bus shelters, to location based mobile apps.

Therefore, bus shelters, for example, should have identical walking maps as on-street Seamless Seattle signs. Conversely, bus stop location changes (removal or addition) should be reflected on Seamless Seattle pedestrian maps.

Mid-journey modal change is one of the key moments in one's journey which sometimes lead to heightened anxiety due to the level of additional information needed at that time.

Hence, transit facility locations, transit service details including fare payment, and real-time information should all be tightly integrated to the Open Wayfinding Platform. This will ensure all stakeholders to use identical datasets on transit to feed their respective content—whether it's maps on a street-sign or inside a transit facility.
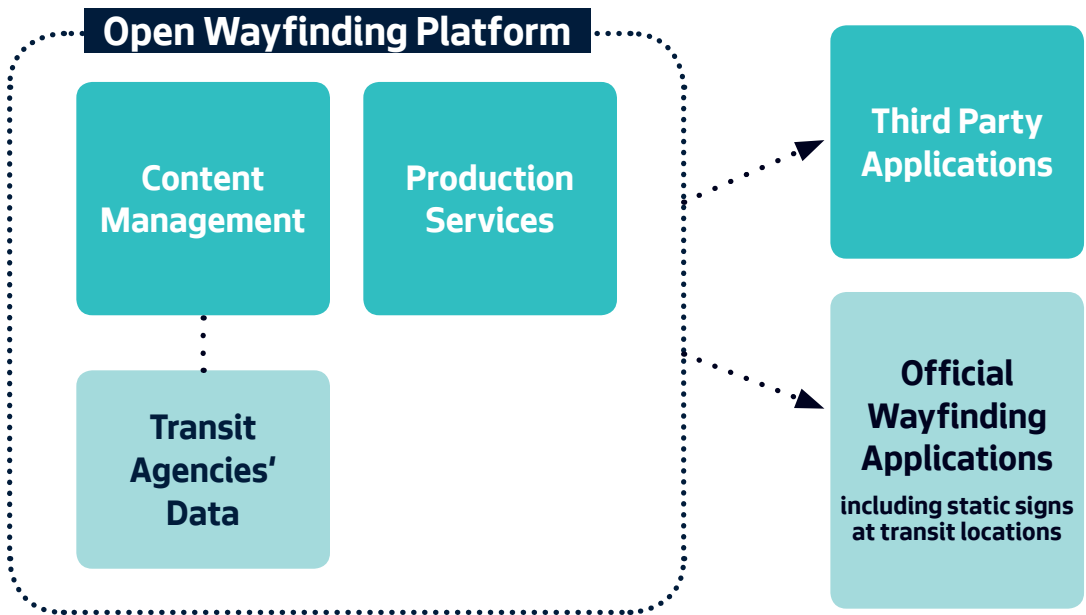
2.1.7   Content Amendment Process

Content changes on a city-scale wayfinding system are inherently difficult to manage, with large areas to cover and diverse stakeholders requesting different changes. This is why a systematic approach to content amendments is recommended. Below are four steps to systematic wayfinding content amendment:

1. Requesting content or wayfinding amendments
An internal manager or stakeholder of the Wayfinding Content Management System should be able to log in, and request amendments. These requests can range from place name changes, wayfinding enhancements, to temporary construction work at a certain location.

2. Stakeholder review
These requests should be circulated to get individual approval from pre-designated, relevant officials across departments and agencies.

3. Amend datasets
If and when an amendment request from the Wayfinding Content Management System is relevant to the underlying dataset, these approved changes should also be automatically updated in said dataset.

4. Ready for publishing
Once approved, new content should be ready to be published from middleware (APIs) and static map & sign artworking.

Content Management System:
Content Amendment Process

1.
Request content amendment

2.
Stakeholders review

Stakeholders' approval

3.
Amend dataset

4.
Ready for publishing

Middleware update

Static map & sign artworking
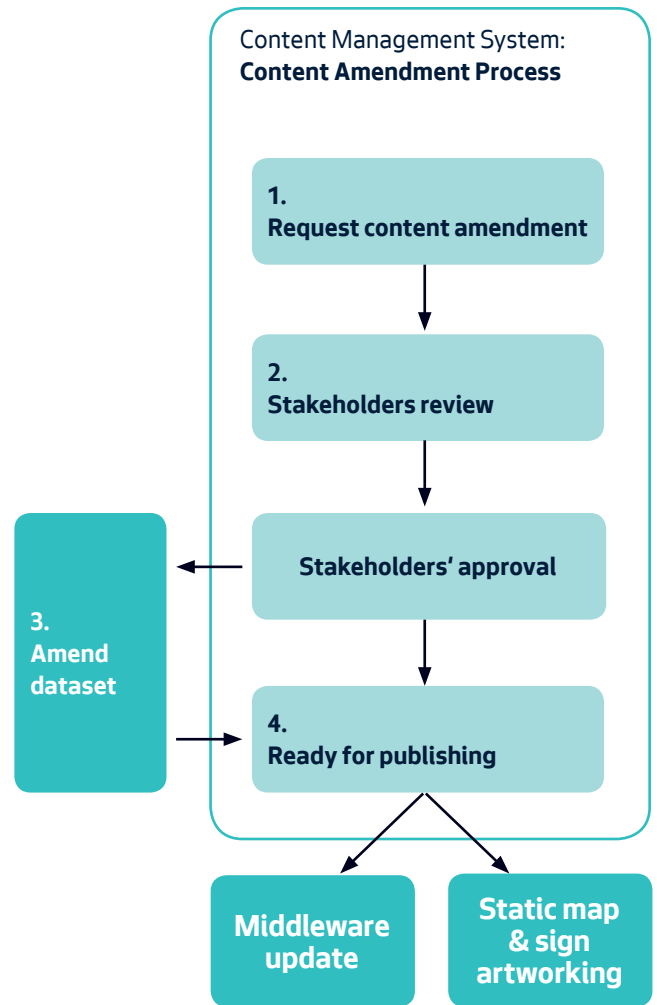
2.1.8   Production Services Overview

Production Services take the wayfinding content from the Wayfinding Content Management System, and turn that data into something usable. We have split the production into two main parts:

–   Middleware – the production of APIs to be published openly, from which third parties can build applications

–   Static Map & Sign Artwork Production – The creation of artwork for use across wayfinding applications such as on-street signage

These production services are described on the following pages.

Production Services

Middleware

API Maker → Live serving of data → API Routing API / API Open Map API

Static Map & Sign ArtworkProduction

Static Map Artworking Process → Automated + manual map artworking → PDF Map artwork for signage / PDF Map artwork for print
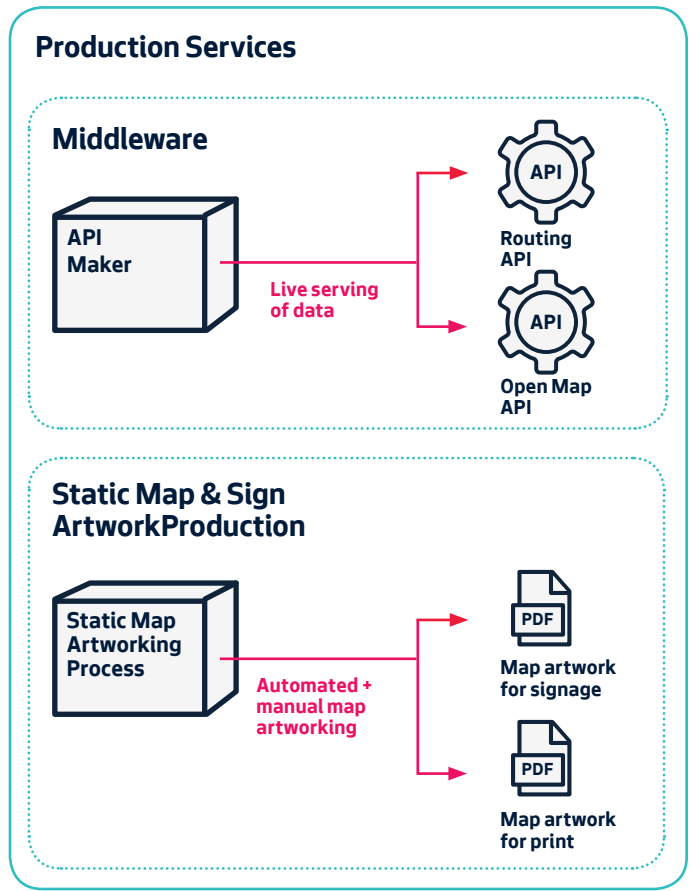
2.1.9   Middleware

Creating middleware is a key component in the digital strategy recommendation. It allows the City to provide accurate wayfinding data to third parties, who can then build useful applications for Seattle's residents and visitors. It will ensure that regardless who builds these applications, there is a common language to the way Seattle is presented, and features consistent and accurate and City-approved content.

APIs are the best method for distributing the wayfinding data to be consumed by digital applications. We envisage these applications to be many and varied and to evolve over time. Initially the wayfinding API can drive City applications. As the API is opened up (and supported) the API can be consumed and used by third-party applications, websites, mobile apps and other digital services that inform and guide the travelling public.

Precedent
Transport for London (TfL) publishes a 'Unified API' [bottom left] which collates live transportation data for all modes in the City, and packages them for third party developers such as CityMapper [bottom right] to build applications from; such as journey planners with real-time information. TfL is essentially solving a public information need without having to build and maintain device specific applications.
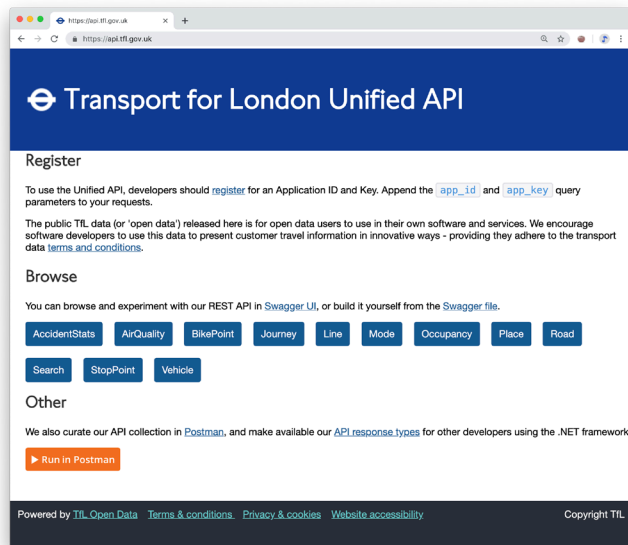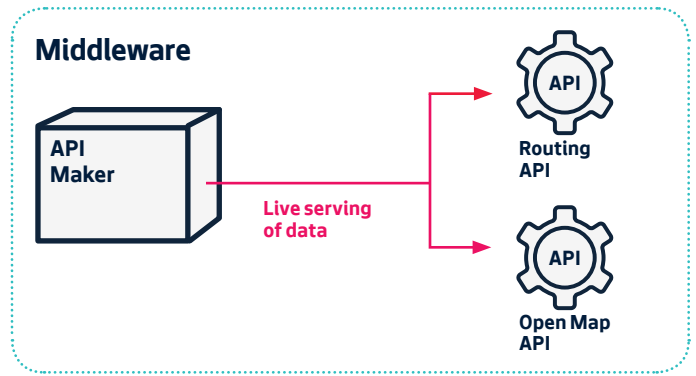
Transport for London's 'Unified API' [13]
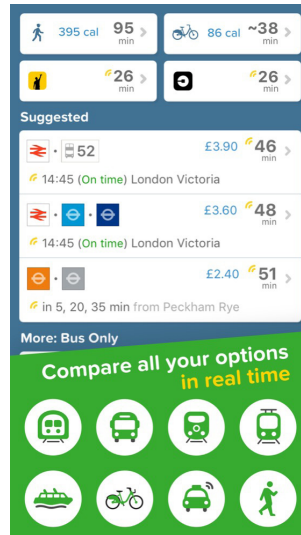
CityMapper's journey planner uses data from TfL's Unified API[14]

2.1.10   **Map & Sign Artwork Production**

The Wayfinding Content Management System includes all content as required by the Seamless Seattle wayfinding system. The artworking process involves selecting the required data for a specific output — be that for a sign directional panel or a map for a print publication — and applying graphic styles to the data to display as intended.

The primary static production service is the mapping, which is the more complex of the artworking tasks (the other being sign artworking). The process of turning wayfinding data into map artwork for use in signage is described on the following page. It can be achieved through a manual or automated process, or a mixture of the two. Each approach has output quality and cost considerations for the short and long term. This relationship is described in further detail on the following pages.

Static Map & Sign ArtworkProduction

Static Map Artworking Process

Automated + manual map artworking

PDF — Map artwork for signage

PDF — Map artwork for print
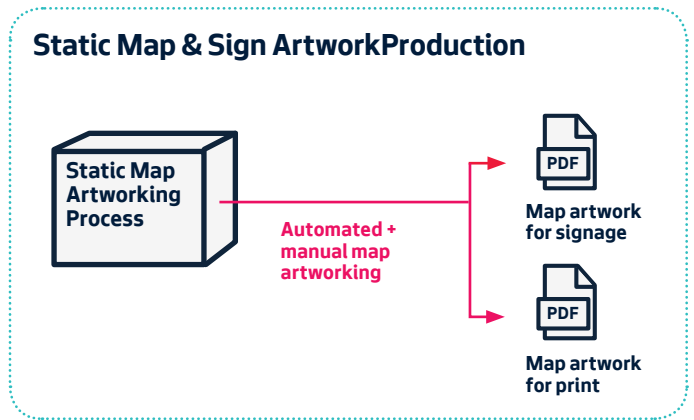
2.1.11   Static Map & Sign Artwork Production Process

The process for creating sign-ready map artwork is detailed here. Investment in an artworking system could yield a largely automated process for achieving the functionality described on this page, though a degree of manual intervention may always be required to achieve the desired design standard. See the following page for more.

1. Data Selection
The system selects the data layers required for the sign-specific map from the Wayfinding Content Management System, according to the content specification in the Seamless Seattle Visual Design Standards (SSVDS).

2. Cartographic Styling
The map is styled in accordance with

the SSVDS.

3. Scale, Crop, Orientation
Based on the specific sign type and its location, the stylized map is scaled, cropped, and rotated.

4. Location-based Content
Location-based graphic elements are added to the map, including:

– You Are Here;

– Walk Circle;

– North Marker.

5. Artworking
Artworking is needed to ensure labels and icons appear as specified in the SSVDS, ensuring their location relates to the topography they are labeling, and they do not clash with other labels and icons. Artworking can be achieved using automated processes with minor manual interventions, or completely manually.

6. Output Map Artwork & Supporting Content
e.g. Legend & Indexes
Finalized map artwork is exported as printable PDFs. Every sign-specific map artwork will require supporting content for legends & indexes.

7. Sign Artworking
Using a sign template of predefined designs and parameters, the exported map and supporting sign content is incorporated. After a check and sign-off process, it is now ready to send out to the sign manufacturer, along with any other sign artwork such as directional information panels.

1. Data Selection
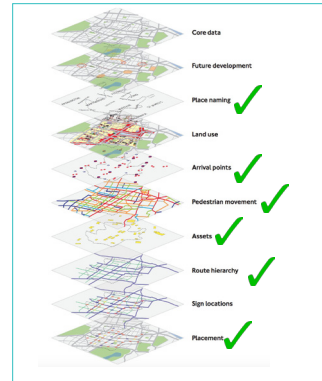
2. Cartographic Styling
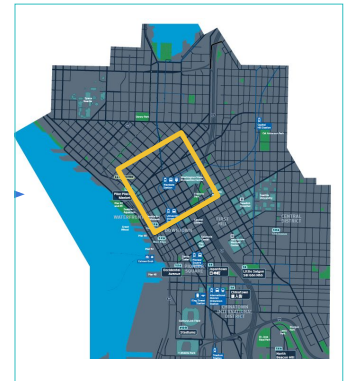
3. Scale, Crop, Orientation
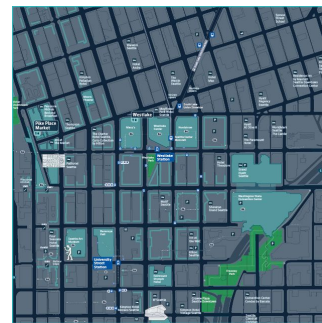
4. Location-based Content
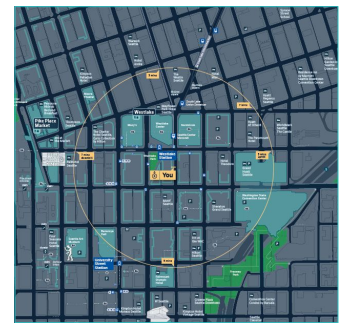
5. Artworking

6. Output
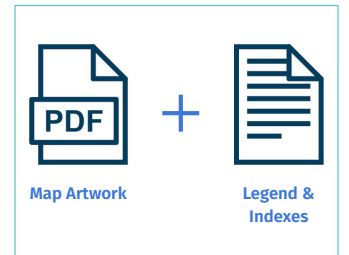
7. Sign Artworking

2.1.12   Quality vs. Automation

With investment in systems and processes, map artwork production can be largely automated and still achieve a high level of cartographic quality in the map artwork. There may always be some degree of manual intervention towards the end of the production process to make final refinements.

Investment in a near-fully automated system may be expensive in the short term, but prove cost effective in the long term. Proprietary systems such as ArcGIS Pro can be modified with scripting to provide further automation than can be achieved using just the provided software. The trade offs are described in the diagram below. If the City wishes to produce map artwork in-house, then it is recommended that work is undertaken to automate certain steps of the process as described on the previous page, particularly steps 1–6, with some added manual intervention at step 5 to ensure the quality of the artwork meets the Seamless Seattle Visual Design Standards.
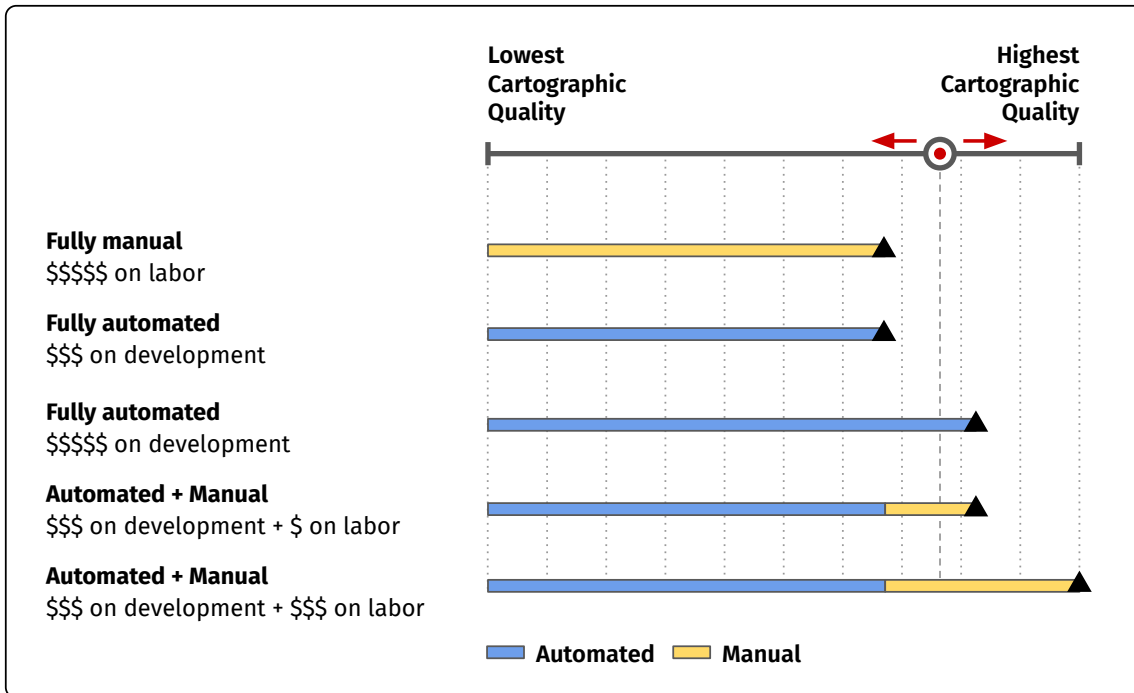
2.2   City-led Accessibility Initiatives

As mentioned, there are diverse private sector applications that focus on innovative methods of digital wayfinding. However, as with other industries, market-driven initiatives overlook certain corners of wayfinding that are not profitable. Accessibility is one of them. This is why there need to be City-led public sector digital accessibility initiatives.

Five Ideas on Accessibility
The following four pages detail five pilot accessibility project ideas within the digital wayfinding scope. They are categorized into three groups (low/medium/high) based on their required financial investment as well as their technical feasibility and efficacy risk. They are:

- Define & Promote 'Primary' Accessible Routes

- Plan for Optical Character Recognition

- Amazon Alexa/Google Voice Assist integration to Seamless Seattle Street Signs

- Location-sounds: Gather City-wide audio clips for the visually impaired

- City-wide Open Beacon Network

2.2.1   **Define & Promote 'Primary' Accessible Routes**
              Low investment & risk

As a principle, all routes in the City should be accessible. However, this is a long-term goal that involves greater investment and planning.

As a short-term measure the following can be initiated:

– Officially defining 'Primary' Accessible Routes & Areas

– Promoting & providing information on accessible routes on the Open Data Program

– Proactively reaching out to major service providers such as Google Maps

– Integrating it with transit agencies' trip planners

These actions can be initiated with relatively little time and investment, but can yield a clear hierarchy of routes based on accessibility.

> NB – Defining 'Accessible'
> Defining what 'accessible' is, and 'who' it is accessible for in the context of wayfinding is a project on its own with wider policy ramifications. There are many criteria to consider, such as:
>
> – Real-time information on hazards, such as street works, damaged sidewalks, etc.
>
> – Curb cuts and tactile paving
>
> – Gradients and cross falls
>
> – Presence or absence of sidewalk
>
> – Crossing point
>
> – Parking
>
> – Washrooms
>
> – Clear width
>
> – Elevators and tunnels (and their operating hours)
>
> – Shuttles
>
> – Lighting

2.2.2 Plan for Optical Character Recognition
Low investment & risk

In the near future, we believe that Optical Character Recognition (OCR) will be more widely used for accessibility. In this scenario, a person with visual impairment would wear a eyeglasses-type device that would 'read out' the signs in front of them via headphones.

In this context, public use of typography in both digital and analog manifestations need to be appropriate for OCR. For example, the differentiation between a 'B' and '13' should be recognized by the OCR system. Color and background should also not hinder the OCR system on its readability.

A City-led study can be commissioned to plan ahead. This study could research the development of OCR specifications, current and future devices, provide typography and color guidelines, and devise user scenarios to utilize OCR technology on a city-scale.

2.2.3   Amazon Alexa/Google voice assist integration to Seamless Seattle Street Signs
Medium investment & risk

Physical street-signs are great location-based opportunities to embed new technologies or devices.

On top of providing static directions and maps to the wayfinding user, the City of Seattle can start a pilot project where it can test out the validity of 'Alexa/Google voice assisted street-signs'.

A select few Seamless Seattle street-signs can be equipped with WiFi, and an embedded version of Alexa/Google voice assist with its microphone and speaker. With necessary modification, it can serve people with location-based content, as well as directional information for the visually impaired. Furthermore, different signs could have different voices in order to distinguish the location, which in turn helps wayfinding.

This would be a comparable approach to human-assisted wayfinding seen in many other cities. For example in Boston, selected Massachusetts Bay Transportation Authority employees are equipped with iPads on key locations to help transit users with any questions they might have.

It will also be a measured approach to on-street digital efforts. These efforts often include large digital screens which is costly, hard to maintain, and vulnerable to harsh weather.

The conversation-data gathered from these signs may be deduced to location-based behavioral insights that the City may use for future wayfinding planning.

Lastly, it could be an equitable approach. Many user cases, such as tourists, especially foreign language speakers and people carrying luggage, can all benefit from a voice assisted street-sign.
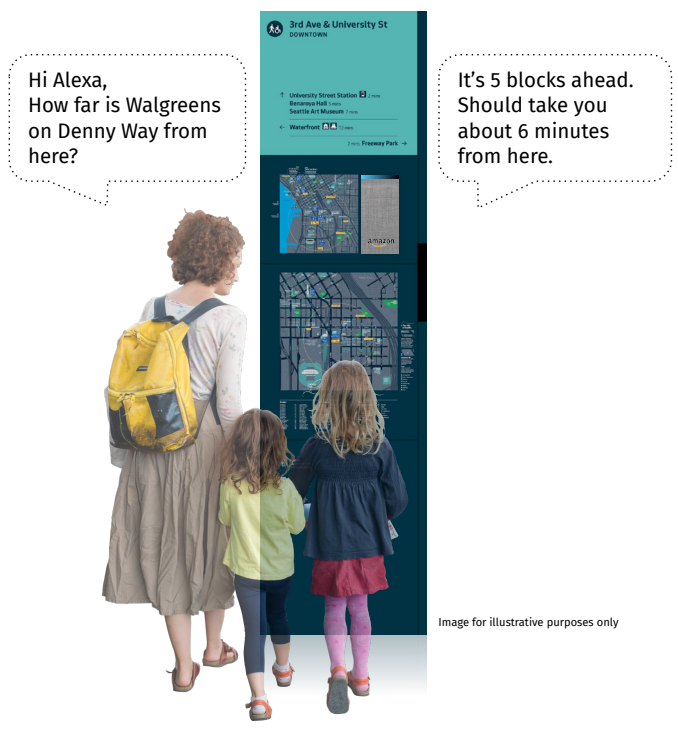
Image for illustrative purposes only

2.2.4   **Location Sounds:**
Gather City-wide audio clips for the visually impaired
High investment & risk

Visually impaired people develop a sharp sense of sound. This sense is used heavily to find their way — they differentiate sounds of different locations based on their general ambience, floor materials, or man-made noises. However these sounds can only be heard on-site.

A public database of location-sounds on key routes, decision points, and destinations can be created and maintained, and be turned into an API. Official and third party wayfinding applications can use this API to aid the visually impaired.

For example, a third party trip planning application can include these location-based audio files in their route directions. The visually impaired user can preview it at home, familiarizing the sound they are about to hear on their way and at the destination.

Location-sounds

Essential datasets for wayfinding such as topography, asset location and place names.
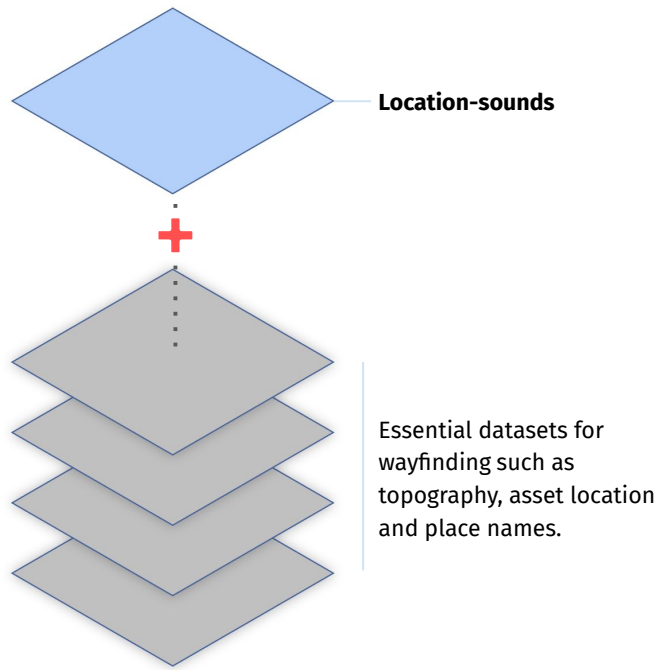
2.2.5   **City-wide Open Beacon Network**
         High investment & risk

The city of Seattle can start an 'Open Beacon Network' infrastructure comparable to that of Amsterdam's efforts.

https://amsterdamsmartcity.com/projects/amsterdam-open-beacon-network

Location-based, information-attached Bluetooth Beacons can be used for a user's accessibility needs, such as:

– Providing information about whether the adjacent location is accessible

– Providing information about whether it provides assistance

– Providing information nearby amenities ,such as accessible toilets or elevators

– Notifying a facility that a wheelchair using person is approaching

Being an 'open' network of beacons, this City-led digital infrastructure will support other uses such as location guides, promotion, or gamification of locations.

3   Implementation Plan

The Implementation Plan focuses on how to create the Open Wayfinding Platform. Conceptually, the Open Wayfinding Platform is simple, but there are many variables to consider when deciding how to build and maintain the platform – particularly whether to do this in-house or outsource all, or parts of, the platform.

Part One of the Implementation Plan tackles the system considerations behind the building and maintenance of the Open Wayfinding Platform, including those relating to:

- Systems – The software/hardware/processes involved

- Roles and responsibilities – Required delivery teams and their tasks. When discussing outsourced processes, we have only listed the roles and responsibilities required of the City in liaising with the external suppliers

- Documentation – Supporting materials to aid delivery

These key considerations apply to the three core processes provided by the platform:

- Wayfinding Content Management System

- Production Services: Middleware

- Production Services: Static Map & Sign Artworking

Because the three core processes are fundamentally different, they require different technologies to deliver them, and are the natural break points for deciding where the platform can be split in terms of in-house or outsourced delivery teams. To investigate these options, this report examines the three core processes if they are provided in-house, or by outsourcing.

While they are discussed separately here, it is possible to devise a platform comprised of a mixture of in-

house and outsourced processes. This places emphasis on the handover of data from the Wayfinding Content Management System separately to Middleware and Static Map & Sign Artworking Production Service systems. These handovers need to be determined with better definition of the delivery teams involved and the systems/technology that will be used.

Part Two of the Implementation Plan outlines a phased process for determining the systems and processes involved with building and maintaining the Open Wayfinding Platform. It highlights development streams from design definition, through prototyping, to implementation and ongoing maintenance.

3.1   System Considerations: In-house

Content Management

The founding principle of the Open Wayfinding Platform is that it centralizes city wayfinding data, ensuring it is up-to-date and accurate, and making that data available for all to create great wayfinding applications for the full range of Seattle's residents and visitors alike.

Keeping this process in-house allows the City to keep control over the most important part of the platform, utilizing its existing skills and softwares to deliver. This is the recommended solution for Content Management.

System
A geodatabase will be required in order to store and manage the data. ESRI's ArcGIS is the market-leading software in this area is, and is also currently used by the City, and therefore recommended. An open source / free alternative is QGIS.

Roles & Responsibilities
   Wayfinding Data Manager
   Wayfinding data needs to be managed centrally. This could be the responsibility of an existing role or a new position depending on existing capacity. This role is however the only way in-house to ensure consistency and accuracy of the wayfinding data moving forward.

   Oversight & Training
   It is recommended that some training and oversight be completed during initial setup and launch of the system, to ensure smooth running of the system moving forward.

Documentation
   Data Standard & Maintenance
    Set the data assessment criteria for initial setup of the system, and explain the processes involved in maintaining all the data sets, including flows of data from managed sources. This is a living document, and should be maintained as and when systems or processes change.

**Production Services:
Middleware**

APIs are the best method for distributing wayfinding data to be consumed by digital applications. We envisage these applications to be many and varied and to evolve over time. Initially the wayfinding API can drive City applications. As the API is opened up (and supported) the API can be consumed and used by third-party applications, websites, mobile apps and other digital services that inform and guide the traveling public.

System
System choices need to be made based on the functional requirements of the middleware. A Routing API will need different systems to produce than a Mapping API, for example.

For the Mapping API, a system needs to take data from the the Wayfinding Content Management System and using agreed attributes from the data, style the data according to the specification. ESRI's ArcGIS Pro provides map API publication capabilities. Mapbox is also an industry leader in the area, and there are new emerging software providers that could also be used. These systems are designed to work with geodatabases, as would be provided by the Wayfinding Content Management System, so using ArcGIS for Content Management does not predicate using ArcGIS Pro for Middleware.

Roles & Responsibilities
   API Production Team
   Depending on which APIs are being produced, there may need to be multiple production teams each with technical skills suited to the needs of each API. These teams could be in-house if the skills exist but more likely will be outsourced as-needed.

Documentation
   Software Development Kit (SDK)
    Gives third party developers the tools they need to create applications using the APIs. Each API the City provides will need an SDK per platform to be used by.

**Production Services:
Static Map & Sign Artworking**

This process selects sign-specific data in the desired crop, scale, and orientation, from the Wayfinding Content Management System and applies graphic styling to create map and sign artwork.

System
ESRI's ArcGIS Pro includes cartographic capabilities. It can also be manipulated to automate some of the artworking tasks. ArcGIS provides a live link to the data, meaning that updates can be simpler than a system that requires importing data periodically. ArcGIS does however, have some limitations and historically has needed the addition of dedicated graphics software to reach the standard for final artworking.

A more manual alternative to ArcGIS would be to use Adobe Illustrator + MAPublisher plug-in. A high graphic standard could be achieved using this, but in a more manual way and repeated for every map artwork update.

On balance, ESRI ArcGIS is the recommended system with the caveat that there is a need to prototype what can be produced directly and reliably to the required standard.

Roles & Responsibilities
   Map & Sign Production Team
   Create artwork, with one person responsible for managing the process.

   Graphic Oversight
   Checks map and sign artwork provided by the artworking agency for content accuracy and that artwork is to the defined standard. Recommended to be brought in-house after first phase of production.

Documentation
   Design Standard
   Specifies what is required from a content and design perspective on different types of map and sign artwork.

   Templates
   As many as required for the different map/sign/print applications.

3.2   System Considerations: Outsourced

Content Management

Outsourcing content management has the benefit of shifting the responsibility for maintenance to a third party. This external Wayfinding Content Management Supplier would need to comply with technology updates and ensure the system runs to the required specification for production.

System
Mechanism for requested content changes should be determined with the content management system supplier. Can be as simple as email-based requests, a managed spreadsheet, up to as sophisticated as portal/login directly to the content management system, where minor content updates can be initiated by the City and automated to change on the maps.

Roles & Responsibilities
  Wayfinding Lead
  The City's Wayfinding Lead requests content changes from the Wayfinding Content Management Supplier, through an agreed system (ideally via a link into the actual CMS, to allow more automated changes). The Wayfinding Lead is also responsible for wayfinding budgets, and commissioning data creation and production projects.

Documentation
  Data Standards & Maintenance
  Set the data assessment criteria for initial setup of the system, and explain the processes involved in maintaining all the data sets, included flows of data from managed sources. Processes focus on the relationship between the Wayfinding Lead and the Wayfinding Content Management Supplier with maintaining the data. This is a living document, and should be maintained as and when systems or processes change.

Production Services: Middleware

APIs are the best method for distributing the wayfinding data to be consumed by digital applications, whether produced in-house or outsourced to other API developers / service providers.

With potentially wide-ranging API services being provided, it may make sense to outsource API production to different third party agencies who specialize in those areas. These APIs must all feed from the Wayfinding Content Management System.

System
It is recommended that the City selects API providers that use systems that are compatible with industry-accepted standards, in case the City ever chooses to change vendor or take the API production in-house.

Roles & Responsibilities
  Technical Lead
  Liaises with third party developers to task them with keeping the APIs up-to-date and compatible with the latest Operating Systems. This position could be merged with the Wayfinding Lead if the manager has the necessary technical knowledge.

Documentation
  Software Development Kit (SDK)
  SDKs will still need to be provided by the API providers so that third parties looking to utilize the APIs know how to use them.

  It is recommended that the City requests system architecture and process documentation from all outsourced API providers.

Production Services: Static Map & Sign Artworking

Map and sign artworking come in inevitable ebbs and flows, as sign systems are delivered in phases. Outsourcing to an agency specializing in artwork production management means that the City does not need to manage the peaks and troughs of demand. It would also allow the City to focus more on content management, should it wish to do so.

System
Third parties can use whichever software they prefer as long as the system can take the supplied data from the Content Management System and produce artwork to the design standard on deadline and within budget.

Roles & Responsibilities
  Graphic Oversight
  Checks map and sign artwork provided by the artworking agency for content accuracy and that artwork is to the defined standard. Recommended to be outsourced for first phase of production, to ensure quality of the initial implementation, and to help guide the new Wayfinding Lead in their role.

  Wayfinding Lead
  Ultimate sign-off of map and sign artwork after graphic oversight.

Documentation
  Seamless Seattle Visual Design Standard
  Specifies what is required from a content and design perspective on different types of map and sign artwork.

  Templates
  As many as required for the different map/sign/print applications.

3.3   **Phased Implementation Plan**

PHASE 1

Design Definition

Design leads system development, to define system requirements.

PHASE 2

System Definition

How the system is to be set up and maintained.

PHASE 3

Prototyping

Small iterative prototypes test different parts of the system and outputs, feeding back into full System Definition.

Seamless Seattle Visual Design Standard

Design & content standards for:

– On-street signage

– Tear-off Map

Both in progress under Pilot Contract

– Additional Printed maps

– Open Map API

Data specification

Defines how the data is attributed

Maintenance & Management Plan

Defines how and who maintains different parts of the system

System Architecture

Defines the structure and behavior of the system(s)

Data Management Prototyping

Tests geodatabase setup and connections with data sources

Open Map API Prototyping

Tests API graphics, functionality, production methods and system robustness

Artwork Production Prototyping

Tests signage and print artwork for quality, manual v automation and system robustness

Content Management Feature Prototyping

Tests Content Management features and dashboard UI

Iterative development

PHASE 4

System Setup & Documentation

Building the system according to the System Definition, hiring agreed staff and providing external oversight and production where needed. Documentation supports setup and future maintenance.
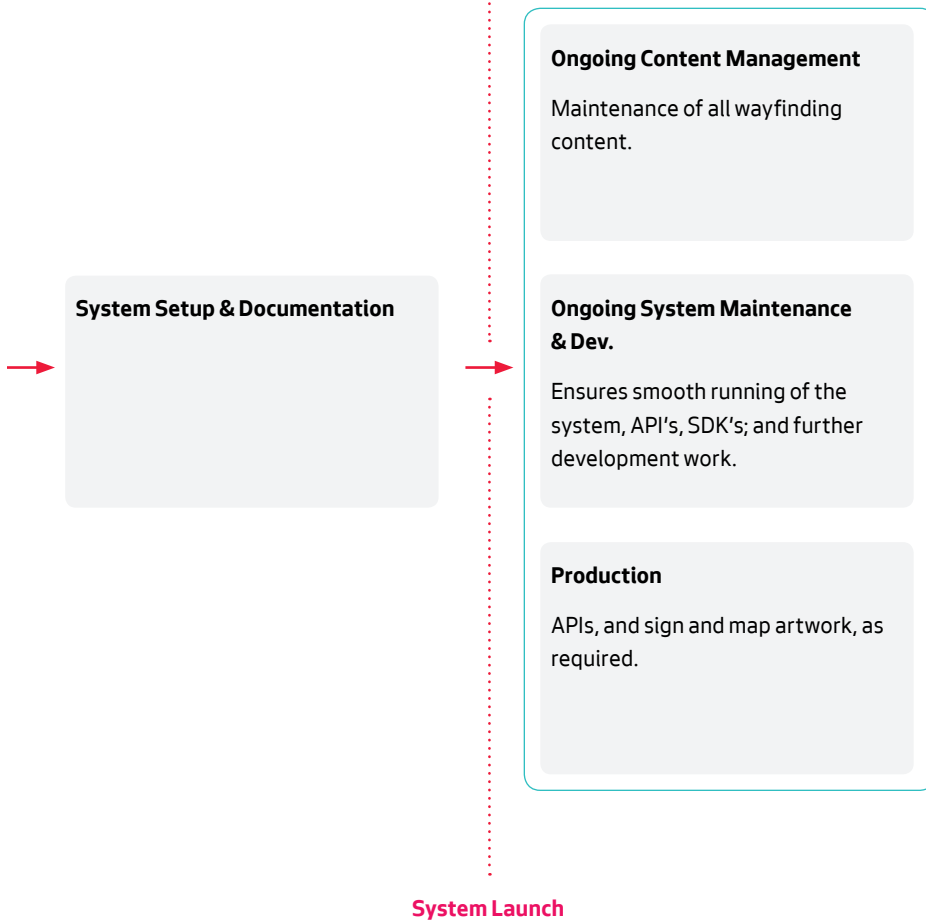
PHASE 5

Ongoing Maintenance and Management

Maintain system to agreed standards and schedules, as well as further planned system design and development.

System Setup & Documentation

Ongoing Content Management

Maintenance of all wayfinding content.

Ongoing System Maintenance & Dev.

Ensures smooth running of the system, API's, SDK's; and further development work.

Production

APIs, and sign and map artwork, as required.

System Launch

3.3   Phased Implementation Plan: RoM when Outsourced

To define what system or systems are needed to deliver the Open Wayfinding Platform, the City should undergo a process of exploration and iterative development to test various requirements, softwares and systems, and how they integrate.

This process needs to be design-led, to ensure that the systems defined can meet the functional and design quality requirements of the system. This in turn implies early design development phases to develop the as-yet undefined parts of the Seamless Seattle wayfinding system.

The RoM costs on the following pages are outsourced costs of doing these tasks, which in turn should provide some indication to the costs when done in-house.

However, please note that an outsourced agency can employ people with different skills and therefore bring these to bare. This is harder to achieve in-house and relies heavily on the skills of the identified team, which are susceptible to change.

PHASE 1: Design Definition

Design development work streams with the brief to define the design and use cases for the full system's wayfinding applications, and documenting in the Seamless Seattle Visual Design Standard.

Design Standards for On-street signage
In progress, as part of the Seamless Seattle Pilot.

Design Standards for Tear-off Printed Map
In progress, as part of the Seamless Seattle Pilot.

Map Design Standards for print
Design Development
To identify different types of further printed maps to be published, potential project partners, and to define their content and detailed design including type and icon sizes.
RoM: $20,000

Documentation
Expand the Visual Design Standard to include additional print design standards.
RoM: $10,000

Map Design Standards for digital applications
Design Development
To develop the Mapping API design standards, defining the content and capabilities of the API and SDK for third parties to use.
RoM: $80,000

Documentation
Expand the Visual Design Standard to include digital design standards.
RoM: $10,000

PHASE 2: System Definition

Once design standards have been defined, work can be undertaken to define the system that will deliver the design.

System Architecture
Defines the structure and behavior of the system(s). Developed iteratively as the overall system becomes better defined. Can be developed in phases, targeting different wayfinding applications and working backwards.
RoM: $30,000

Data Specification
Defines how the data is attributed, taking the design standard and available systems and resources into account.

Data Compilation
Compilation of the available data with wayfinding data sets to deliver the design, identifying suitability for use, where there are gaps, and how these gaps may be filled. Based on complexity, requirement and quality.
RoM: $20,000 to $100,000 over 1 year

Data Source Engagement
Work with data providers to determine where and how data is to be maintained, identifying the mechanisms for data compatibility and transfer between the data source and the Wayfinding Content Management System (synchronous or asynchronous). Includes data agreements.
RoM: $20,000

System Research
Research into which systems will be effective/appropriate in performing different aspects of the Open Wayfinding Platform. Options and selections.
RoM: $10,000

Maintenance & Management Plan
Defines how/who maintains different parts of the system.
RoM: $10,000

PHASE 3: Prototyping

Small iterative prototypes test different parts of the system and outputs, feeding back into full System Definition.

Data Management Prototyping
Tests geodatabase setup and connections with data sources.
RoM: $50,000

Open Map API Prototyping
Tests API graphics, functionality, production methods and system robustness.
RoM: $10,000

Artwork Production Prototyping
Tests signage and print artwork for quality, manual v automation, and system robustness.
RoM: $20,000

Content Management Feature Prototyping
Tests Content Management features and dashboard UI.
RoM: $20,000

PHASE 4: System Setup & Documentation

Building the system according to the System Definition, hiring agreed staff and putting external oversight and production in place where needed. Documentation supports setup and future maintenance.

Adjust, develop and System setup
Includes publishing SDK's and API's.
RoM: $50,000

Documentation
Data Standard & Maintenance
RoM: $10,000
API documentation, per API
RoM: $5,000

Software Development Kit (SDK) per platform
RoM: $10,000

Templates for sign & map artwork
RoM: $20,000

PHASE 5: Ongoing Maintenance & Management

Maintain system to agreed standards and schedules, plus further planned system design and development. Maintenance and management falls under three areas:

Content Management
Maintenance of all wayfinding content. This is a broad range as the amount of data change and amount of in-house resource is unclear at present.
RoM: $30,000 to $60,000 per year

System Maintenance & Development
System maintenance to ensure smooth running of the system, API's, SDK's and development streams for upgrades.
RoM: $30,000 per year

Production
API development costs per API
RoM: $10,000

Artworking costs per sign
RoM: $1,000

Appendices

Data Assessment Criteria

Recommended criteria for assessing wayfinding data quality and making decisions on data creation, maintenance and management.

Availability & Governance
- Any copyright restrictions?

- If a license is required, what are the cost implications?

- Who produces the data, and are there risks that they will no longer maintain the data in the future?

- Is the data quality controlled?

- Is there a process for submitting change requests to the data?

- Are the data owners willing to collaborate, perhaps even edit their data to suit wayfinding purposes?

Compatibility
- Is the data format compatible with the

- Wayfinding Management System?

- Is it georeferenced?

- Is it georeferenced in a compatible projection?

- If Wayfinding Data needs to be added, is this added & maintained in the WMS or at the source?

- How will updates be incorporated into the Wayfinding Management System? Can this be automated?

Data Quality
- Is the information correct? (Up-to-date, free of factual errors, free of spelling errors, capitalized and punctuated correctly, etc)

- Does the data cover the desired area/extent?

- Is the information maintained regularly enough?

- Is the data detailed enough? Or too much?

- What is involved with cleaning the data up? Is this sustainable?

Cartographic Quality
- Is it the correct type of data for the desired cartographic styling? (point/line/polygon)

- Is the data attributed correctly for cartographic styling?

- If the data is to be represented topographically

- on the map, is it drawn to cartographic quality?

- If the data is to be represented topographically on the map, is it drawn to work at the desired scale or scales?

- Is it located accurately for detailed map scales?

Appendices

Image sources

1. Seamless Seattle Wayfinding Strategy

2. Seamless Seattle Wayfinding Strategy

3. Google Maps
   https://www.google.com/maps/

4. OpenStreetMap
   https://www.openstreetmap.org

5. Transitscreen
   https://transitscreen.com/

6. MBTA Project Page
   https://www.mbta.com/projects/solar-powered-e-ink-
   signs

7. Wayfindr
   https://www.wayfindr.net/

8. Go Jauntly
   https://apps.apple.com/gb/app/go-jauntly-discover-
   walks/id1150399087

9. LinkNYC
   https://www.link.nyc/

10. Amsterdam Open Beacon Network
    https://amsterdamsmartcity.com/projects/
    amsterdam-open-beacon-network

11. Hello Lamp Post
    http://www.marisanbjensen.com/hello-lamp-post.
    html

12. Adweek
    https://www.adweek.com/brand-marketing/these-
    out-of-home-avengers-ads-displayed-showtimes-at-
    the-closest-theater-to-you/

13. Transport for London Unified API
    https://api.tfl.gov.uk/

14. CityMapper
    https://citymapper.com/london