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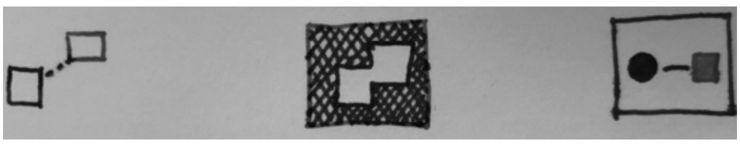

Bicycle-Train Floor Circulation

Analysing the floor between enclosed bicycle parking facilities and train platforms at Dutch train stations according to its spatial composition

by Edgard Andrés Zúñiga León-York

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Summary

Despite extensive literature on the benefits of bicycle-train combination and integration at a station, it remains unclear how the transfer space between each mode's facilities can be framed to measure its performance and possible improvement. This research deals with the definition transfer floor within a station between bicycle parking facilities and train platforms. Through its definition would it be possible to describe it, evaluate it, and produce it.

Because this floor exists in all cases where a Bicycle Parking Facility (BPF) and a train platform are present, the transfer floor is implicit in academic literature, industry documentation, and physically at the stations. Adapting the approach of architectural type, this research uses the framework to find constants despite variation in both literature and infrastructure to find the tools to define the transfer floor. This is done in three parts, namely, a literature review, the formulation of a methodology for a case study, and its analysis. The literature review is carried out to clarify the transfer floor's position within the existing body of knowledge according to three concepts denoting different scales (BT intermodality, multimodal station, and internal circulation), and inform what methodologies can be used for its analysis. The methodology consists of a framework (spatial composition) following architectural type with the ability to frame a whole across various spatial scales and makes use of various visual representations to describe each of the three scales, which is adapted to the available data regarding the case study: BPFs at Dutch train stations. The analysis consists of capturing, identifying, analyse, and categorise the floor in all cases on each of the three scales to find what is constant in the transfer floor to define it and through its definition, measure its performance.

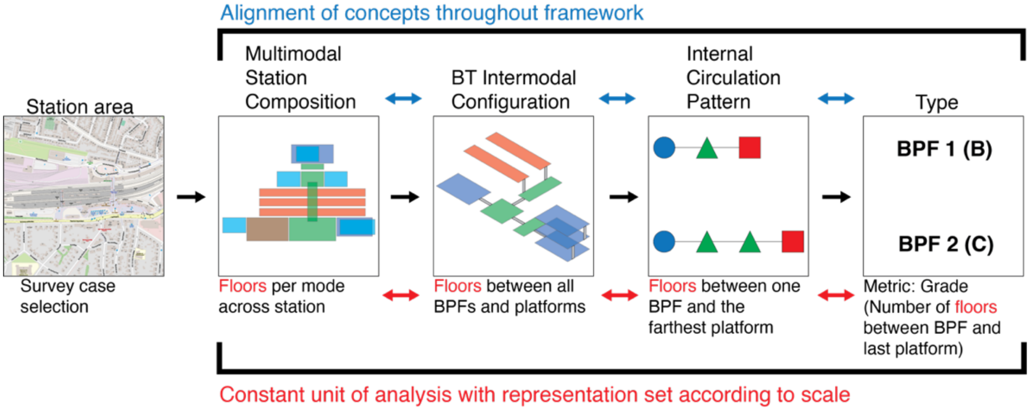

Figure 3.2. *Analysis framework flow diagram*

By analysing the cases at various scales, the results produced a lot of data that can be grouped in multiple ways to find the essence of the transfer floor. Due to the multimodal station's complexity, each scale has a higher level of abstraction, or simple representation. An attempt is made to group and regroup the cases according to different aspects towards the minimisation of exceptions. Upon finding an aspect under which all cases can be categorised, the next level of abstraction is analysed, and the number of categories is reduced. This iterative process ensured the relation between each level of abstraction and resulted in the categorisation of 4 levels of abstraction leading to four types of BT transfer floor, based on grades (A, B, C, and D).

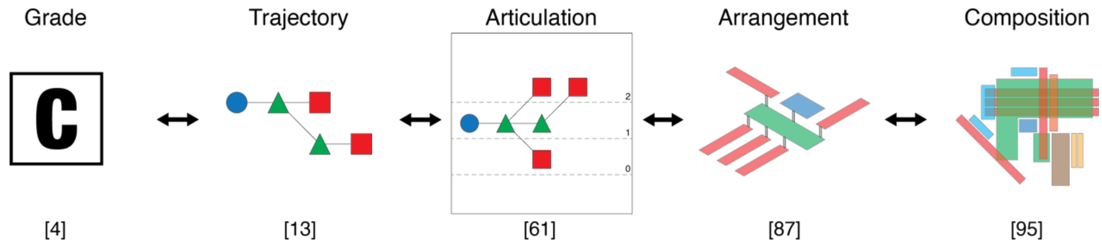

Figure 4.14. *Analysis results categorisations overview*

It was found that BPFs at Dutch train stations tend to have a good grade, where every other BT floor (75/136) has a B grade (one transfer floor between a BPF and the farthest platform). Both the best and worst cases (A and D) were found to be related to the way space is used at the site and how the floors relate to each other. An example of space is placing the BPF under the train platforms, and the floor relation is to enable circulation between the two. Based on the way floors are segmented, the analysis of all cases showed how the position of floors at the same level is beneficial to reduce the number of transfer floors vertically, and reducing obstacles such as misaligned orientation, road, and train tracks horizontally. Although every composition was unique and many seem very complex, it was found that most cases have a total of 4 to 15 floors (72/95) and 3 modes (train, bicycle, bus) across 2 or 3 floors (69/95).

Table 4.11. *Internal circulation grade overview.*

Trajectory	Graph	Total Floors	Transfer Floors min	Transfer Floors max	Articulation	Cases	Grade
t01	● ■	2	0	0	3	5	A [5]
t02	● ■ / ▲	3	0	1	1	1	B [75]
t03	● ■ / ▲ ■	4	0	1	2	2	
t04	● ▲ ■	3	1	1	13	69	
t05	● ▲ ■ / ▲ ■	5	1	1	3	3	
t06	● ■ / ▲ ■	4	0	2	1	1	C [43]
t07	● ■ / ▲ ▲ ■	5	0	2	2	3	
t08	● ▲ ■ / ▲ ■	5	1	2	10	15	
t09	● ▲ ▲ ■	4	2	2	16	24	
t10	● ▲ ■ / ▲ ■	5	1	3	4	5	D [13]
t11	● ▲ ■ / ▲ ▲ ■	6	1	3	1	1	
t12	● ▲ ▲ ■ / ▲ ■	6	2	3	2	4	
t13	● ▲ ▲ ▲ ■	5	3	3	3	3	

The main findings of this research are the definition of transfer floors between BPFs and train platforms at the station through the contextualisation of transfer floor within existing literature, the development of a station composition analysis methodology, and the analysis of circulation. The contextualisation made it possible to position the transfer floor as a span within a BT trip, while delimit its physical position within the scale of the multimodal station and its defining factor of internal circulation. The developed methodology derived theory and existing data a way to make a composition object using a unit of analysis, the floor, towards its framing within the multimodal station. The analysis made it possible to understand circulation as compositional principle, where floor is divided and integrated according to the movement (vertical or horizontal) across different planes, or floors.

Based on the main findings, this research recommends the adaption of a terminology for the spatial dimension of stations and its circulation, further research into the spatial dimension of multimodal stations, and the consideration of spatial dimension as a precedent to inform goals for both policy and design of BPFs at train stations from a spatial composition perspective. The proposed terminology used in this study offers a way to frame what would otherwise have blurry limits within a bigger whole, which creates a definition for transfer floor able to describe, evaluate and produce it within multimodal stations. This signals to future research, where the methodology borrows itself to frame station spaces at multiple scales or even between them due to the framework's flexibility. Lastly, the precedent is the idea of how a canon, or database, can inform the goal of improvement on existing or new BPFs at train stations in regard to circulation. As circulation gains a shape and form, it becomes possible to define policy goals and design briefs for future interventions with existing reference to what is possible and desirable.

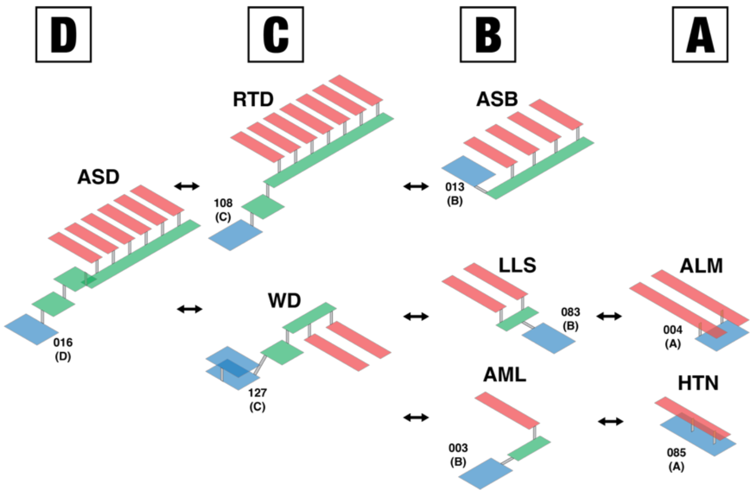

Figure 4.13. *Grade informs circulation improvement according to spatial arrangement*

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Chapter 1: Introduction

1.1. Background

In multimodal transport networks, connection among different transport services is important, as increasing connections between modes at stations leads to a more robust network and increase patronage (Alessandretti et al. 2023; Curtis & Scheurer. 2017). Among these connections, bicycle-train combination has been found to increase train travel and improve traveller chain mobility and mobility reach (Jonkeren et al. 2018; Ploeger, 2024; Kager et al. 2016). In this combination, the bicycle is used as the access or egress mode to/from the station and the train is used as the main mode to travel the greatest distance in a journey. This combination makes it possible for the traveller to get to the station comfortably before travelling to other cities by parking in an area nearby or within the station. The bicycle parking area is referred to as Bicycle Parking Facility (BPF).

BPFs come in lot of sizes and forms, with many of its features, such as parking racks and amenities varying from case to case. Recurring features in similar BPFs are grouped as types, such as underground or indoor denoting location, or unguarded and guarded denoting security features (e.g., staff or entry gate) (Piersma & Ritzema, 2021). Like BPFs, stations are also categorised according to their recurring features (e.g. number of facilities, passenger flows, or location in network) (NS, 2021; ProRail, 2023, van Hagen & Exel. 2014). In both cases, types are associated with a level of quality or number of features, such as larger stations being more reliable due to more services and higher frequency of those services to possible destinations than a small station with one train every 30 minutes, or a bigger BPF being more comfortable because the parking spot availability is higher due to its capacity in comparison to a small BPF with little space and capacity. It could be the case that the quality of the connection between the two could also be categorised as a recurring feature between them.

In academia and industry, the connection between these two modes is measured qualitatively and quantitatively. The most straightforward is the modal share of travellers that access/egress to/from the station by bicycle. This proves the demand of BPFs for a station. Although there is no specific case analysis, different station types (urban function) have been assessed in relation to BPF types (guarded/unguarded) using user preference (comfort), average distance (metres) and directedness (Hoksam, 2021; Geurs et al. 2016; Scheltema, 2012). The first shows the demand for parking capacity at station, the second shows that users prefer BPFs higher quality and closer to the station, the third shows that the performance of the combination can be quantified in meters or minutes, and the fourth shows that the visibility of the destination improves the quality of the path between the modes. Across these and other studies concerning this connection, little attention is paid to the physical space that lie between them, implicit in the connection but lacking a consistent definition.

1.2. Problem Description

The quantifiable distance/time/path between the modes forms a transfer space. As a walking surface a passenger traverse from one mode endpoint to the other, this space can be referred to as the *transfer floor*. Although this floor is implicit in the above examples, it is not explicitly integrated to the notion of BT combination, the BPF/station relationship, or metrics as a discrete object. This absence makes the notion lack the component responsible for its improvement or hindrance. For the BPF/station relationship, it remains unclear how their combination creates a transfer floor or inversely, how a transfer floor affects their combination. And for the metrics, the distance/time is based on an average or is Eucledian (straight line between endpoints disregarding physical boundaries), which may provide a number, but can't be acted upon without knowing what the transfer floor looks like and how it works.

This implicitness can be accredited to the transfer floor being a void, an interstitial leftover space with no jurisdiction or clear limit, not a BPF and not a station. As an ambiguous space, voids can be defined according to their relation with their surroundings, where voids are delimited by built objects, such as buildings, walls or roofs (Dacarro & Yim, 2021). Existing spatial frameworks for a station may see all other space between BPFs and train platforms as transfer floors, but tend to be unassigned and disregarded, or rather, not factoring into their relationship, despite it linking the two together. Whereas there are frameworks to classify both BPFs and stations, there is no framework to classify the floor between them. Moreover, the frameworks for those two are not based on spatial principles compatible to integrate transfer floor into their classification. Therefore, a common framework that can frame voids and it able to classify the three spaces as components of a composite whole would be necessary to define it within the context of the station.

1.3. Aim and question

Based on the above argumentation, the hypothesis of this study is the assumption that the definition of this void through a spatial framework may provide both the language to make the transfer floor explicit and a metric to measure its effect on the relationship between BPFs and train platforms at a station. In other words, the aim is:

"To formalise, through the development of its spatial framework within the appropriate scale, the transfer floor and measure its impact on the relationship between BPFs and train platforms at a station."

In line with this aim, the research main question is formulated as follows:

"What constitutes a transfer floor and how does it affect the BT combination within a station?"

1.4. Approach

This research approaches the problem of defining and evaluating transfer spaces through the concept of “type.” In architectural and urban studies, “type” refers to the recurring characteristics that define a specific spatial configuration, regardless of its variations. By analyzing transfer spaces as a “type,” this study aims to distill the essential attributes that characterize these spaces across different station layouts. This approach treats transfer spaces not as isolated or incidental features but as typological components that hold a consistent purpose and set of functional qualities, even when their physical forms vary. Using “type” as a guiding principle, the research develops a framework to systematically assess the quality and connectivity of transfer spaces.

The study unfolds in three stages, each applying the concept of type in distinct ways:

Theoretical Exploration: The first stage applies the concept of type to identify core characteristics of transfer spaces by examining existing theories on multimodal transport, station design, and circulation. Through a review of the literature, the study aims to define what makes transfer spaces a distinct type within the broader context of station design. This exploration identifies gaps in current knowledge, particularly in understanding transfer spaces as a unified typological element rather than separate, incidental pathways.

Framework Development: In this stage, type is applied to create a systematic framework that evaluates transfer spaces based on shared characteristics, regardless of station-specific variations. The framework sets criteria for spatial composition, connectivity, and user flow, emphasizing how the arrangement and articulation of elements within a transfer space define its typological quality. By focusing on recurring patterns and structures, this framework provides a method to assess transfer spaces consistently across multiple contexts.

Empirical Analysis: Finally, the concept of type is applied in the empirical analysis to categorize and grade transfer spaces at Dutch train stations based on the framework’s typological criteria. Observing and evaluating transfer spaces across different stations allows the study to validate the framework while generating insights into best practices. This stage ultimately uses type to identify patterns and recommend design improvements that can enhance multimodal connectivity at a broader scale. In summary, this approach leverages the concept of type to create a structured path from theory to practical application, offering a typological lens for understanding and optimizing transfer spaces as integral components of multimodal stations.

1.5. Thesis Outline

This report is divided into chapters. Chapter 1 introduces the research problem and objectives. Chapter 2 reviews existing literature on BT intermodality, multimodal stations, and internal circulation to identify reasearch gaps of the definition and analysis of the transfer floor. Chapter 3 describes the development of an analysis framework based on the spatial composition theory and the context of a case study for BPFs at train stations in the Netherlands. Chapter 4 applies this framework to a selection of Dutch stations, evaluating the BT floor in terms of circulation grade. Chapter 5 presents the conclusions and recommendations, discussing implications for policy and architectural design.

Chapter 2: Literature Review

The use of interchangeable terms in academic literature makes researching a topic difficult. This can stem from terms used depending on geographical context (e.g. public transport (Europe) vs. transit (North America)) or from terms having a trajectory within a research field (e.g. accessibility in transport planning vs. transport economics) (Loukaitou-Sideris et al. 2015a; van Wee et al. 2023). One solution to this problem is to carry out a systematic review to identify, define and assess research on the topic (Aromataris & Pearson. 2014). Examples include the hospital layout, looking at overlapping methods to design layout across disciplines, and the overlap between transport and urbanism to find common terms that represent the same indicators (Jia et al. 2023; Yang et al. 2020). The benefit of this exercise is to reframe problems to have a specific departure point and to have clarity despite being used within different disciplines.

A literature review serves research to situate a study within the body of the relevant literature. Whether the topic at hand exists is unknown or could be said to not exist yet. So, how can one situate a non-topic within a body of knowledge that may serve as a foundation to it? One way would be the idea is that literature review of a non-topic can be validated via the systematic review of adjacent literature. There are many systematic reviews on bicycle train relationship, but all use different terms, all of which do not imply the transfer space (Heinen & Buhler, 2019; Egan et al. 2023; Kosimidis & Muller, 2023; Weliwitiya, 2020). Hence, this solution synthesises why the topic is not there and at the same time narrowing down what can be used to define and study the topic.

In this case, transfer space is mostly implicit in the literature, but is omitted by talking about qualities of space, not its span or content. There are mentions of space through examples, such as specific stations, but not general framework to describe this space within a station. In other words, there isn't a way of delimiting the transfer space without a reference, so it becomes inconsistent to frame one without precedent, which are most cases. This chapter attempts to solve this issue by addressing "why there aren't any among the existing terms, or why these terms do not translate to what we need?" and "how these reasons to narrow down a possible list of terms to talk about this space from a spatial perspective. This chapter is divided into sections, which follows a framework to use general concepts bicycle-train intermodality, multimodal station, and internal circulation, to define the topic at hand while answering these questions.

2.1. Approach

The first step to understand what literature should be reviewed to situate a topic that is not clearly defined in existing literature is to reduce the topic to a reduced number of concepts that may act as working definitions. Respectively, an approach was developed to delimit the research problem, determine a search strategy, and formulate a conceptual framework.

2.1.1. Delimiting the Problem

The notion of a transfer space between bicycle parking facilities to train platforms at a station is a convoluted topic. It is difficult to grasp to what literature and terminology it is aligned to because it exists between established topics. The transfer space may exist between disciplines as a subject matter (railway engineering, infrastructure, architecture, urban design, and urbanism); between structures as a setting (bicycle parking facility, train platforms, and the city); and within a setting as an activity (movement and space). This means that the literature review spans multiple disciplines, settings, and activities that may be implied but not be explicitly defined.

Moreover, when prioritising a subject matter, setting, or activity as the research topic, there are various possible settings and activities for a subject matter, and so on. This is compounded when the setting changes its definition according to subject matter and activity. One example is when the station scale changes according to the activity being analysed, such as from payment point to payment point (e.g. ticket gates within station building) in fare integration, or from facility to facility (e.g. facility entrances within station area). In both cases, the transfer space has a different span and content. It is unknown if there is any overlap between the transfer spaces of these variations, which may help establish more a specific and consistent definition compatible with variation.

The notion of transfer space between bicycle parking facilities to train platforms at a station is not a new subject, but there the way it is studied and framed varies per case. Whether previous research focuses on bicycle parking as a parameter for train travel, or the parking at the station user profiles, using the existing terms or keywords within the transport discipline would showcase literature that is not aligned with the research problem. Therefore, to limit the expanse of the literature searched and reviewed, the topic is contextualised as keywords by centring on three ideas turned into concepts that can guide the literature search. It is important to note that these concepts were developed iteratively through the literature search. They have been defined considering all possible alternatives for each term. They are the following:

- Used in Weliwitiya (2020) as an umbrella term for the subject matter, **bicycle-train intermodality** allows to structure the compiled documents and clarify the position the research problem within the existing body of knowledge on the modal relationship of the bicycle and the train and its transfer space.
- In van Nes (2002) the multimodal transport is when two or more different modes are used for a single trip between which the traveller must make an intermodal transfer. The traveller changes modes a transfer node. This node, being a physical delimited space called a station, includes facilities of multiple modes.

The setting where the transfer amongst modes' facilities occur is therefore defined as the **multimodal station**.

- Used in Paksukcharern (2003), **internal circulation** makes the distinction of the bi-directional movement between two points within system, as in inside the station, in opposition to through-circulation (flow in and out of system or station). Here, the concept can be used to understand the circulation from a bicycle parking facility to a train platform within a multimodal station.

2.1.2. Search Strategy

Positioned between movement and space, this research focuses on a transport issue (bicycle-train connection) from an architectural perspective (station spatial configuration), the literature review collects and assess sources from both disciplines and anything in between. These include transport geography, transport planning, transport policy, station planning and design, architecture, urbanism, urban form, and spatial configuration. Another consideration for the search strategy is that because this topic is more present in industry than academia, document review was also done to find information on the concepts within practice.

For academic literature, academic journals, university repositories, and academic books were assessed. For grey literature, different sources were used, such as government policy papers, train operator and manager guideline and vision documents, civil organisation reports, archive documents and books related to these topics. All search queries were made in Google Search, Google Scholar, and Scopus. Although there was a preference for documents within the Dutch context of this research, other contexts were used where deemed useful to contribute information. The literature was collected using the Obsidian note-taking app, and the documents found relevant for analysis were listed in a Microsoft Excel spreadsheet. The results of this literature review are discussed in the following sections. The search and literature selection procedures per concept and relevant terms can be found in **Appendix A**.

2.1.3. Conceptual Framework

Using these three concepts and the search strategy as the foundation of the literature review, this chapter's framework is based on a notion:

- *Internal circulation is a function of the bicycle-train intermodality, which is a function of a multimodal station.*

Following this framework, the literature review aims to find an answer to "what is the bicycle-train intermodality, the multimodal station, and internal circulation?" By asking these questions, the structure enables expanding on their various definitions to then narrow down to the term that best fits the study's context and as such informs what literature to review for the following concept. In other words, once bicycle-train intermodality is specified, it informs what literature to review regarding the multimodal station, which in turn informs what to look for with regards to internal circulation. This operation filters within each section how to specify and clarify the position of this research within the discourse of transport and architecture as well as providing a continuous narrative where the choices in terminology are evidenced.

2.2. Bicycle-Train Intermodality

When talking about the relationship between the bicycle and train modes *at the station*, there are various terms that are used to either represent an aspect of the relationship or to encapsulate all aspects of the relationship. One such term is Bicycle-Train (BT) intermodality, which can be understood as umbrella term for the subject matter, or represent the aspect of the relationship, such as the presence of BPFs at the station (Weliwitiya, 2020; Pazzini et al. 2023). As to why these terms are used interchangeably is unclear. One explanation could be the various ways the term intermodality is applied in transport research.

"Intermodal" can be strictly defined using the Latin roots of the word (inter = between; modus = way), where intermodal suggests transportation between different ways of transporting a good or a person (Capelle, 1994). Multi-modality and inter-modality are concepts in which two or more transport modes are used to fulfil the door-to-door service as the uni-modal is insufficient to connect the origin and destination for longer distance trips (Kager et al., 2016). In passenger transport, multimodality represents the potential and flexibility of travelling using multiple modes within a single trip, while intermodality represents the ease of transfer between two modes (EC, 2017).
These terms can be confused in the literature. In Loukatiou-Sideris & Peters (2015), intermodality refers to a level of the convenient and seamless transfer between travel modes. In Pazzini et al. (2023), intermodality is considered as the simultaneous presence or absence (within the station or in the immediate vicinity) of other mode stops; terminals, or parking lots. The first implies a condition for travellers, while the second considers the physical conditions of the station. In this study, the second is considered the multimodality of the station, while the intermodality is the traveller's condition according to the conditions of the site when moving between two modes inside a multimodal station.

Based on the above, BT intermodality can be used as the umbrella term for a research field that encompasses all research on the modal relationship between the bicycle and train mode. Because this same definition vagueness exists in terms across the proposed research field's subfields and topics, this section uses this term to map out the research field, structure the relevant terminology and parameters that may specify the subject matter and inform the subsequent concept of the multimodal station.

2.2.1. Research Field

BT intermodality represents the relationship between the bicycle and train modes at the train station. Although BT intermodality can be used as the umbrella term for the field concerning BT research, this term often overlaps with other terms used to describe the field, such as BT combination and BT integration. BT combination is any travel that includes the combination of bicycle and train in it (Leferink, 2017; Hoksam, 2021). BT integration, as defined by Pan et al. (2010), is the use of bicycle mode to access the station for train travel.

These terms differ in span. BT combination can be understood as door-to-door (Origin - Destination) travel, while bicycle-train integration can be understood as door-to-access station (Origin – Access). Both spans include the segment that is considered the span for this research: from parking to platform at the access station (Access-point A - Access-point B) or (Facility - Platform). Hence, BT integration is a segment (O-A) of bicycle-train combination (O-D), and the research span (Af-Ap) is a segment of BT integration. In other words, intermodality is part of integration and integration is part of combination.

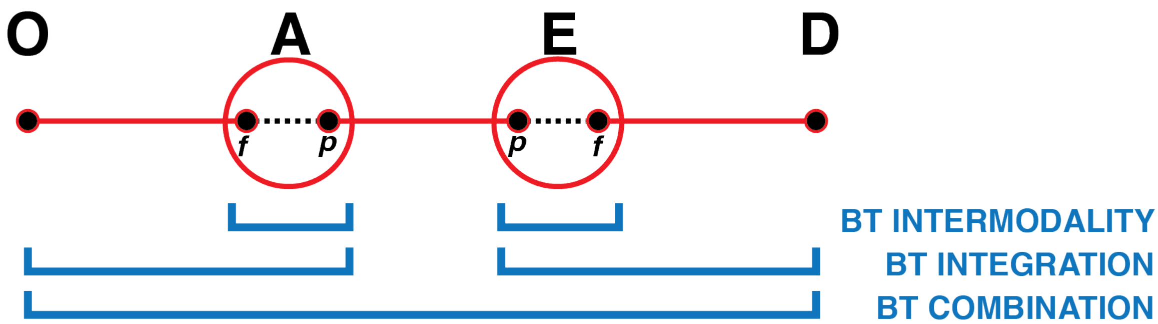


Figure 2.1. *Bicycle-Train research fields according to span*

2.2.2. Physical Integration

Integration measures at a train station include having a single ticket between the modes, a single transport operator for both modes, to a single building hosting facilities for both modes. These measures are often grouped into categories that relate to domain, such as institutional, operational, or spatial (Saliara, 2014; Potter & Skinner, 2000; Miller, 2004). Spatial measures can be grouped under physical integration. Physical integration has various definitions in literature. According to Miller (2004), physical or infrastructure integration relates to physical changes such as integration of new routes and establishment of interchange or transfer points. It refers to the planning of stops, stations and transfer centres, their location, and facilities, as well as their design. It also embraces the coordination of vehicle movements for transfers to be safe without any conflicts between pedestrians and vehicles movement. In Luk & Olszewski (2003), physical integration is defined as “the close proximity and ease of access at mode interchanges that will greatly enhance public transport services”. Here, it can be noted that while physical integration relates to material reality of the integration, the spans it covers can range from the walkways between modes to the coordination of routes between different mode transport services and networks.

In a systematic review of bicycle-train integration, Weliwitiya (2020) identifies two physical integration themes associated with bike-and-ride levels: the Built Environment and the Station Environment. The themes lack spatial definitions, but their physical span can be understood through their factors. Built Environment factors include urban density and cycling infrastructure (e.g., segregated bicycle lanes), which consider the space from origin to an intermediary destination (access station), that is, BT integration span (O-A). On the other hand, Station Environment factors all deal with the characteristics of bicycle parking facilities in relation to the train station at the station, or the intermodality span (Af-Ap).

2.2.3. Bicycle Parking Facility Integration Factors

In a review of bicycle parking infrastructure literature (Buhler et al. 2021), the research concluded that “bicycle parking supply appears to be a determinant of cycling for current and potential cyclists. Conversely, a lack of bicycle parking and/or inadequate bicycle parking discourages cycling. Both cyclists and potential cyclists prefer higher-quality (e.g., weather-protected) and more convenient bicycle parking facilities over lower-quality facilities or no bicycle parking. Convenience includes easy access to bicycles (e.g., no stairs, and short distances between bicycle parking and actual trip origins or destinations)."

These insights are in line with other reviews of literature concerning bicycle parking facilities at the train station (Heinen & Buhler, 2019; Weliwitiya, 2020; Egan et al. 2023; Kosimidis & Muller, 2023; Hoksam, 2021). Across these reviews, the various integration measures can be grouped under three categories: capacity, cover, and circulation. These categories distinguish clear aspects of BPFs that can improve or hinder physical integration between the bicycle and train at the station environment span:

- **Capacity** encompasses a station's ability to supply parking for travellers accessing the station by bicycle. Terms within this factor category include provision of BPFs, availability of parking spots, and diversification of BPFs.
- **Cover** encompasses characteristics of a BPF at the train station that relate to the aspects of security and safety. Terms within this factor category include the protection from bicycle theft, protection from the weather, monitoring, lighting, and parking fees.
- **Circulation** encompasses characteristics of the space between a BPF and the train station's point of departure/arrival (the train platform). Terms within this factor category include BPF proximity to the station and ease of transfer.

While the three categories improve BT physical integration, circulation more specifically relates to the space between the facility and the train platform. However, they are interrelated in the process of implementation, where selecting a position of a bicycle parking facility in relation to the station may change its capacity and cover (Piersma & Ritzema, 2021). As such, the transfer space tends to result from various external operations, rather than being itself designed according to the aspect of circulation.

2.2.4. Bicycle-train Intermodality Research

In this section, the exploration of the concept of intermodality resulted in the distinction among terms based on span. Span enables the distinction between combination and integration, between built environment and station environment, between circulation as a bicycle-train integration factor relating to movement and space in contrast to the others.

Beyond span, the biggest barrier to organise the available literature on bicycle-train intermodality was found to be a lacking notion of scale. Alessandretti et al. (2020) mentions that human mobility research tends to be considered as scale-free. This is convoluted, as the place in which mobility occurs, geography, uses the concept of scale as level of description, from rooms to buildings, neighbourhoods, cities, regions, and countries to describe human behaviour. As such, a spatial entity of typical size (e.g. station environment) could organise the literature into delimited research topics and derived parameters.

Moreover, scale by itself can be problematic because it is not entirely fixed (Paasi et al., 2004). For bicycle-train intermodality, both the transfer movement and space, cross boundaries between different scales, where the move/space relationship can be between a room (parking facility) to a site (train station exterior space), or a room in a single room building (parking facility) to a room within a multi-room building (train platform). The framing of these scales depends on whether a station's definition includes the bicycle parking facility as being inside or outside the station (building or site). Additionally, a generalised framing is further complicated by the additional facilities and platforms at any station, which also varies from station to station. Combined, the above demonstrates the challenge present to generalise this relationship within the object that is the station.

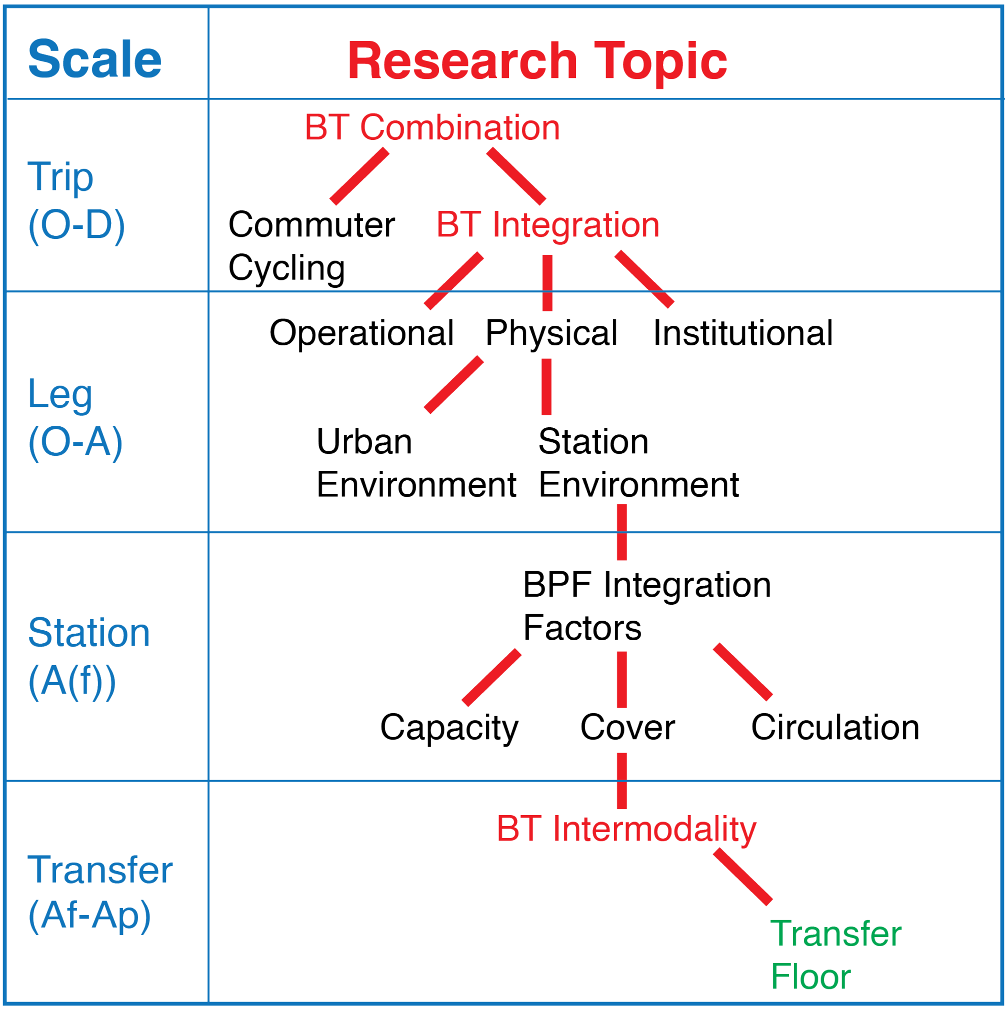


***Figure 2.2**. Bicycle-Train research topics according to scale.*

2.3. Multimodal Station

Like the problem of scale, the station as a delimited place is not fixed. Many refer to the station as a piecemeal project, a place 'in becoming', or a composite form of station buildings and surrounding environments (NetworkRail, 2021; Cresswell, 2006; Inamochi, 2015). The station is dynamic rather than static. The station typically refers to the 'train' station, although there are also 'metro', 'tram', and 'bus' stations. The presence of two or more modes in an area tends to be considered as parts of a composite station made up of various parts positioned in parallel or overlapping, blurring the boundaries of each mode's facilities to form a larger entity. This larger entity is therefore “multimodal”, in that it has spaces shared among them to facilitate movement from one to other modes. However, as described in van Nes (2002), the multimodal station is the transfer point, or node, where multimodal transport (use of more than one transport mode to make a trip). This makes it difficult to see the parts of the space when multiple modes, their facilities and shared space is reduced to a point or node rather than a composite space with multiple components, or a network itself with a set of nodes and links.

Moreover, the spatial definition of multimodal station is unclear because it tends to be defined by parts other than structures for specific modes and the shared space among them. In Kandee (2004), the multimodal station is defined via the "intermodal concept", which refers to the interaction between people, services, and different modes of transportation in the form of four functional areas (core, transition, administrative and peripheral). As pointed out by Floyd (1993) and Tolliver (1995), an intermodal transportation centre can be a new form of structure, a distinctive building, or a group of buildings at a single location which are intended to introduce new methods and patterns in handling many people.

In a study assesses physical integration across mode facilities at the JFK Airport, the term ‘multimodal’ represents the system with more than one mode, and the term ‘intermodal’ represents the connection between any two of these elements (Kanafani & Wang (2010). As such, bicycle-train intermodality is one among the possible intermodalities contained within the multimodal station. Whether the bicycle-train intermodality has been considered as an intermodality within the multimodal station in previous research is unknown. A definition of its outline, uses, and configurations of parts to accommodate the movement among different modes remains unclear. This section explores these two statements by defining the multimodal station through its function and form, including previous studies on the functions of the station, its geographical demarcation, and its segmentation and arrangement of its parts.

2.3.1. Multimodal Station's Function

The station has various functions, such as to link catchment area and transport network, support transfer between modes of transport, facilitate commercial use of real estate, provide public space, and contribute to the identity of the surrounding area (Zemp et al. 2011). These functions are assigned to the station based on whether it is seen as a node within the transport network, a place within an urban area, or an intersection between a place and node (Bertolini, 1999; Peek, 2006). Moreover, these functions can have a hierarchy, where the node precedes the place definition, and the primary function is that of a transfer-station/transport-stop, followed by secondary and tertiary functions related to place (e.g. urban centre, retail, leisure) (Julchenka, 2002). This distinction is based on the idea that transport interconnections is the sole function of the station, while its relationship with the surroundings are part of urban development processes (Wulfhorst, 2003). As a transfer-station, the goal is to reduce the barriers or obstacles to move between modes. Therefore, the transfer function entails the movement between rooms of a building and among facilities from different modes within the multimodal station.

The notion of transfer concerns the experience of a traveller moving between modes. To a user, transfer is described in terms of quality (ease, speed, comfort, and logic) to move between modes at the station (Piersma & Ritzema, 2021). Transfer measurements include travel time (seconds) and travel distance (metres), and transfer quality (Likert scale). For example, a study using travel time as measure of transfer quality in a bicycle-train integration model finds that a reduction in travel time from facilities to platforms would increase the likelihood of bicycle-train combination (Geurs et al. 2016). In said study, the actual travel time is recorded for six stations, but they do not include a description of a specific space traversed to measure said travel time, meaning it’s unknown from which of the present bicycle parking facilities to which of the train platforms the travel time is recorded for, if the distance is an average of all possible routes or the shortest/longest distance (closest/farthest bicycle spot to closest/farthest train platform). Hence, the description of transfer, given the emphasis on the user and not its environment, often lacks endpoint that delimit where both the transfers space and the multimodal station starts and ends.

2.3.2. Multimodal Station Form

Outline

The physical limits or geographical demarcation of a station depends on what is meant by station as whole, which depends on what is considered part of the station. An example of how this demarcation is made is by shading the station site or building in a map, where outlining the station creates a boundary between what’s inside the station and outside the station, or by delimiting the station according to the street (Scheltema, 2012; Loukaitou-Sideris et al. 2015). The station can consist of the train tracks through or ending at the station, the platforms, the station building, the station building rooms, the station square, a combination of a few of these, or all the above. For example, from a transport planning perspective, the station is considered as a train track layout, where the station can be a “through” station (track go through) or “terminal” station (track end at station) (Amtrak, 2022). Assigning a station one of these types provides a mental image of the station and solution space. As such, in the transport industry stations can be classified according to type depending on recurring parts, patterns or requirements ((Bureau Spoorbouwmeester, 2012); Zemp et al. 2011).

For a multimodal station, this could consider each of the above parts for each mode or use the combination for each mode as a single unit within the station. Despite the possible categorisations, multimodal stations are considered a type of station "multimodal hub" and do not have a categorisation within the type, meaning it does not describe what modes are included and what components they have (Bureau

Spoorbouwmeester, 2012). Moreover, a station type that includes the bicycle parking facility as part of the station is the "integrated station" (Piersma & Ritzema, 2021). However, this definition does not make distinctions of how the facility, or facilities are configured along all other station components, but simply claim that it includes a facility that is integrated by acting as entrance to the station.

Studies on multimodal stations have varying outlines that are based on their definition for multimodality. Cases include framing the station as its own city (da Conceicao, 2015), as the station site (Siblesz, 2021), or the station concourse (hall) (Paksukcharern, 2003). In terms of scale, they are all essentially focused on the site, but the first covers a scale beyond the station site to include nearby buildings, the second includes the physical endpoints of transport services according to possible transfer between transport services, and the third focuses on the main shared space between all modes. Although multimodality aims for cohesiveness among adjacent modes, the outline varies, where the first considers the cohesiveness via a superstructure, the second considers all modes as connected via services, and the third as a single room housing different modes. Hence, even within the same scale, the station's outline can shift depending on what aspect of multimodality is being considered.

Segmentation

Another way to define a multimodal station is by what it is made up of. The station is divided into parts, where each serves a purpose, has a relation to adjacent parts, or is designated to a specific position within the station. The multimodal station is a therefore a composite object made up of smaller objects. Its composition can be framed according to what parts are considered, which influences how the station is segmented, and how said segments are arranged.

In practice, many countries, including the Netherlands, United Kingdom, Germany, and USA, segment the station according to three zones that make a distinction in parts' use: forecourt (or enter), station (or wait), and board (or go) (ProRail, 2005; NetworkRail, 2021; Lehmann, t. 2011; Amtrak, 2022). These zones tend to follow an order, expressed via a user journey (steps the user takes to traverse the station) to further breakdown sub-processes within each zone (e.g., enter, orient towards ticket gates, walk, pay). Other segmentation methods include distance hierarchies, components, layers, and in relation to structures, such as the platforms or tracks on the train side, and towards the sidewalk and the urban area in the opposite mode side (e.g. walk or bicycle) (ProRail, 2005). Among these segmentation regimes, only in distance hierarchies are bicycles and their facilities are portrayed as requiring a position closer to the station than other modes, such as tram or taxis. This provides a rule of thumb where a range is created as to maximum distance in relation to other modes when possible.

Arrangement

As the station can be segmented according to different logics, they can also be integrated in different ways. The arrangement of parts, or how they are laid out, may vary on a case-by-case basis due to spatial context, but all cases are geared to compose a continuous intelligible space to move through the station. As such, it could be argued that there is limit to the combination of parts to form the station. However, there is currently no inventory of the possible combinations in theory or practice.

Existing categorisations of station layout tend to group stations with similar layouts in relation to passenger throughput, station size, station position within the transport network or urban area, or a combination of attributes, rather than spaces. When considering a multimodal station, for example, spaces in the station are denoted for pre- or post- transport modes, without specifying what mode needs to go where. Among these layout categorisations, only one in the Netherlands includes bicycle parking facilities as part of the station across 6 NS-types (Bureau Spoorbouwmeester, 2012). Although the bicycle parking facility is mentioned for the latter three, it omits the notion that BPFs can potentially be present at all station types.

2.3.3. Multimodal Station Composition

In this section, the concept of the multimodal station was explored via its function and form. Due to the various possible interpretations the train station and the multimodal station, it is difficult to ascertain what a multimodal station is. There is a disjunction between the scale used to describe the multimodal station and the way it is segmented, preventing a clear demarcation of space, as well as what physical spaces exist within the boundaries of the stations, which may be implied between major components, but not explicitly due to case-specific context.

As mentioned before, the station tends to be composed, or made up of different parts. For stations that have the same parts, they can be categorised according to unique configurations, a pattern representing how the parts are organised. This is currently not possible for multimodal stations because they lack a principle of enclosure. For example, when considering bicycle parking facilities, it is not clear if they are considered an internal part of the station or an external part connecting to the station. Because the space between the bicycle parking facility and the other parts of the station are not considered within the station, they can be implicit, as they are physically present, but omitted because they are not included within the enclosure of the station.

Therefore, a multimodal station can be understood as being a composition delimited by a principle that explicitly includes these spaces, where the station’s composition works as a grid that allows for different configurations of parts. How the multimodal station is composed and how the space within is configured through a principle can be traced back to the relationship between the movement and space within the transfer-station: its internal circulation. Through circulation, the scale of the multimodal station is fixed, providing a combinatorial logic within a span and its parts.

2.4. Internal Circulation

Stemming from the discovery of the circulation of blood in the human body, the 19th century's preoccupation of mastering space and time found the concept of circulation most fitting to reflect the process of modern traffic (Schivelbusch, 2014). The century's social organisms were replicas of events in both the biological and the traffic sphere. In other words, when the nineteenth century saw the health and vitality of social institutions and processes as dependent on a functioning circulatory system, whatever was part of circulation was regarded as healthy, progressive, constructive, while all detached from it was diseased, medieval, subversive, threatening. This complex meaning of the circulation concept in the nineteenth century became quite explicit in French, where circulation refers to the actual movement of traffic as well as to the circulation of blood and the circulation of goods.

Circulation is essentially the movement of a unit within or through a system. The system, movement, and unit can vary according to their definition. The system can consist of one or multiple parts, be open-ended or enclosed, and the movement can vary in directionality, between two or multiple endpoints or go through the system and can vary in its rate of movement depending on properties of the unit moving (e.g., person, blood, car, air, money, etc.). In this study, internal circulation is the bidirectional movement of a unit between points inside a system. As such, the internal circulation at a multimodal station between the bicycle and train consist of the passenger (unit) moving from the bicycle parking facility to a train platform within the system (multimodal station).

The station includes both transportation elements (train platforms and other infrastructure related to the train tracks, as well as bicycle parking facilities) and architectural elements (areas inside and outside station buildings for passengers to move through and wait). For both disciplines, circulation refers to how a person moves within a space. However, circulation tends to be applied differently in these two disciplines due to different definitions for the system, movement, and unit, and their relationships. In transport, circulation often refers to the addition/removal of trains in a train line network (circulation planning), or the rate of movement through a space over time (flow), while in architecture, circulation tends to refer to the function of transitory spaces (corridors), the sequence of spaces within a building (flowline), or the visibility within the space (visual field) (Pan et al. 2024; Xu et al. 2014; Schubert. 2010; Kaijima et al. 1997; Natapov et al. 2020). Whether these definitions are incompatible or can align when studying the internal circulation of an intermodality within a multimodal station remains unknown.

This section explores the concept of internal circulation through its definition and analysis in stations from the perspective of the transport and architecture disciplines, as well as their overlap in “transport-architecture” studies, study of a transport space from both transport and architectural perspectives. This exploration informs aim to understand the relationship between movement and space of a station through its internal circulation as its compositional and analysis principle. The following subsections give an overview of distinct and overlapping definitions of circulation.

2.4.1. Transport

In transport studies, circulation can refer to the movement of different units within a system at various scales. Most commonly, circulation tends to be related to the research topic of rolling stock circulation in a train line network, which refers to the scheduling of services adding, removing train units from the system to fulfil all scheduled services (Wang et al. 2017a; Alfieri et al. 2006). At the scale of the station as a network, circulation tends to be related to a transition space within a station is described as circulation area, transfer zone, or pedestrian circulation system, whereas the movement of passengers in this space is referred to as flow (Khattak et al. 2018a; Khattak et al. 2018b; Zhu et al. 2017; Ahn et al. 2017). Moreover, the focus of flow within the station can be more granular, where the passenger flow is analysed for a walking facility, including an entry point, a platform, a ticket gate, or a stairway. (Haghani et al. 2019; Dellasin & Hool. 2018; Yamada & Utaka. 2023; Jiten et al. 2016).

At the transfer space scale, the station is abstracted as a network. The system (space) is segmented in parts where nodes can be assigned to areas rooms, zones within rooms, connecting elements (passageways, stairways), or obstacles (ticket gates) (Shen et al. 2024; Starmans et al. 2014; Ahn et al. 2017; Khattak et al. 2019; Xianyu, 2017). Here, the movement (flow) is understood as either the recurrence of trajectories (path) or intervals of passengers moving through space (passengers/m^2) (Banos & Charpentier. 2010; Eldakdoky, 2016). The first is used for research focusing on route choice, while the second on design optimisation or station capacity evaluation.

These systems tend to be analysed using queuing models via factors that affect passengers' performance in circulation areas according to passengers' walking speed, passengers' density, and dimensional features (lengths and widths of the circulation area) (Hu et al. 2015; Khattak et al. 2017; Khattak & Hussain. 2021). These analyses can be categorised as route choice, design, and capacity. Route choice studies evaluate how space or implemented restrictions (closing a corridor) affects user movements. Design studies alter dimensions or quantity of facilities to derive an optimal layout and dimensions of parts. Capacity studies evaluate how existing conditions affect user comfort and the level of service in crowdedness of a space.

Despite the different systems, flows, and measures, the transport concept of circulation refers to a space's ability to facility people to move in and out of a system (station). Circulation is measured as the space available to move through, or the degree of unobstructed space that allows for a single flow/path to keep constant flow. The improvement of circulation can be considered the reduction of distance to reduce time, or reduction of time via the increase of floor area to reduce the probability of crowding. However, what may improve for one may counteract another (Vanumu et. al. 2017). An example is that shorter distances lead to shorter travel times, but less space leads to more crowding and hence slower flow leading to longer travel time. Increasing proportions of space may reduce crowding but increases travel time due to increased dimensions. Previous research has found that width has a higher impact in this regard than length of a space (Khattak et al. 2018b)

For transport circulation, space is only a constraint on free flow, which makes movement than the space. Following physics of movement, the space guides the passenger through the station as long as there is an opening to continue the path. Whether the space can communicate, like signage would, of where to go next, or anticipate how to move through the station, to find their way and not waste time going towards dead end or second guessing the path taken.

2.4.2. Architecture

In architecture, circulation is defined as the user's experience of movement in time through a sequence of spaces (Ching, 2023). There are many ways in which space informs movement, such as the width, height, position, or openings of various planes (floor, wall, roof) (van der Laan, 1983). Moreover, there are built space attributes that assists space to inform movement, such as light, material and colour (Matsushima et al. 2020; Piersma & Ritzema, 2021). Stemming from this definition, transitional spaces that connect rooms are referred to as circulation areas, such as corridors, footbridges, tunnels, stairways, escalators, ramps, and elevators (Schittich, 2013; Schubert, 2010). These in-between, liminal, transitory spaces, work at the boundary of two or more dominant spaces, horizontally for a corridor and vertically for a stairway, while not fully part of either (Jarzombek, 2010; Rundblad, 2023). Despite the effect of space on movement, circulation in architecture tends to look at both the physical and psychological effort of movement, be it as spatial or visual continuity within a space (Emmons, 2005; Marriage, 2012).

Architectural studies on circulation analyse how the arrangement of spaces communicate movement, where circulation is the mechanism to navigate through and interact with space. These can be divided into two camps: room relation (function) and pattern of the whole building (form). Circulation is used to understand the relationship amongst a space's segments (e.g. house rooms) as a characteristic of the whole (house). For function, the circulation can be focused on the sequence of rooms and how they relate to each other. For example, in a hospital, the room relation of a lobby to each type of room (e.g. Surgery, ICU) and their function can opt to reduce the distance between rooms that benefit from being next to each other (Nourian, 2016; Cubukcuoglu, 2023). For the second, the building as a whole is considered to have an order stemming from the circulation, which drives the building's sequence of rooms and form. Studies for this cohesiveness tend to be carried out via comparative analysis of circulation types (e.g. linear, round, grid) in order to inform design and understand which types work best depending on the function of the building and its rooms (Ching, 2023; Natapov et al. 2020). Another use is to understand the evolution of rooms and how they relate within a building, such as development of recurring combinations of rooms that form an apartment building over time (Gorny, 2021).

In architectural studies on circulation of stations, including circulation spaces as parts and the multimodal station as a whole, movement, space, and their relationship depends on what is considered a part and what is considered a whole. Unlike transport studies on circulation of station, these studies look at the relation of spaces to enable movement. An example would be how different alternatives are compared as to what would perform better, if a tunnel or over pass to connect two modes' concourses, or how a different shape of footbridge would grant better connection to more spaces

(Kumar, 2011; Liu, 2023). Upon reviewing the literature, there are four cases that elaborate the differences and similarities found in the analysis of a multimodal station from an architectural perspective of circulation. The definition of space and its relationship to movement and the improvement varies per case, so these cases are briefly described below to derive what is the same and what is different.

London Terminals

The first study focuses on various London train terminal buildings and their relationship of movement and space at different scales, namely station building, station area, and at the city scale (Paksukcharern, 2003). At the station building scale, the study analyses the relationship between the space within the station building and passenger's routes for two stations. The multimodal station consists of a single room: the station concourse with its floor being shared space that connects train to metro (underground) mode under one roof. The space is analysed by using space-syntax, a theory with techniques that analyses how space is experienced and used by people (Hillier, 2007). The techniques used in this study are axial line analysis and convex space analysis. Axial lines are defined as the longest and fewest straight lines of visibility and permeability that cover all the open spaces of the urban area. Convex spaces are defined by polygons where no line drawn between any two points in the space goes outside it.

An axial line analysis consists of mapping a plan to the fewest number of straight lines that covers all spaces in the environment (Ostwald & Dawes, 2018). Axial lines represent idealised paths through space and the analysis of the topological relationships between axial lines is effectively an investigation of the movement potential of an environment. The maps produced as part of this technique abstract the environment into a network of paths (nodes) and the connections between them (edges). A convex space analysis consists of abstracting the environment into the fewest number of visually coherent spaces and the connections between them. This technique is used to investigate the configurational relationship between spaces as defined by the capacity to pass between them. Thus, the resultant map is effectively a graph of spaces (nodes) and their connections or adjacencies (edges).

These analyses aim to assess the station's spaces with regards to passenger movement in terms of moving and staying, where axial lines are associated with movement properties that give information concerning movement to destinations while convex spaces relate to the position where people are in the system, or where they are stationary. Both analyses are carried out by computer software constructed based on an accurate scale map, in this case, the interior layout plans of both stations, which include all public accessible areas of their concourse floor levels. Passenger movement is captured via observation by tracing passengers' route into and out of the terminal or between modes (entrances, metro stairs, and ticket gates to train platforms), and taking snapshot to record where people stand still.

The results of the analysis superposition the dispersal traces (passenger routes) over the axial map and the stationary points over the convex map. This results in confirming the correlation of axial lines to passenger routes. However, for both cases and both maps, it was found that passengers movements are highly influenced by the visibility of their destination (e.g. train platform or underground entrance) for movement and for standing (timetable billboards, ticket offices and the food court).Therefore, the improvement in this study is defined as configuring the interior space with entry points to align axial lines between destinations, and to arrange convex spaces so that they do not collide stationary with moving passengers to facilitate better circulation.

European Station Areas

The second study focuses on the effect architecture has on the performance of High-Speed Train Station areas in Europe (da Conceicao, 2015). The study centres on the comparison of different station areas before and after architectural interventions (e.g., expansion, redevelopment, renovation) to assess how architecture affects the performance of these areas and derive possible design strategies for future cases. The performance of the station area is defined as its capacity to facilitate movement through it to the city on however many sides it can. The relationship between space and movement here revolves around a main corridor that connects to most parts in the station and across modes. Often called the concourse (circulation space, passage, passenger tunnel or bridge), this space is the combining element or central element of a station. Therefore, this study is focused with through-circulation rather than internal circulation, and the movement of passengers within the station is centred around the concourse that allows people to move across the station and into the city.

Upon surveying 360 stations, the study derives a timeline and categorisation of the station areas' development and configurations. While focusing on the circulation between the city and transport through the station, comparative analysis is made (based on plan analysis, and the development of sites over time and the development of isometric circulation diagrams of the station site) to better understand how the arrangement of the station's parts may improve or hinder the circulation with the outside. Circulation is applied in the analysis via spatial design in the floor plan, like the Nolli map, where white space (negative space) is free to move through and black is built mass (positive space) that constraint movement. Additionally, three-dimensional diagrams are created for each station (before and after), to visualise how circulation has changed after the intervention. Circulation is therefore used to capture the environment to later analyse spatially. Because in this case, through calculations is the aim, how the space is arranged (rooms, levels) is captured in diagrams but not discussed or analysed.

Because not all stations have the same properties, comparison among cases are grouped with other that may have similar properties, such as urban location or size. A reduced number of cases are selected for a comparison among similar cases: six cases, two of each type. The stations are categorised according to the station building relation to the track in terms of service (terminal, through, mixed) and in terms of position (underground, ground-level, elevated tracks, cross). The comparative analysis that follows distinguishes the urban and building scale of the station area. At the building scale, the comparison before and after and across cases provides an overview of how circulation is affected by changes made in the area, such as how by expanding the concourse space within the station, and rearranging parts, such as positioning the train tracks underground, open up space to facilitate circulation through the station and into the city. As such, the design recommendations are to have a corridor that goes all the way through the station and is designed in a way that it blends with the city. In this case, ticket gates would be positioned perpendicular along the concourse to prevent obstruction of its endpoints (the city), where the station is an in-between space. As such, built space within the station is seen as an obstacle to be removed to make room for circulation through the station and connect its sides to the city.

Because this study focuses with through circulation (centres on how all modes coincide or connect through a corridor) and not specific circulation between modes, there is no notion of circulation within station parts, unless it is a part of the passage and then it is shown as a single continuous space. As such, while these stations are multimodal and different mode facilities are included as part of the building, the circulation paths to and from each mode's platforms is assumed to be adjacent and accessible via the concourse. Nonetheless, the survey of various cases provides a better insight into spatial configuration and how many cases can evolve in their intervention towards types. The categorisation of cases allowed for insights to be derived among similar cases.

Brussel-Zuid

The third study focuses on the redevelopment of Brussels-Zuid multimodal station (van Weerdenburg, M. 2022). This study analyses multimodal station configurations to propose design interventions for the Brussels-Zuid station in Belgium. The study first carries out a precedent analysis where various station similar in size and function to Brussels-Midi (Hamburg Hbh, Austelitz (Paris), and Berlin Ooster) to derive common features of such a type of station that serve as a guide to analyse the case study in more detail and compare them all together to see how Brussels-Zuid could improve those factors via a design intervention.

In this study, station floor plans are used to analyse the station area and determine the segmentation of the whole. Moreover, wayfinding is used as an analysis tool to understand the cohesiveness of the station via the circulation of its interior. In the analysis, the station is segmented by tracing the routes around and through the station, tracing the layout of spaces for each station, such as structures (platforms), main spaces around the station (important destinations nearby), and space layout per floor. Stations are broken down into spatial networks makes up of standard parts (platforms, hall, passages, station squares, approach streets, platforms, and underpasses) where corridors, stairs, and circulation spaces are represented as edges (links) between the nodes (space such as the concourse and platforms (all modes). Unlike other studies in this review, the endpoints in this study are from stops to station entrance to platforms, which means it multimodal in nature and considers intermodal circulation for various intermodalities, although bicycle-train is not one of them.

The study results with design insights and recommendations that span from tectonic considerations (using load bearing structure as waiting areas, merging previously separated spaces) to stacking of modes along the floors of the station according to speed and range of modes (faster longer distance modes at lower floors). As such, the results provide or clarify how space affects movement and how space can be arranged differently to improve the movement in a multimodal station and across different modes. (mention stations are turned into spatial networks, mapping the relation amongst parts towards a whole.

Here, space is the medium to circulation, where the space itself can communicate how movement occurs. It also derives insights on how the way stations are constructed result in particular arrangements of parts, and as such considers design solutions for circulation from the architectural perspective, such as tectonics, materiality, and fenestration as strategies to improve both the space and its movement. As such, circulation diagrams are developed to assess the intelligibility of the station's space: whereas the arrangement of spaces within the station help or confuse the passenger to anticipate and plan where to head next to get to their destination (a mode's platforms. As such, this is the only architectural study that considers actual endpoints among modes (platforms).
However, while it is more granular on how each part contributes to the whole, better circulation is implicit but not quantified, in the sense that solutions go beyond the arrangement of parts, so whereas parts could be rearranged, it remains unclear what contribution each part makes to the whole. Also, it looks at global circulation and not at how each intermodality can be improved, in terms of travel time or travel distance, and although other modes are considered, it centres on the circulation to and from the train platforms, meaning it remains train centric.

Tokyo Metro Laminated Space

The fourth study focuses on framing the station and its surroundings as a three-dimensional layered space, to analyse the station's layered structure within urban space (Inamochi, 2015). Although focusing on Tokyo metro stations, the framing of the station area includes surrounding spaces that include bus stops and different train line platforms, making it multimodal in nature. As a multimodal station that is a multi-layered space, the study starts by defining space, breaking down the different layers and their characteristics by framing the limits of the station area (station building and surrounding area), made up of constituent planes, defined as units of surface area based on height level and use, such as car parking, station square, platform, concourse, road, train tracks, and others). The constituent plane is then broken down into division fields, which are defined as segments of the plane divided by changes in cross-sectional configuration from adjacent planes. In other words, the focus of the study is to assess how visibility of the whole urban space changes as one walks along from entering the station area to the train platforms.

The complexity of the continuous space is analysed by capturing the number of layers (levels), the combination of planes, the relation between planes and layers, and later the subdivision of planes (division fields) based on changes in space (roofed section or change how many other planes are visible from a field). The method used to frame this definition and their analysis is called Spatial Composition (Sakamoto et al. 2012). Like Space-Syntax, Spatial Composition is a theory and has various techniques, although these rely less on mathematics and have more to do with how to frame relationships among the parts and their characteristics in terms of recurrence or combination to find the recurring configurations, which then can derive the principles that drive the composition of the parts into a whole. As such, it's possible to mend different infrastructural elements and architectural interiors and frame them all together as a frame whole, to analyse its circulation. Here, circulation is also guided by observing, but unlike space-syntax, this considers form as more important. Also, unlike previous cases, rather than being flat, this study considers the multimodal station and its parts from a three-dimensional perspective.

While circulation is not the focus of this study, through the spatial composition of the station, it is the mechanism of moving through the station to capture different points-of view, a mechanism though which this network of planes is understood, as the whole point of the arrangement of space is to both "communicate visual continuity, enable a linear sequence of space despite overlapping layers, and ensure the efficiency of movement, or use the planes themselves as queues to more towards, away, along, under or over. An example is how the train tracks point to the presence of a station, and as one follows the tracks visually, one is bound to find a visual cue (station building, concourse or platform canopy) to confirm movement orientation.

In the analysis, due to the area being framed by planes, which due to their interaction, are broken down into fields, where sharing the same spatial framework of spatial composition, the area can be then described in terms of both planes and fields, their relation, creating granularity for the relationship between an area's parts, a part's parts, a part to another part's parts, back and forth, towards understanding the parts-to-whole relationship. The results of this study show the effect of visual and spatial interaction of planes on the visual and spatial continuity and integration based on the three-dimensional plane network that forms the station area. One of the main insights is that there is an inherent hierarchy of spaces, where a higher degree of cohesiveness is found when the platform is at a higher level, being visible from various points within the area, hence ensuring visual continuity, and by extension, ensure circulation within the station area and amongst its planes.

While this study best represents how to capture and abstract the relation amongst parts of a multimodal station, there were some caveats with regards to this study. While the movement spans from the nearby buildings of the station to the platforms, the internal concourse is not considered. As such, there is a missing link between the concourse and platform, which would be the internal space between the ticket gate and the train platforms. As such, there is a fragmentation with regards to the end points and points of circulation at the station area. Also, while the stations can be multimodal (presence of bus or other modes) they are simply assigned a plane type of either platform or station square. Hence, while this study informs how different modes are connected within the station area, these connections are not considered within the scope to the study. Nonetheless, because they do represent what this study is aiming to capture, thus its method can inform this study's methodology.

Disarray

Across these studies, some insights can be derived for multimodal stations from an architectural perspective. In this discipline, space is more important than movement. This is because in architecture, the arrangement suggests movement, so it must be effortless, which can make it faster, but speed or distance between rooms within the space depends more on their relationship, that is, if their function are complementary or sequential (e.g., buy ticket in one room next to the space to pass the ticket gate and enter the paid area of the station).

This is understood via the concept of intelligibility, or how readable the space is comprehensible. Intelligibility is proportional to the amount of signage needed; where more paths is not bad if the whole can be read from all or most points. Complexity is inversely proportional to intelligibility, where harder to read space become a constraint on a passenger's movement. Whether seen as spatial cognition or visual fields, the view from a starting position (station entrance or platform) enables people to anticipate how to navigate through the space. Space determines the composition of visual field and how parts are both arranged inside space, provides user the visual relationship among parts. Hence, intelligibility becomes movement without visual breaks in the user's perception of space.

However, across the studies, circulation is not the subject matter, but an aspect of the object (the station), or a mechanism to capture space. While the space is captured and in turn analysed according to how the whole is made continuous by its parts, the studies do not assess how circulation could be improved from part to part. Put in another way, seen as a bridge, the station's internal parts and their alterations is not as relevant. As such, there is still the gap of whether both space and movement can be considered in parallel to the improvement of stations.

2.4.3. Transport-Architecture

After looking at the previous sections, where the station is assessed from a transport perspective and then an architectural perspective, several studies in this review fell somewhere between these two disciplines. For the sake of simplicity, these studies conform the field of transport-architecture. Transport Architecture studies tend to delve on circulation, as they focus on the movement of people in a transport related building or space. However, they are distinct from both the transport field perspective, where the station or site acts as a container, as well as distinct from architecture studies, where the focus is on the intelligibility space provides for circulation.

From a different perspective, a main difference can be understood according to what the studies measure. Whereas circulation in transport is the time or rate at which people move and the continuous experience of space in architecture (degrees of continuity), these studies consider weights to represent spatial aspects of the station while considering the time it takes to move through a continuous space. The studies are briefly described in the following paragraphs.

Tokyo Metro Wheelchair Accessibility

The first study focuses on assessing the accessibility, defined as both shortest time and lowest probability of collision with other travellers, of wheelchairs from the sidewalk entrance to a metro station to the platforms for 26 metro station in Tokyo. (Arai et al. 2022). The station is abstracted into a series of spaces within a spatial network, based on physical separation of what would otherwise be a straight line. The spaces are considered nodes, while edges are vertical connective components in the station, such as stairs, escalators, and lifts. To include spatial and temporal characteristics associated with the movement between levels of the station, these edges are weighted with time to represent waiting time and walking effort from a gradient. Additionally, the station's capacity is captured via the number of people inside with ticket gate check-ins in order to assess the second aspect of the accessibility, the probability of collision with other passengers. Both aspects are derived from spatial data made available by open-data database on the spatial three-dimensional drawings of the stations and using Rhino CAD-software and a program called Walking Space Data Standard, the calculations are made for each station.

The analysis considers all points of entry to the train platforms, analysing multiple routes, and as such, considering the whole of the circulation within a station. While this study is not multimodal in nature, because it considers different train lines within a single station, all paths (entry point) to all platforms are considered, where are defined as routes, can be understood as an aspect of intermodality. The study results in the comparison of accessibility for each route in a station between a walking passenger and a wheelchair passenger. The study found that the pedestrians have more ways to access stations' platforms (e.g. presence of stairs but absence of elevators). Moreover, it is found that the improvements for the circulation to the platforms consist of improving travel time via elevator position (platforms' centre) and avoiding collision by positioning elevators away from stairs/escalators.

A major insight from this study is that spatial data, such as the walking path networks for stations, makes it easier to carry out quantitative assessment of the performance of space with regards to movement. While this study deals with the wheelchair passenger, this kind of studies, deemed barrier-free facilities at station, encompass the ability of circulation, which is for passengers with limited mobility to move into and within the station. As such, this study provides an idea of how space and movement are related, where the position of one component can change how the space is configured and how fast one can move through it.

Amsterdam Stations' Intermodality

The second study focuses on the intermodal connections within multimodal Amsterdam stations (Siblesz, 2021). Here, the distance between modes is measured from platform to platform, meaning there is a case where spatial endpoints are clearly defined in a multimodal station study and not simply refer to the mode as the endpoint. This study uses the notion of circulation and names it path quality, as a factor group that is weighted to give connection grades to each possible intermodality at each station. While it does not include a way of segmenting the station, it does take into account spatial characteristics of the transfer space, such as cover, changes in height, traffic intersections, and presence of escalators/elevators. This study is the only one to capture these qualities of the path for a study on train stations in the Netherlands.

From the analysis of the intermodality at the stations, the study finds that position outside modes inside (indoors or under a common roof) reduces a lot of obstacles, such as height changes, traffic crossings, distance, and the probability for bad signage. Moreover, while there are other aspects of path quality, these three factors are seen as the most important on which to improve. The study positions that locating a mode outside a station building and serving it with a level crossing to connect the platform are deliberate design choices, the ill signage however is obviously not a deliberate design choice. As such, the possible interventions at the stations remain to place the modes closer and have better signage between them.

The main takeaway from this study is that as it can measure Path Quality (PQ) between modes aggregated, meaning not at the level of each platform, but averaging the distance between modes. It is also sad that while this study is promising in terms of circulation quality, the aspects and their weight are only part of other considerations, where PQ as a whole is not as important as other factors, such as services and information (signage). Also, while weights are given for observed "survey checklist (13)" to consider factors such as traffic crossing, elevators, roofs, and levels, it does not consider how their position/orientation/segmentation affects the travel distance (all or nothing). However, it is very positive that this study acknowledges the relationship between space and movement in terms of intermodalities at a multimodal station. A problem for this study on multimodal station however is the idea that not being all part of an "inside" is a recipe for failure.

Disarray

Interestingly, while both cases consider the spatial structure of the station to assess circulation between modes in the station, one can see that in both, the more important topic is the vertical changes imposed by elevators and stairs on users based on their weights, which affect the performance of the users' circulation. So, they do consider the station as a sum of its parts but come back to use or classify the parts according to their bottleneck or obstacle property. As such, a network graph can represent the sequence of steps and where there are constraints to free flow based on the actual built environment, but from the results, Arai suggests positioning elevators connecting to the centre of the platforms, while the other suggests that placing modes outside the main building worsens in all measures of transfer quality, given the outside, increased distance, traffic crossings, and poor signage).

2.4.4. Spatial Framework

In this section, we want to understand circulation as the motion aspect of a (spatial) system, which is studied from two perspectives to narrow down a third perspective which merges concepts from the other two. It can be appreciated that circulation means a different thing in each perspective. In transport, circulation is an input, where it represents a requirement to have a certain speed to provide a good level of service or be considered safe to traverse within a space. In architecture, circulation acts as a design mechanism where both the arrangement of spaces and the form of each space inform the user how to move within the space. The relation between the two disciplines could be said that architecture proposes a circulation space in the form of a sequence and transport evaluates its efficiency. The third perspective of transport architecture provides an overview of how both disciplines come together, where circulation is as much based on space as it is on movement Nonetheless, it falls short on the role each part has and how their configuration affects the whole. This could be associated to the spatial framework used to establish what is the whole, what are its parts, and how they relate to each other.

Despite all the studies reviewed being based on different disciplines and applying different methodologies and having different goals in mind, a recurring pattern across all of them is the use of graphs to represent the relationship between movement and space. The station is seen as a network of spaces (nodes) that connected to each other via links (edges). Depending on the study, the definitions of nodes and edges can vary, but they nonetheless represent the aspect of circulation. As such, it can be argued that the methodology for this study should also implement the graph as an abstraction of the bicycle-train intermodality at the multimodal station. This can be better understood by briefly describing the use of graph theory in space-movement research and then compare the methodologies used in the reviewed studies.

Whether it is the network analysis of a multimodal network (van Nes, 2002) a train station (Ueno et al. 2009), the network of rooms in apartment buildings (Gorny, 2021), network of spaces in a Hospital (Cubukcuoglu, 2023), or a network of streets in a city (Boeing, 2017), all studies use graphs to represent connection among parts of the whole and are based on graph theory (Franz et al. 2005). The recurring concept for connection to abstract the complexity and connections within a station tends to narrow down to a boundary graph. The three disciplines apply it, although with different aims. In architecture, graphs are an abstraction tool used to make buildings that maybe can't be compared according to their form, but can according to their structure, that is, how their parts are organised. By translating the form into a graph, these buildings can be compared in terms of network or node properties. What separates the graphs needed for this study versus those of in the transport disciplines is then the definition of the boundaries to delimit the network, and to separate its nodes via links.

Each discipline uses the same abstraction based on graph theory: steps, depth, pattern, these are supplemented by theories (Dijkstra, Space-Syntax, or Spatial Composition). For example, in the London case, the selected stations are analysed for circulation using Space-Syntax at the station hall, neighbourhood scale, and setting the 5 stations against the city street grid. As such, space-syntax can frame the space (system) to assess the circulation inside it using the different available metrics. One particularly interesting metric is depth, where the framed space is abstracted as nodes and edges in a graph. Here the metric depth refers to the number of spaces from the initial space to all other spaces, indicating how “deep” into the building a space is. However, because this study revolves around a single space at the site scale, this metric is not applied for the stations.

Depth, being a justified graph, is not dissimilar from what Inamochi uses to abstract the relationship of layers conforming a Tokyo metro station by applying Spatial Composition. Spatial composition is applied to assess the relationship of parts through the framing of a whole, meaning, where a typical analysis is would be to assess a building and its parts, framed by its conventional borders (building enclosure), spatial composition is used to add spaces not considered within this framing as parts of the whole, such as considering voids within and outside the building as spaces, and assess the properties of this parts in relation to other parts and to the whole. In the Japanese context, this method has been previously applied to assess characteristics of the built environment around and in stations by framing them together. Examples include the framing of spaces under train tracks, station’s square visibility to buildings around, facades making a station elevation, and the continuous space that are station passages that run longer than the station itself, creating a composite passage

connecting to adjacent buildings and towards the street (Saito & Almazan, 2020; Yasumori et al. 2008; Inamochi, 2015).
Assuming both Space-syntax and Spatial Composition can be applied to frame the whole and analyse its parts, spatial composition seems more appropriate because it can frame the whole and parts according to its own formulated logic, where the BPF can be included, and the separation of spaces can be defined according to available data and consideration for circulation. Given none of these are about circulation, it nonetheless expresses a tool that sets apart our definition of circulation, where rather than flow or route, the ability to both frame BPFs together with the station and able to isolate the intermodality as a graph allows to not only see the route, but assess the properties of each part, characteristics between/amongst parts, and specific configuration using generalised parts to explain the composition. Therefore, it can be concluded that graphs abstracted from a spatial composition can provide a methodology that treats the relationship between space and movement in a horizontal rather than hierarchical manner.

2.5. Reflection

In this chapter, a review of literature was carried out to better understand how intermodality, the multimodal station and circulation could be studied for this investigation. Starting with an approach section to contextualise the literature search narrow down what information to look for, the concepts of bicycle-train intermodality, the multimodal station and internal circulation were reviewed, followed by a review of relevant theories of spatial configuration. The latter were considered as the tool that could tie in the three concepts discussed, which provided insights as to why the state of research is where it is for a subject matter that is at the intersection of many things (e.g., research fields and spatial scales). Upon concluding the literature review, some reflections can be observed, which somehow nice cascade into each subsequent section. They are described briefly in the following paragraphs.

Firstly, the BT intermodality is centred around span. Whether considering a whole trip (O-D pair) a trip leg (origin-access) or a segment within a trip leg (access station arrival – access station departure), these spans are the most basic way to separate what the research field is and what topic within the field is the subject matter. Moreover, each span has multiple dimensions and focusing on one specifically, such as physical integration in this case, provide a clearer picture of what kind of research exists on the transfer between bicycle and train physically at the station. Within this span, there were many types of research found that do provide information on the relation between the bicycle and train mode, but in most cases, they were either focused on one of the two sides, or one belonging to the other (mostly bicycle parking facility as an addition to the station). As such, a missing sense of spatial scale is present in existing research. In other words, while the span is defined, what the content of the span is unknown.

Secondly, the multimodal station is centred around scale. Because stations are a piecemeal endeavour and additional mode facilities are added over time wherever space is available, the scale of a multimodal station doesn't fit perfectly into a conventional spatial scale. Preceding the form, a brief overview of the transfer function of the station informed what was crucial to a spatial definition and what may be outside the scope. By looking at how the outline, segmentation and layout of a multimodal station can be defined, it was better understood how existing categorisations of the station are and why they are missing a spatial definition of intermodal spaces such as that between bicycle parking facilities and the train platforms. Because bicycle parking facilities remain an additional facility to the station, existing spatial definitions would render it external to the whole.

Thirdly, to integrate the bicycle parking facility into the multimodal station, internal circulation facilitates tracing the transfer movement that makes both objects part of a bigger whole. Literature in transport and architecture research was explored to understand how the space is traced and how the concept of circulation is used to measure movement within the station. It was found that transport research uses circulation as a requirement, where the space is simply a container which should aim to reduce impedance and be streamlined to facilitate flow. In architecture, circulation relates to the movement through a building, but which is directly affected by the form and/or function of a space. The review of both help to better understand how these understandings of circulation come together in transport research architecture, where both optimisation and configuration are complementary to each other. In these cases, even when the span and the scale is clearly defined, it was found that circulation was used to measure connections and its quality but did not delve into how each part contributes to the whole. As such, the segmentation and configuration of the station and its parts was largely unquestioned and was divided according to pre-established notions of separation between the station and adjacent spaces. At the end, there is a lot of methods to potentially analyse intermodality within a multimodal station, but it's not clear what spatial framework can be used to integrate the bicycle parking facility into the whole.

Finally, it was found that the analysis frameworks of the reviewed studies rely on using the graph as an abstraction of circulation. Not apparent at first sight, the relationship of part to whole is most simply abstracted into a justified graph. From the studies reviewed, it was found that space syntax and spatial composition could be applied to tackle the research problem and work as the methodology, bringing the three concepts together for this study. Due to spatial composition's focus on the combinatorial logic of the parts to form a whole and how wholes can be classified into types, this method informs or rather could be further developed as the proposed methodology to study the relationship between space and movement between bicycle parking facilities and train platforms at multimodal train stations.

Chapter 3: Methodology

Upon reviewing available literature on the concepts of BT intermodality, the multimodal station and internal circulation, some limitations and opportunities can be observed. The literature review informs the development of a methodology to tie in the three concepts to analyse the effect the station configuration has on the circulation between a BPF and the train platforms. Given the history, experience, and extensive inventory of BPFs at train stations in the Netherlands, the train stations in this country are selected as the case selection for a case study. Due to the variability across stations, it is important to first establish the general principles of the multimodal station as a spatial network, to then contextualise to how the spatial network can be analysed in the Dutch context in terms of circulation.

To create a framework to analyse these stations, this chapter explores the limitations and opportunities offered by the literature review of the three concepts. This informs the proposed methodology, which includes theoretical underpinnings and conceptual goal and procedure. This is followed by an overview of the case study by explaining the current state of bicycle parking facilities at train stations in the Netherlands, the data available to study them, and the case selection for this research. From the description of the case study, a methodology is established. Here, the unit of analysis that frame both parts and whole of the multimodal station is explained, as well as the data collection methods and conclude with two analysis examples.

3.1. Repositioning Problem

This research's question is "what constitutes a transfer space and how does it affect the circulation between a bicycle parking facility and the train platform at a station?". While the question remains intact, but we observe another problem on how intermodality, multimodality and circulation relate to each other through the configuration of the transfer space. It becomes necessary to reposition the problem with the derived insights from the literature review to specify a methodology that may tackle more than one of these concepts and do so simultaneously. In this section, this exercise is done by first going over the relationship between these three concepts within the research's problem. The relation of concepts provides arguments for the existing limitations of the subject matter and exhibit the challenges of formulating a methodology that could take the three into account at once. This is followed by the opportunities found from these limitations. Explained via an analogy, this exercise intends to inform the approach to the rest of this chapter in the formulation of the methodology and the case study.

3.1.1. Concept Limitations

The relationship between intermodality, multimodal station and internal circulation is volatile according two points: the demarcation of the space considered the station and its parts, and the alignment of the terms intermodality, multimodal, and circulation in their application on a study as a hierarchy of scales. While the second has been addressed in the literature review, the first remains a problem. The constant change and variation of stations, both in movement and space, makes any demarcation of the space specific a study and to that moment in time. An example would be catalogue of stations that needs updating over the years, where the categories created do not stem from a logic of a root, say the platform and its additions, but may rely on features such as integrated, intermodal or multimodal, which do not offer a general way of describing how all stations are related spatially. Therefore, the main limitation is that the relation between these three concepts cannot resolve the issue of the demarcation of the space that is the multimodal station, its intermodalities or internal circulation through their hierarchal relation.

This unresolvedness can be assessed by relating the concepts to a spatial framework. In this case, we can see how each concept can inform what framework is used. If circulation considers the path through the station, each part becomes less important. If intermodality considers the distance between modes, its spatial framework delimits the borders of each mode facility (e.g., entrance or ticket gate) as the endpoints, instead of actual endpoints (e.g., platform or a surface area a passenger steps in or out of a mode). If internal circulation is studied within a single room (hall) that connects multiple modes (intermodalities in a multimodal station), its spatial framework delimits endpoints at ticket gates and not the actual endpoints (platforms). Seen from the perspective of the framework, there's no framing of intermodality according to a framing of multimodal station and there is no method to assess its circulation. There is circulation of the multimodal station as a whole, but no way to compartmentalise the focus on a specific intermodality and its spatial characteristics. In other words, Circulation frames the station as a flow through a corridor without considering the configuration of multiple spaces within an intermodal transfer space or throughout the multimodal station.

3.1.2. Framework Opportunities

Despite these limitations, it is evident that the three concepts are interlinked via the spatial framework, as considered in the literature review. The spatial framework can be based on the circulation between two or more endpoints of the multimodal station that represent an intermodal transfer. Moreover, the representation of the spatial framework can be based on a network graph, hence understanding the multimodal station as a spatial network, with intermodalities as sub-networks within the network and circulation as links between spaces (nodes). Understanding the station as a network allows for it to be compatible with scale, framing, and analogy.

Scalability

The relationship among the three concepts can be understood as hierarchical, where circulation is a function of an intermodality, which is a function of a multimodal station. It should therefore be possible for a multimodal station to be described in terms of its intermodalities and circulation. Increasing the scale, a multimodal station network across a county can be described in terms of multimodal stations, intermodalities, and circulation. This allows the concepts to work under the same spatial framework, one where the parts that describe each concept contribute to the explanation of the other concepts as they increase or diminish in scale.

Network graphs are useful in this case because one can study a thing at different levels of detail, or granularity, without losing too much fidelity. As such, network graphs can be used to represent objects within a room, rooms within a building, buildings within a site, and intersecting transport services across a geographical area. As such, the relationship between BPFs and train platforms within a train station lie somewhere between rooms within a building and buildings within a site. To develop a spatial framework for this scale from the perspective of network graphs allow for the scale to be compatible with the concepts' respective scales and other scales relevant to both the transport and architecture discipline.

Framing

Because the framing of a space outside conventional scales requires an explanation of how it is framed, architectural theory can be applied to assist the definition of the network, nodes, and edges of a multimodal station. Additionally, because of ongoing changes at stations and their surroundings, existing standardisation of parts is very basic, while architecture can develop these definitions at any point in time, specific to the focus of analysis. As explained previously, spatial composition can frame basically anything according to the definition of a whole through the definition of its parts and the intended relationship between them to analyse. Although there are many advantages to applying this framing method, one that seems interesting is that of how space changes over time, that is, its evolution.

Analogy

The idea of analogy is to be able to position the multimodal station and what constitutes part of it as a broader idea present in other built spaces. Two examples of this are the dwelling bathroom and the shopping centre car parking lot, where their relation is that of multiple objects being morphed into a single object over time. The two may stem from comfort, but they end up being regulation, such as a dwelling not being one without a bathroom, or a shopping plaza requiring one parking space per chair within a module. What the framing of a spatial framework makes possible is the ability to understand how these came to be, tracing back to the moment before they were coupled within a whole, and how it has evolved since being included (e.g., position within whole and what are considered necessary adjacent spaces to them). This could be easily understood with the framing of a house, when over time, a bathroom appeared and was part of a house, but not as easy is the bathroom is the focus and all of a sudden, a house appears and takes over, and it becomes more difficult to question the position of the bathroom as just a part of the house and not being able to alter what the house means through modification to the house. An example of this could be the addition of the bathroom alters where pipes and wet rooms are positioned (e.g., vertically to use the same drainage pipe).

With the station, there are standard parts, such as platforms and parking facilities, but space between them is the result of their spatial context, constituting a space that includes standard and non-standard parts. To be able to explain spatial changes in a station over time, such as luggage facilities becoming redundant and ticketing areas being phased out by automated payment systems, it could be possible to theorise space in the station so that the constituent parts remain the same despite changes over time, demonstrating which parts are constant and which are temporary. Depending on what becomes the part, this could also be compatible with other scales, framed by the same part.

3.2. Case Study: Bicycle Parking Facilities at Dutch Train Stations

To ensure the proposed methodology is aligned to the case study's context, the selected case study and the available information of its space can inform how the methodology is implemented. As found in literature and media, the best context in which to study their relationship of BPFs at train stations is in The Netherlands due to it being more developed (MVVI, 1997; Harms et al. 2014; Rietveld & Daniel 2004; Nello-Deakin and Harms, 2019). This could be due to the number of parking spots at train station and access/egress to train stations via bicycle. The Netherlands currently has 535,000 parking spots across 400 stations. This is higher than other countries that also promote bicycle-train intermodality, with the closest being Germany (400,000 across roughly 5,400 stations) (Veloplan, 2021). Moreover, the situation in the Netherlands is they are victims of their own success, as parking demand increases across the country, put pressure on capacity in many stations (Dolders & Reiling, 2020). This section explains what is the current state of affairs of BPFs at Dutch train stations, followed by the selection of cases to analyse and the available data for their analysis with regards to the research problem.

3.2.1. Dutch Context

Although the first BPF in the Netherlands was built into the current Deventer station in 1916, the current state of affairs can be best explained through the policy to actively implement them at train stations across the country (Piersma & Ritzema, 2021). Since 1999, the Netherlands has had an active bicycle parking at train stations policy to promote the combined use of bicycle and train in trips via the improvement and Implementation of bicycle parking facilities at train stations (Piersma & Ritzema, 2021). The improvement sought by the policy has been attributed to the general increase of bicycle share as access and egress mode for train passengers and the increase in total capacity of parking spots at train stations since the policy was introduced (Martens, 2007).

As of 2020, there are 810 BPFs across 398 stations (Piersma & Ritzema, 2021). Between 1999 and 2024, capacity has increased from 279,000 to 535,000 bicycle parking spots at train stations, with 50,000 deployed in 2020 alone (Martens, 2007; ProRail, 2024). The share of the bicycle mode as access and egress mode has also increased over time, from 27 and 6.7 percent in 1993, to 36 and 10 in 2006, to 43 and 14 percent in 2019 (Martens, 2007; Jonkeren et al. 2018). The increase in capacity has also been possible due to the development of design guidelines that have developed both standard facility solutions and solutions tailored to a station's specific conditions, based on design criteria such as parking demand, available space, security requirements, and available budget (Piersma & Ritzema, 2021).

An increasing complexity in the design of facilities has recently resulted in various large facilities resembling their own station, such as the 12,300 spot mega-facility at Utrecht Centraal, completed in 2019. Recent years have seen the propagation of both guarded facilities and bigger facilities, such as Zwolle (3,800 parking spots), Leiden Central Station's Del Lorentz (4,000), Den Haag Central Station's Koninginsplein

(8,000), and Amsterdam Central Station's De Entrée (8,800) and IJ-zijde (3500), which are all underground facilities. Along these past and upcoming projects, ProRail expects to reach 660,000 spots by 2040 (ProRail, 2024).

With its main objective being to get more people to commute to the train by bicycle, the implementation of new facilities and improvement of existing ones distinguished two types of parking infrastructure from the start back in 1999: secured and unsecured facilities (Jonkeren et al. 2018). Initially concerned with an aspect of security, today they are called guarded and unguarded, and they can differ in built form (uncovered, canopy, roof, walls, levels), parking regime (free or paid entry), security (unsupervised, locker, self-service, staffed), and placement in relation to the train station (in, at, under, next to, opposite, up to 50 or 200 meters away) (Piersma & Ritzema, 2021). Among the variations per facility feature, the distinction between these two categories can be narrowed down to construction complexity, where unguarded facilities tend to be relatively cheap and able to be implemented as standard outdoor ground facilities with no cover or partial cover, while guarded facilities tend to be context dependent and be developed as a 'special' tailor-made solution, resulting in more expensive investments (Piersma & Ritzema, 2021). Guarded facilities present more challenges and tend to be implemented in complex environments, that is, where available space for the facility is limited and parking demand is high.

In the Netherlands, a bicycle parking facility can mean many things. The bicycle parking facility at the train station is generally defined as a space that facilitates the parking of multiple bicycles close to the train station (CROW, 1996). The term facility is a container term for space, as it can stand for a parking area, object, structure, or building. The area is a space assigned with the function to park bicycles. The object, structure and building exist within this area. The object, a bicycle rack consisting of a series of bicycle clamps in one or two levels (a double-layer bicycle rack). The structure typically consists of a partial or full roof sustained by columns and or walls. a parking building, often referred to a bicycle station, may include more features such as personnel, security cameras and repair service.

As mentioned for design guidelines, the differentiation of properties prompted a classification of facilities as they have been implemented at stations over time. To standardise design solutions, NS has established five facility types: ground-level, bicycle-flat, indoor, underground, and mega-facility. Their descriptions can be read in Appendix B. In 2020, the percentages for facilities, counted as 507,000 parking spots, are divided as follows: ground level (60%), bicycle flat (3%), indoor (11%), underground (24%), and mega (2%) (Piersma & Ritzema, 2021). In this study, the distinction among them is the separation from ground-level and all other four types. The distinction between them is that the first is open-ended, being a parking open area, while the others are enclosed at least on one side, be it corralled (fence) or covered (canopy or roof). As such, the facilities are considered open (ground-level) or enclosed (flat, indoor, underground, mega). This is to say because guarded facilities have a security feature that is not exclusive to specific structural properties, where a facility can look like guarded, but may in fact not have security or staff. As such, the distribution of parking spots between open and enclosed facilities are 60 to 40 percent. It is unknown what their distribution with regards to the 810 facilities.

3.2.2. Case Selection: Stations with Enclosed Bicycle Parking Facilities

Considering that there is currently no inventory on the spatial features of each facility at each station, that enclosed facilities are considered an improvement over open facilities, and that enclosed facilities are potentially less facilities with greater capacity, this study delimits the analysis of BPFs at the train station to those with enclosed facilities. The only available information on facility presence at train stations is based on the number of parking spots per facility type per station. Although this number per type could be concentrated in a single facility, it could also be distributed in multiple facilities of the same type. Therefore, the case selection for this study begins with the selection of train station that have presence of facility types within the enclosed facility category.

Using the most recent list with all parking spots per facility type per station in the book "Fietsparkeren bij Stations", dated from June 2020, there are 95 train stations in the Netherlands that have the presence of parking spots for a facility type withing the grouping of enclosed facilities. The stations are numbered with an "s" before the station number to differentiate from facility numbers (e.g. s48: Heerlen and 073: Heerlen). These stations are listed in the table as follows:

#	Station Name	#	Station Name	#	Station Name
s01	Alkmaar	s33	Deventer	s65	Maarssen
s02	Alkmaar Noord	s34	Dordrecht	s66	Maastricht
s03	Almelo	s35	Driebergen-Zeist	s67	Meppel
s04	Almere Centrum	s36	Ede-Wageningen	s68	Middelburg
s05	Almere Buiten	s37	Eindhoven Centraal	s69	Naarden-Bussum
s06	Alphen aan den Rijn	s38	Emmen	s70	Nijmegen
s07	Amersfoort Centraal	s39	Enschede	s71	Oss
s08	Amersfoort Schothorst	s40	Goes	s72	Rijswijk
s09	Amsterdam Amstel	s41	Gouda	s73	Roermond
s10	Amsterdam Bijlmer ArenA	s42	Groningen	s74	Roosendaal
s11	Amsterdam Centraal	s43	Groningen Europapark	s75	Rotterdam Centraal
s12	Amsterdam Muiderpoort	s44	Haarlem	s76	Schiedam Centrum
s13	Amsterdam RAI	s45	Harderwijk	s77	Sittard
s14	Amsterdam Sloterdijk	s46	Heemstede-Aerdenhout	s78	Steenwijk
s15	Amsterdam Zuid	s47	Heerenveen	s79	Tiel
s16	Apeldoorn	s48	Heerhugowaard	s80	Tilburg
s17	Arnhem Centraal	s49	Heerlen	s81	Utrecht Centraal
s18	Assen	s50	Helmond	s82	Utrecht Overvecht
s19	Baarn	s51	Hengelo	s83	Utrecht Vaartsche Rijn
s20	Barendrecht	s52	s-Hertogenbosch	s84	Venlo
s21	Bergen op Zoom	s53	Hilversum	s85	Vlissingen
s22	Best	s54	Hilversum Sportpark	s86	Voorburg
s23	Beverwijk	s55	Hoofddorp	s87	Weert
s24	Bilthoven	s56	Hoogeveen	s88	Weesp
s25	Boxtel	s57	Hoorn	s89	Woerden
s26	Breda	s58	Houten	s90	Wormerveer
s27	Castricum	s59	Houten Castellum	s91	Zaandam
s28	Culemborg	s60	Kampen	s92	Zaltbommel
s29	Delft	s61	Leeuwarden	s93	Zutphen
s30	Den Haag Centraal	s62	Leiden Centraal	s94	Zwijndrecht
s31	Den Haag HS	s63	Leiden Lammenschans	s95	Zwolle
s32	Den Helder	s64	Lelystad Centrum		

Figure 3.1. *Case selection of train stations with enclosed facilities*

A detailed account of each station and its characteristics can be found in Table B.2. in Appendix B. Having this list of stations narrows the scope to investigate enclosed facilities at this set of train stations. While there is a possibility that other train stations not included in this list could have enclosed facilities, because this list was made in collaboration with NS and ProRail, the list is taken as definitive and therefore other train stations are not checked for enclosed facilities. Also, although new BPFs have been implemented in the last four years, only those implemented in this list are considered.

3.2.3. Available Data

To carry out this research on the transfer space at train stations, it is necessary to collect and process data related to both the facilities and the train stations. This includes identifying the number of facilities at each station with regards to their characteristics, such as type, capacity, construction year, and position. Hence, three main methods are used: literature review, on-site observations, and visual representations. The following subsections provide more detail of how each was used to carry out the analysis of enclosed facilities at the stations.

Document Review

The Document review was used to collect background information on the stations with enclosed facilities and their locations, as well as the historical development of the station site to understand where and when facilities were added to the site, as well as the number of services, train platforms, and passenger flows of each station. Literature was also reviewed regarding the types for facilities and train stations to understand if there was an inventory for spatial configurations to use as a mechanism to analyse the cases typologically. Literature was reviewed on the various policy and design guidelines to find how facility types are identified in the field, that is, how types are distinguished according to their specific properties. Lastly, there was also a review of literature to get an overview of what components within the bicycle-train space have been defined and how they are produced. While this research develops its own terms, the literature review of these topics informed the developed terms used.

Online and Field Survey

Following the collection of background information for each case, it is necessary to corroborate the known data with the spatial data on each station site. This was done in two phases: first, the station sites were mapped using online mapping services, such as Google Maps and Openstreet Maps. These two provided the outline of the station site, and in most cases where the facility is a detached building, locate both facilities and platforms. Secondly, the arrangement and articulation of components was carried out by using Google Images and Google Streetview of locations within and outside the station. This provided more detail on the site, and its content, that is, the arrangement and articulation of its components. From this information, an initial analysis was carried out to categorise spaces when comparing all components across all cases.

Given that both map services can be updated or outdated, the maps, as well as the images and Street View images could cease to be factual. While initially considered to make fieldwork at the station sites, it was assumed that most stations were up to date. Also, because the inventory of used to select the case stations to study are from summer 2020, new facilities were added as found within the analysis of each station. Keeping updates on new BPF implementation via sources such as ProRail and NS, it was found that all new BPFs were implemented in the selected 94 stations, with one additional station (s04, Almere Centrum), which through a redevelopment of the ground floor upgraded its two main BPFs at the station in 2022. Additional new BPFs can be identified according to their built year in Table B.2.

Upon checking the literature and maps of the station sites, 136 facilities where found. It is important to note that facilities at the train station can be operated by NS, the municipality, or a third party. Facilities that serve other destinations, such as offices, housing, or universities that were in the vicinity of a train station were included in this category. Examples of this are P3 at Delft Station (040), Doornzijde at Nijmegen (100), and LUMC facility at Leiden Centraal (090). The facilities analysed in this study are listed in the table below. Because the facility name could make it confusing as to what station it corresponds, facilities are primarily discussed according to their inventory number (001 – 134), their station and number according to added date (e.g. Leiden Centraal (4)), and lastly their official name or alias (e.g. Doornzijde, IJ-zijde). A detailed account of these facilities and their background information can be found in Table B.3 in Appendix B.

Table 3.1. *Case study list of identified enclosed facilities (136)*

#	Station Facility (Number)	#	Station Facility (Number)	#	Station Facility (Number)
001	Alkmaar	047	Den Haag HS	093	Leiden Centraal (5)
002	Alkmaar Noord	048	Den Helder	094	Leiden Lammenschans
003	Almelo	049	Deventer	095	Lelystad Centrum
004	Almere Centrum (1)	050	Dordrecht	096	Maarssen
005	Almere Centrum (2)	051	Driebergen-Zeist	097	Maastricht
006	Almere Buiten	052	Ede-Wageningen	098	Meppel
007	Alphen aan den Rijn (1)	053	Eindhoven Centraal (1)	099	Middelburg
008	Alphen aan den Rijn (2)	054	Eindhoven Centraal (2)	100	Naarden-Bussum
009	Amersfoort Centraal (1)	055	Emmen	101	Nijmegen (1)
010	Amersfoort Centraal (2)	056	Enschede (1)	102	Nijmegen (2)
011	Amersfoort Schothorst	057	Enschede (2)	103	Oss
012	Amsterdam Amstel	058	Enschede (3)	104	Rijswijk (1)
013	Amsterdam Bijlmer ArenA	059	Goes	105	Rijswijk (2)
014	Amsterdam Centraal (1)	060	Gouda (1)	106	Roermond
015	Amsterdam Centraal (2)	061	Gouda (2)	107	Roosendaal
016	Amsterdam Centraal (3)	062	Gouda (3)	108	Rotterdam Centraal
017	Amsterdam Centraal (4)	063	Gouda (4)	109	Schiedam Centrum
018	Amsterdam Muiderpoort	064	Groningen (1)	110	Sittard
019	Amsterdam RAI	065	Groningen (2)	111	Steenwijk
020	Amsterdam Sloterdijk	066	Groningen (3)	112	Tiel
021	Amsterdam Zuid (1)	067	Groningen Europapark	113	Tilburg (1)
022	Amsterdam Zuid (2)	068	Haarlem (1)	114	Tilburg (2)
023	Amsterdam Zuid (3)	069	Haarlem (2)	115	Utrecht Centraal (1)
024	Apeldoorn (1)	070	Haarlem (3)	116	Utrecht Centraal (2)
025	Apeldoorn (2)	071	Harderwijk	117	Utrecht Centraal (3)
026	Arnhem Centraal (1)	072	Heemstede-Aerdenhout	118	Utrecht Centraal (4)
027	Arnhem Centraal (2)	073	Heerenveen	119	Utrecht Overvecht
028	Assen	074	Heerhugowaard	120	Utrecht Vaartsche Rijn (1)
029	Baarn	075	Heerlen	121	Utrecht Vaartsche Rijn (2)
030	Barendrecht	076	Helmond	122	Venlo
031	Bergen op Zoom	077	Hengelo (1)	123	Vlissingen
032	Best	078	Hengelo (2)	124	Voorburg
033	Beverwijk	079	s-Hertogenbosch	125	Weert
034	Bilthoven	080	Hilversum	126	Weesp
035	Boxtel	081	Hilversum Sportpark	127	Woerden
036	Breda (1)	082	Hoofddorp	128	Wormerveer
037	Breda (2)	083	Hoogeveen	129	Zaandam (1)
038	Castricum	084	Hoorn	130	Zaandam (2)
039	Culemborg	085	Houten	131	Zaltbommel
040	Delft (1)	086	Houten Castellum	132	Zutphen (1)
041	Delft (2)	087	Kampen	133	Zutphen (2)
042	Delft (3)	088	Leeuwarden	134	Zwijndrecht
043	Den Haag Centraal (1)	089	Leiden Centraal (1)	135	Zwolle (1)
044	Den Haag Centraal (2)	090	Leiden Centraal (2)	136	Zwolle (2)
045	Den Haag Centraal (3)	091	Leiden Centraal (3)		
046	Den Haag Centraal (4)	092	Leiden Centraal (4)		

3.3. Methodology: Station Spatial Composition

The previous section provides an overview of the Dutch context and the case selection for the case study, including the data available for the analysis. While there is information on the stations and their BPFs, the space between facilities and platforms remains elusive. One way to describe this space could be according to type. Types exist for many things, animals, people, professions, and buildings. Generally, types are used to distinguish among things of a same category according to recurring features. In architectural research and theory, type can be used to synthesise a model, a constant despite variable, a recurring phenomenon, or a deep structure among a grouping of buildings (Vidler, 1977; Lechner, 2021; Aris, 2021; Rossi. 1984; Lee, 2012). Stations and BPFs, as briefly discussed in the previous chapter, are also categorised in types according to recurring features, such as underground facilities or open-sky stations (without a station building). These categorisations work within the variance of a discrete object for recurring parts, or patterns.

This becomes more difficult to apply types when the object in focus is composite, meaning it includes more than one discrete object. The multimodal station includes not only bicycle parking facilities and the station, but other station components and other mode facilities. As such, the problem of categorisation stems from the framing or demarcation of the composite object. As the composite object can become complex where the features of each part within it have varying parts per case, the notion of categorisation can be narrowed down to a principle that represents the relation between the objects that form the whole and can therefore become a recurring feature for a type and a distinction to other types according to the relational principle between or amongst parts. One method for composite objects includes typo-morphological analysis, which compares across urban areas to classify them according to recurring patters or outlines (Morobaki & Oktay. 2022). While useful for composite objects, the transfer space is falls between the scales of building and block and therefore lacks the category of analysis of a composite object framed for analysis but an “established” scale.

The space between BPFs and train platforms, when not designed together in tandem with the others, is more likely than not leftover space. Leftover space can be defined as space created as a void between other buildings that results from the space left over by build space, such as a courtyard within a Parisian block, or the shape of the space between two university faculty buildings that were designed and built twenty years apart. This space is urban in nature, part of the street rather than part of buildings, which normally to be considered requires scaling to the urban area. While in Western architecture, framing a space is mostly focused on the building’s outline and interior, Eastern architecture can also focus on the leftover space, the void, or negative space, between buildings (Grabar & Dupre. 2023). As such, this study proposes tackle this problem is by using a Japanese architectural theory: spatial composition theory.

In this section, the research methodology is proposed to answer the research question at hand for the definition of the transfer space and the hierarchy of defined concepts. First, the theoretical background of the proposed methodology, spatial composition, is introduced. This is followed by adapting the theory into the current application, specifying the unit of analysis in Sub-section 3.3.2. Sub-section 3.3.3. provides an analysis framework of the application of the methodology in the case study.

3.3.1. Spatial Composition Theory

The purpose of architectural theories is to find a narrative that can both describe why buildings are the way they are and formulate the set of principles on which new buildings are built. Spatial composition is an architectural design theory and methodology concerned with the way in which parts that make a whole are assembled and what the meaning of the space related to it is through the comparison of formalised types based on spatial arrangement. The concept of composition used entails the formation of architecture, where an object, such as a house, is segmented from the whole into parts (e.g. rooms, floors, surfaces, volumes), to be later integrated back into the whole. While the first is descriptive (how many rooms, positional relation amongst the rooms), the second engages the creative process as to why they are these many rooms and why there are arranged in the way they are, as if giving the composition its meaning (Sakamoto et al. 2012). As such, this relationship between the parts and the whole is the main aspect of the theory's framework and can be considered its compositional principle, which clarifies the whole's unique attribute.

Although assembly and meaning are not particular to spatial composition, where other architectural theories, such as type, could easily denote the room arrangement to centre around a function or a form, the concept of composition distinguishes from other theories because it is based on the premise that any whole will have an inherent structure based on the relation of its parts to its whole. This means that while a house would only be segmented within its built space, spatial composition could include nearby houses or external space (e.g., sidewalk, void, adjacent lot) as parts of the whole, which in turn would have a relationship of part-to-whole. It could be said that using spatial composition, a house's design could be explained via the presence of sidewalks and their position in relation to the house. If they can be framed together, they have a relationship. As such, one can keep adding parts, and the framed whole will make sense regardless of where you draw the line, the frame composition will explain the relationship among all parts when considered within a whole and an array of types will be derived to clarify the constant despite variation among all selected cases. In this way, spatial composition is not limited to a discrete object, a single piece of architecture, such as a building, but can also include civil engineering structures, trees, voids, and bodies of water between built spaces to grasp the urban environment at the level of composition by considering them as parts of a whole.

Previous research on Spatial Composition is extensive, covering framed spaces (wholes) such as houses, station areas, groups of combined architecture and infrastructure, to name a few. For some of them, the same whole is tackled from different perspectives. For example, contemporary Japanese houses have been considered according to their relation to their outline, surfaces, internal volumes, external space, façade, and eaves. Evidently, each study takes a different perspective and ends up with different compositional principles and a rhetoric of what the composition communicates through the relationship between the parts and the whole, such as the outline affecting room arrangement, external spaces affecting flow through the house, and the number of floors affecting position of bedrooms. Moreover, these studies, through their definition of the whole and parts, also provide an insight into how expanding or contracting or shifting the focus of the composition helps to better understand the relationship between parts and between parts and the whole. A small overview of previous research on Spatial Composition is provided in Appendix B.5.

From this overview, the procedure changes per study, but they all follow the same framework, where the goal of composition is to clarify the unique attribute of a framed whole through its relationship to its parts based on their segmentation and integration. To do so, the composition is first defined. This consists of defining the type of composition being the subject of analysis as the whole. One or various objects is framed as a whole. This whole is then "segmented" into several elements, where the whole is defined through its unit of analysis. Because spatial composition studies are in nature case studies, the unit of analysis is derived from capturing the cases as framed and devising how the compositions could be analysed through an abstraction of their reality. The quantification of the cases' segmentation allows for the relation among parts to create a compositional principle, the "how" behind the relations. The compositional principle is the aspect that emerges from framing these parts together into a whole. This second process is known as integration. It consists of analysing the combinatorial logic of parts-to-whole by distinguishing unique patterns (configuration) and then formalising types present across different configurations.

This dual process of segmentation and integration provides the idea of what to assign as the part in the segmentation, its unit of analysis. As an example, the framing of a house can be analysed through its rooms. If these are divided in categories, such as main and non-main rooms, and then the segmentation (number of rooms and number of rooms per category) and arrangement (positional relation between rooms and between main and non-main rooms) the categorisation enables an explanation to the relation of room categories within a house (Tsukamoto, 1996). Upon having a unit of analysis, cases can be observed, recorded, and analysed according to this unit. The resulting grouping according to number of rooms and positional relations as recurring or unique configurations are subsequently formalised into types that explain the rhetoric of relation between parts and how the whole changes in function according to the type. When framing composite objects, such as a site, unit of analysis must also take into consideration exterior space (e.g. exterior open floor or a courtyard between two buildings (interior exterior volume), and whole buildings as volumes or composite spaces (e.g. building partial volume unit).

The analysis of spatial composition is represented by both isometric diagrams and justified graphs to show the relationship between parts and part-to-whole. The first is an abstraction of the built environment into a simplified model of the framed object. The abstraction tends to be related to the unit of analysis. For example, a study where volume is the unit of analysis, the diagrams would be the abstraction of the framed object as a composition of cubes. Hence, the relation among these cubes is then represented in justified graphs. These graphs consider units as node and the connection between them as links. In the same example, a link would be the relation between two or more cubes, and the nodes are each cube. Moreover, the various captured compositions abstracted as diagrams or graphs can be categorised under a type, be it according to segmentation, (e.g., 4 cubes' frame object) or integration (e.g., A multiple cubes framed object with one underlying cube connected to all cubes above). Ultimately, the type in a spatial composition is the abstraction of the compositional principle across the graphs that represents the diagrams, which are the representation of the framed object according to the established unit of analysis.

3.3.2. Unit of Analysis: Floor

Spatial composition is compatible with the problem at hand because the theory and method can be applied into framing the space between BPFs and train platforms at Dutch train stations for their analysis with regards to circulation. In this case, circulation is the compositional principle, which is the aspect that emerges from relating a facility to a platform and frames the composition according to the movement through space to get from one end to the other. However, due to the variation of these spaces across the case selection and possible exception to a selected unit and the issue of what terminology to use, this must be argued for.

A common device to come up with a unit of analysis is the distinction of inside and outside. A unit that follows this principle is the room, which is either an interior or exterior space. In train stations, rooms tend to be limited to the station building and to stand-alone waiting rooms next to or at platforms, and facilities tend to be separated from platforms through a combination of rooms and open spaces. It is not to say that this is not a possible unit of analysis, and it may be able to explain how circulation is informed by visual continuity of spaces within the composition, but it makes it difficult to understand how more or less spaces and their arrangement affect the movement between them.

The unit of analysis must be one thing they all have. As in type, it can also be considered the common denominator (Aureli, 2024). Under the definition of type according to building function, the station is a type of building with the sole purpose to facilitate movement between people and vehicles. However, type being either to represent a building or an element of a building, the station, when considering the building, leaves out the rest of the station, namely, the train platforms and its shed (e.g., Amsterdam Centraal). Hence, for the station to be a type, it would be a composition, including both the station building and the train platform structure. This could then be its common denominator: all stations have a building and a platform structure. But this is not the case. As discussed previously on station types, stations can lack a building or canopy for the platform(s), so the common denominator would be the presence of two spaces: on for access/egress of the station and another for the stepping in/out the train. This denominator is compatible with the notion of a station that integrates the two spaces, such as those that have essentially integrated the platform hangar into the station building by becoming enclosed by the building (e.g., Antwerp Centraal and Hamburg Hbf) or placed it under the building (e.g., Grand Central Station in NYC and Brussels Central Station).

Therefore, instead of making a distinction through change in interiority, a change in height can be considered a segmentation device. Throughout this study, the transfer space has been found to have multiple names, including circulation area, pedestrian circulation system, and transfer zone. Regardless of their focus, they are not aligned with the notion of the fact that all stations consist of planes. Among the planes, namely floor, wall, and roof, the common denominator of a station being the two spaces, the access and platform spaces are floor, as both are required to allow a passenger to move on them. For a multimodal station, an additional space for the other mode is necessary, and the space to change between them can be the same access space as before or can have an additional one.

The floor as the unit of analysis is defined as a horizontal surface a traveller walks when transferring between bicycle and train modes, demarcated by a change in height (via presence of stairs, escalators, or elevators) leading to a change in level (to adjacent floor). This definition excludes sloped surfaces (ramps) and single to triple steps grading a floor, as this doesn't stand for a change in layer. By making floor the unit of analysis, spaces are categorised as follows: train platforms are Train floors (Tn), BPFs are Bicycle floors (Be (enclosed) and Bo (open)), and all floors between the two are Transfer floors (T). Because the first capture of multimodal stations is needed to be mapped as diagrams, all other layers that are included in the station, but are not between platforms and facilities are considered mode specific floors (Bu, Tm, Me, Fe). For the train and bicycle modes, each facility and each platform are considered a floor. For other modes, all platforms for a mode at a layer are grouped together as a single floor for the sake of simplicity.

The BT intermodal space that includes the transfer space, BPFs and train platforms is therefore seen as a network of floors, divided into three categories (Bike, Transfer, and Train). While other terms could be applied, such as layer, platform, surface or plane, floor seems more straightforward. Plane can be any of the three (floor, wall, roof), layer tends to represent all space at a level (more than one space), surface in not incorrect but tends to relate to materiality and texture of a plane, and platform, which can be defines as the interface where movement occurs, is already standard for the train platform, so it would be confusing.

3.3.3. Analysis Framework

After repositioning the problem, proposing a methodology to solve it, and adapting it to the transfer floor of the intermodality within a multimodal station, an analysis framework can be established. This framework is the conclusion and merging of the conceptual framework from the literature review, and the opportunities to align the concepts via a spatial framework. Its formulation provides a link between the conceptual framework and the framework opportunities, using a spatial framework to study the topic, and a conceptual structure relating terms as interrelated via part of a whole.

Positioning that internal circulation is a function of the bicycle-train intermodality, which is a function of a multimodal station, using floor the unit of analysis and circulation as the framing device, it becomes possible to describe the three concepts under the same terms. Spatial composition makes it possible to capture space, analyse it, and then abstract the three concepts into information that remains clear at different scale. The principles behind this framework stand to be transparency, in the sense that the epistemological process of analysis is understood through the relationship of these three concepts, replicability, where the use of floor as unit of analysis enables this framework to be applied to other intermodalities (e.g., tram-bus, bus-bicycle, train-ferry, etc.), and type, which stands for the intention to compartialise categories within categories to the point that all share a common denominator for their grouping at the smallest scale that can be used reversely to explain larger scales. Hence, the explanation above is therefore synthesized in a flow diagram representing the analysis framework. The next paragraphs elaborate on what each step consists of. More details on the analysis procedures and the argumentation for their design can be found in Appendix B.4.

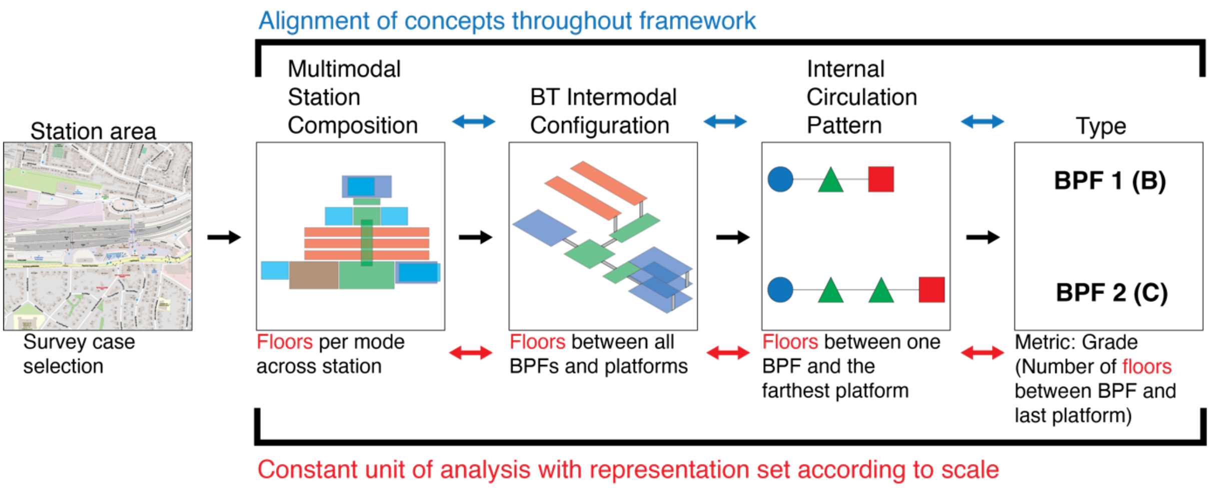


Figure 3.2. *Analysis framework flow diagram*

The flow of the analysis framework is divided into four parts: data, capture, analysis and abstraction. These parts have the following procedures, explained via an example station (s57, Hoorn).

Data

The data from which we depart is the list of stations and their geographical representation, viewed in both OpenStreetMaps (OSM) and Google Maps when searching “Station Hoorn” in their search bars. From Figure.3.3, it can be seen how OSM has more detail both for the outline of BPFs and their distinction (purple for enclosed, blue for open), and pedestrian pathways (red dotted lines in and around station).

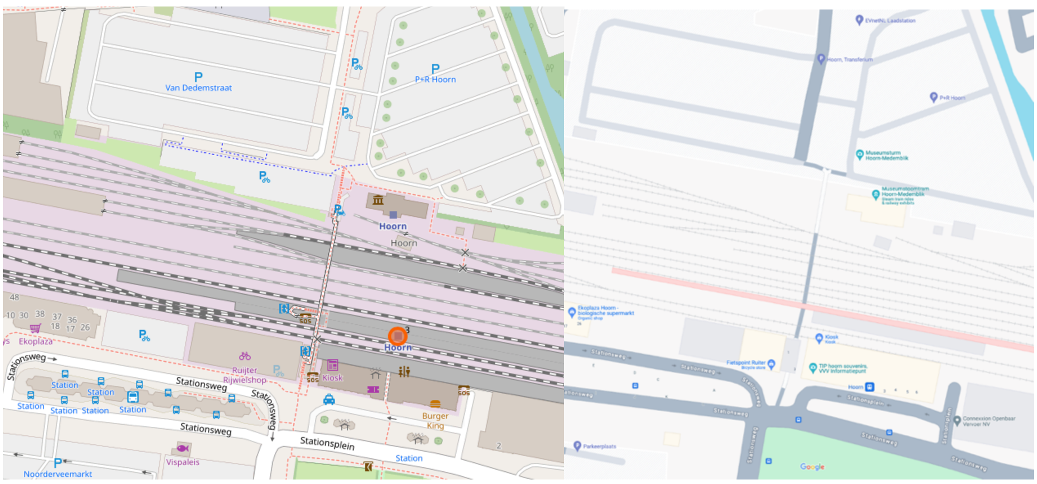


Figure 3.3. *Hoorn station area maps (s57). Source: OpenStreetMaps.org (left) and GoogleMaps.com (right)*

Capture

The capture of the station consists of composing the multimodal station by identifying floors for all modes to frame the whole, then classify each floor and then identifying the transfer floors between mode floors.

The framing of whole and parts gets abstracted into a station composition drawing and a spreadsheet with information including number of modes, which modes, number of levels, number of platforms, and number of BPFs.

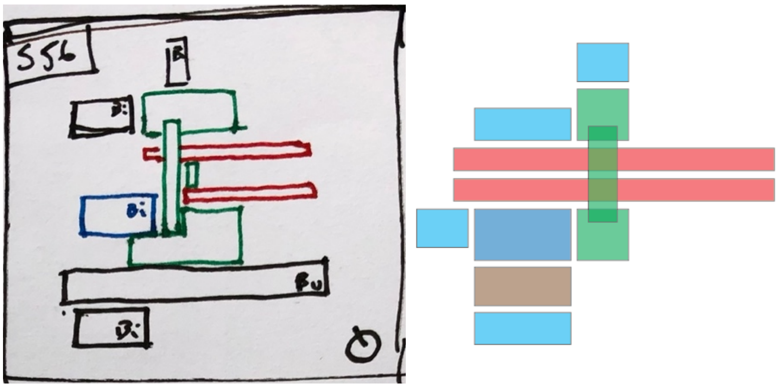


Figure 3.4. *Multimodal station composition diagram*

The information captured from the multimodal composition can then be written in a table, which provides data to compare with other stations on the factors collected. From the diagram, it can be derived that Hoorn (s57) has 3 modes (train, bicycle, bus) 2 train platforms, one BPF (082), and 2 floors (0,1).

Analysis

Upon having the information, the diagram can now be transformed into 2.5D to better understand the positional relationship among the spaces within scope and filter out other spaces, leaving only bicycle floor, transfer floor and train floor and changes of level. Here, the BT intermodal arrangement diagram is composed that includes transfer floors between all BPFs and train floors.

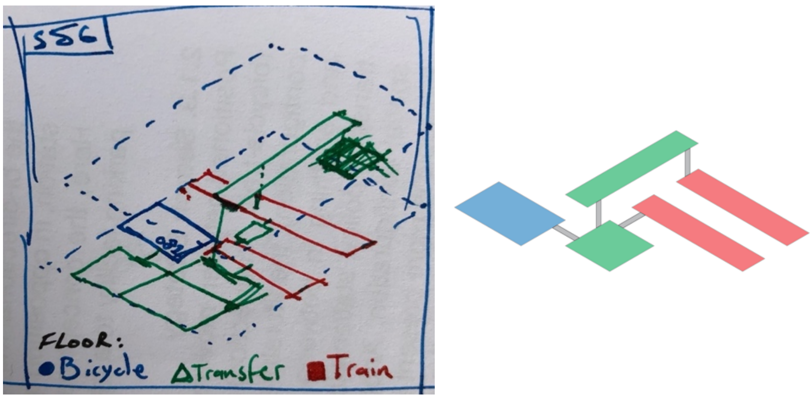


Figure 3.5. *BT intermodal configuration diagram (all BPFs to all platforms)*

The diagram is analysed for the internal circulation articulation, which represents the circulation between one BPF to all platforms.

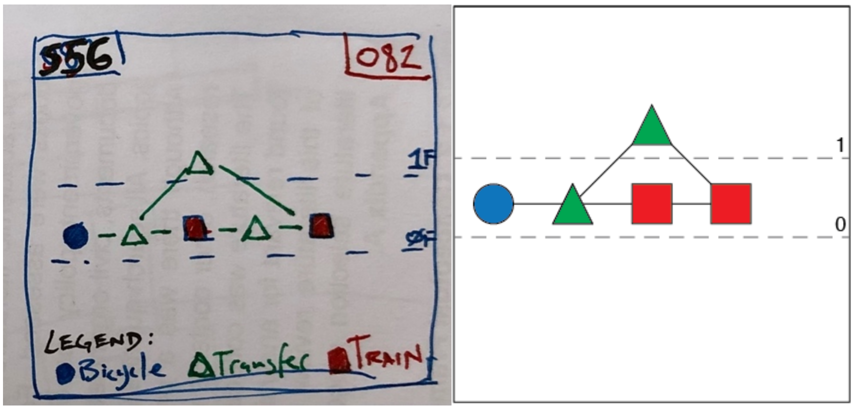


Figure 3.6. *internal circulation articulation diagram*

The information analysed deals with, among other things, the positional relationship between the BPFs and the platforms, their relation to transfer floors, and the different possible combinations existing across the different platform to BPF ratios.

Abstraction
In order to simplify the information in the graph, the articulation is further abstracted into a circulation trajectory, which consist of the path between one facility and the farthest platform. In this case, the last platform can be accessed via the first platform (3 transfer floors) or via the overpass on the first floor (2 transfer floors), the shortest route is chosen, so the trajectory becomes 2 transfer spaces (Figure 3.6).

The trajectory is then abstracted from a graph to a letter denoting a metric, a grade. The grade here represents a type, that which has two transfer floors between a BPF and a platform.

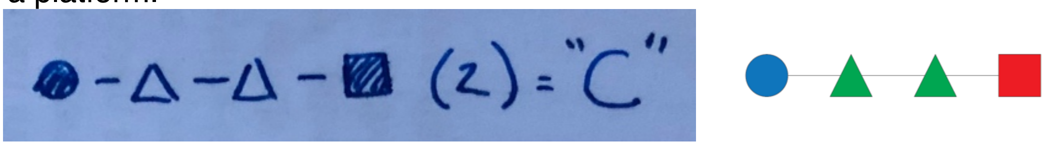


Figure 3.7. *Internal circulation trajectory pattern and grade*

The information abstracted ends up providing a way to evaluate the internal circulation of a BT intermodality within a multimodal station. By carrying out this for the case selection, an inventory of all possible compositions, configurations, articulations, trajectories and grades for BPF at Dutch train stations becomes available to better understand what the transfer floor is and how it affects circulation between BPFs and train platforms at a train station in a single row (Figure 3.8). This procedure, when digitalised, represents the analysis resuts format in this research (Figure 3.9),

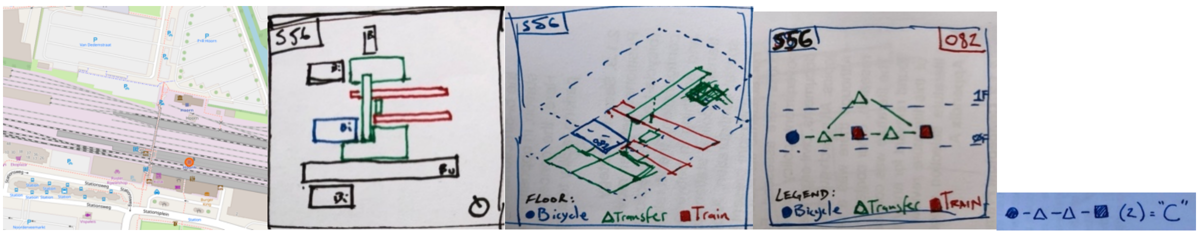


Figure 3.8. *Station composition analysis procedure (sketched)*

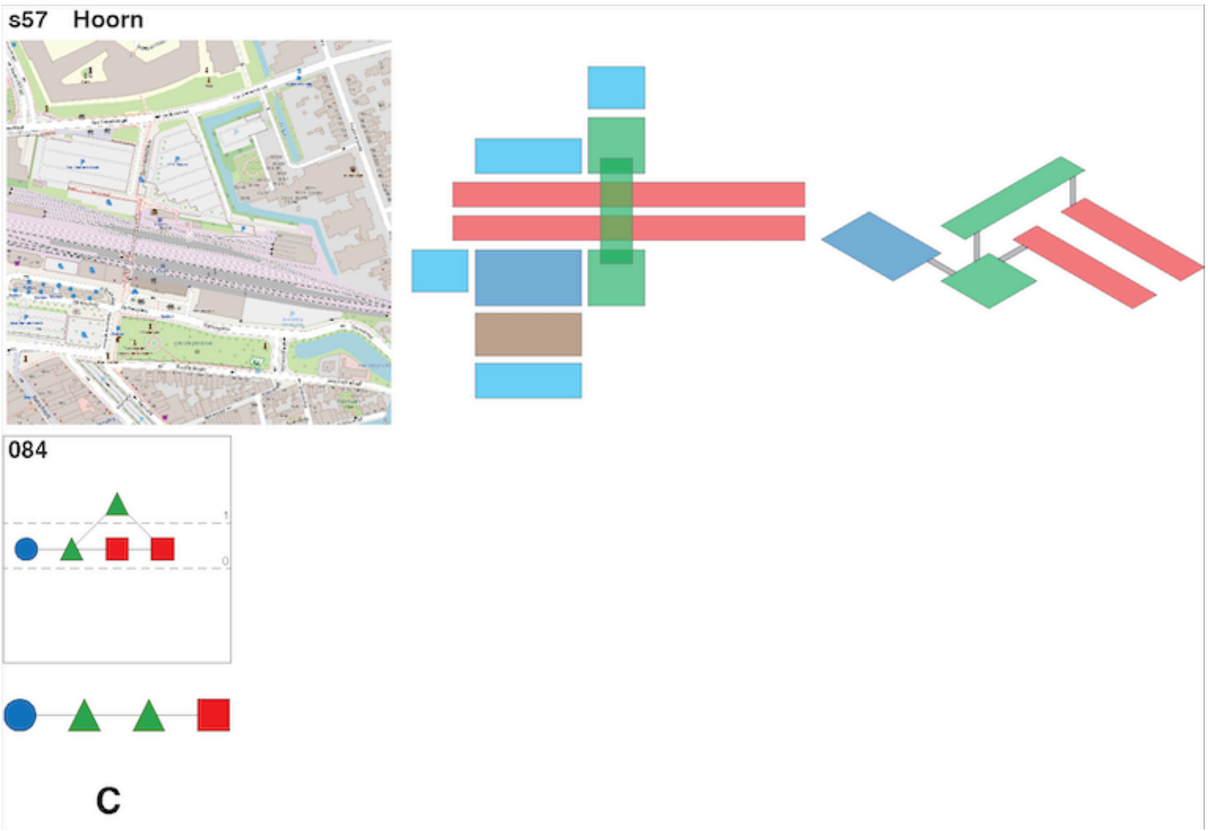


Figure 3.9. *Station composition analysis results (digitalised)*

Chapter 4: Analysis

At the beginning of this study, it was unclear how to define the transfer space, how to capture it and how to evaluate in in terms of circulation. This is mostly due to the implicit notion of all the terms dealt with in this study, where, for example, the transfer floor would be leftover space without determinate shape or endpoints or delegated to a specific entity or function. What the literature and methodology have revealed is that the capture and analysis of such terms is possible through the visual abstraction of space and movement. Through them, it has become possible to theorise and formalise space to translate reality, or frames of reality into diagrams. Each diagram represents a different scale, with different focus on the factors at play in relation to said scale. Looking at each diagram in sequence and placing them along all other cases. Provides insights now accessible when considering one case or a series of cases. As such, the results of the analysis provide a better understanding of how space and movement are related to each other across scales and the concepts considered in this study.

Applying the analysis framework to the case study, the results from analysis of the multimodal stations is discussed in this chapter. Section 4.1. consists of describing the multimodality of station compositions and their characteristics. In Section 4.2., the BT intermodality of each station is analysed and through it, each individual BPF and the BT space can be describe and categorised. This is followed by Section 4.3., which presents the metric derived from the analysis to evaluate the performance of the transfer space between BPFs and train platforms at the multimodal stations.

4.1. Multimodal Station Composition

In this case study, 95 multimodal stations were observed and analysed. The station composition are form, outline, as informed by its components, which are the facilities for each mode, and the spaces that connect them. The following paragraphs describe the results extracted from the station composition diagrams regarding the modes present at each station, followed by the form developed by the arrangement of different modes and their facilities at a station site, and their relationship.

4.1.1. Multimodality

As multimodal stations, it was found that all 95 stations had at least the presence of three modes (95/95) (train, bicycle, and bus) and expanded up to six modes (tram (13/95), metro (9/95), and ferry (2/95)). Multimodality was found to be 3 (80/95) ,4 (7/95), 5 (7/95), and 6 (1/95). Echoing previous categorisations of stations according to urban setting, it can be observed that stations with tram and metro tend to be located in urban areas and tend to be part of the same mode network. This can be seen for cities such as Amsterdam (s09 – s15), Rotterdam (s75, s76), and Utrecht (s81, s83) (Figure 4.1.). The two cases with ferry (s11, Amsterdam Centraal and s85, Vlissingen) have ferries adjacent to the station to connect to an urban area opposite the water at the station site.

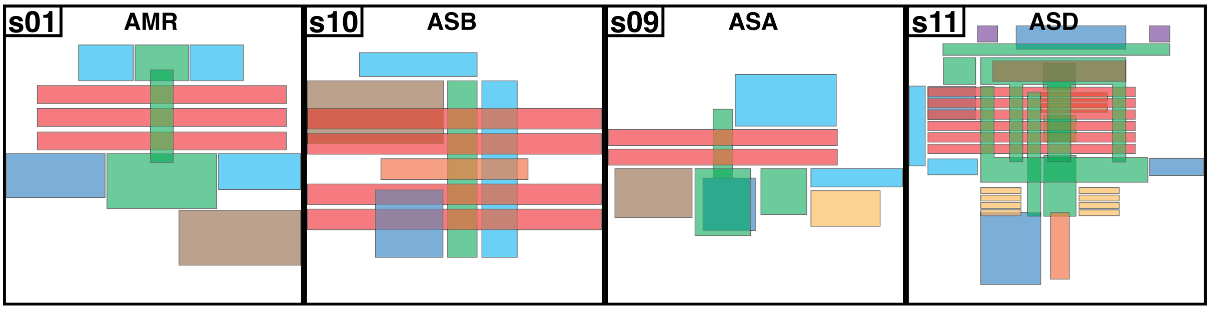


Figure 4.1. *Station composition varying in multimodality (3,4,5, and 6 modes)*

4.1.2. Form

As a consequence of identifying the modes present at the station, it becomes possible to capture the faciltiies per mode and the transfer spaces connecting them all into a whole multimodal station. These are captured as floors, and categorised according to their mode (train, bicycle (enclosed), bicycle (open), bus, tram, metro, and ferry). Although both bicycle floor (enclosed and open) are captured, open ones contribute to the composition, but remain out of scope for further analysis. From the diagrams, the station composition are segmented and the total number of floors found are described below.

Table 4.1. *Distribution of floor per mode across 95 station compositions*

Floor category	Tn	Be	Bo	Bu	Tm	Me	Fe	T	Total Floors
freq.	225	136	164	435	44	17	3	224	1248

There are a few insights tht can be derived from these numbers. First, it can be seen that there is almost a 1:1 relation between train and transfer floors (226:224). The explanation for so many bus floors is due to the high number of bus platforms at stations that have not opted for a bus island (bus platform with access to all bus services) and result in upwards of 9 to 20 bus platforms per station. Although it depends on the orientation of the bus station within the station site, newer stations tend to opt for bus islands. Also, from this analysis, it can be seen that the total BPFs (both open and enclosed) represent almost fourty percent of all facilties according to literature review sources (300/810 facilities).

Although the station composition diagram is flat, showing horizontality and not verticality, the number of levels were captured to segment to station into floors. With regards to the number of levels at multimodal stations, it was found that stations range from 1 to 6 levels. It was found that there is a correlation between the number of modes to the number of floors, where the more levels were present at the station, the more modes and floors it has.

Table 4.2. *Levels to modes and levels to floors relation*

Levels \ Floors	4-10	11-15	16-20	21-30	31-40	Total	Levels \ Modes	3	4	5	6	Total
1	5	-	-	-	-	5	1	4	1	-	-	5
2	21	22	4	3	-	50	2	44	4	2	-	50
3	13	6	5	5	-	29	3	25	1	3	-	29
4	-	5	-	2	1	8	4	6	1	1	-	8
5	-	-	-	1	1	2	5	1	-	1	-	2
6	-	-	-	-	1	1	6	-	-	-	1	1
Total	39	33	9	11	3	95	Total	80	7	7	1	95

From this table, it can be seen that as levels increase, so do modes and floors. The highest frequency for levels to modes is 2 levels to 3 modes (45/95), where the platform setup is elevated tracks over the ground floor. For level to floors, the correlation is directly due to the approach to segmentation, level change. Moreover, the highest frequency is that of 2 levels to 4-10 floors, which can be attributed to transfer floors that span across the site and are not segmented by changes in level.

At a closer look, levels at the stations were 8 distinct levels, ranging from -3 to 2, including half floors above and below the ground level (-0.5 and 0.5). As seen in the figure below, a distribution of the levels provides an overview of how often some levels are used to compose a multimodal station. The most common combinations are for 2 levels (51/95) (-1, 0) (25) and (0, 1) (24) and for 3 levels (30/95) (-1, 0, 1) (15) and (0, 1, 2) (5).

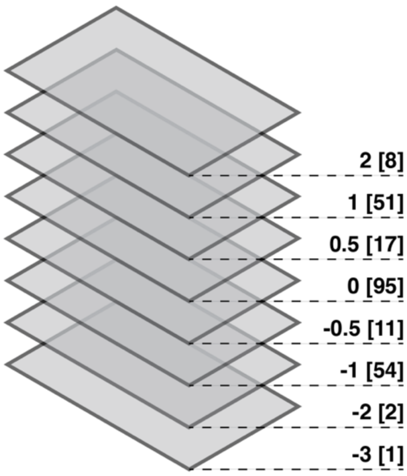


Figure 4.2. *Level presence at station compositions*

4.1.3. Complexity

Multimodality implies complexity, more modes, more floors, more levels, more transfer spaces. Form implies complexity in how the vast number of floors have to be organised to be intelligible as a space users can circulate within and be considered a whole. With the station composition diagrams, these correlations become explicit.

The diagrams can abstract the positions of floors per modes, transfer floors among them, number of levels, and their relation. Every composition is unique at this level of abstraction. It was found that all are unique in form, despite identical properties. An example of this can be seen with the common combination of factors: 3 modes (80), 9 floors (15), 2 levels (8), (-1, 0) (5).

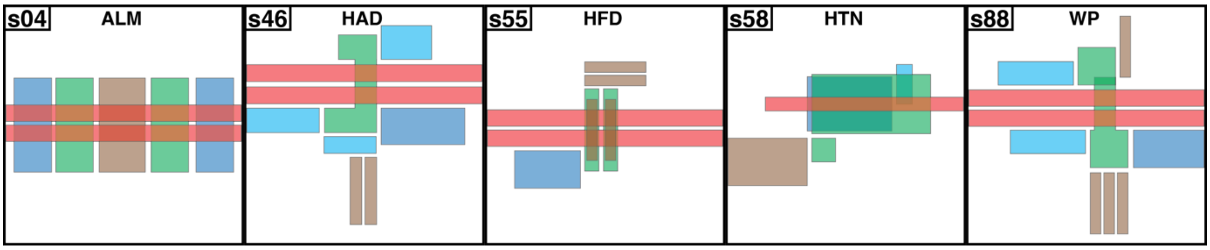


Figure 4.3. *Multimodal Station Compositions with same properties (Left to right: Almere Centrum, Harderwijk, Hoofddorp, Houten, Weesp)*

There is a trend from horizontality to verticality, as seen in the cases of Houten and Almere Centrum positioning most floors under the train platforms in comparison to more spread out horizontally cases of Harderwijk, Hoofddorp and Weesp. This superposition, while increasing the number of levels, can develop be a more compact composition, signalling the advantages of reducing distances when opting for a vertical organisation of space, or stacking, instead of a horizontal organisation of space, which still needs multiple levels to work, and so is not making the most of having multiple levels.

4.2. Bicycle-Train Intermodal Configuration

Following the station composition, the next step was to change the level of abstraction from the whole multimodal station and filter out everything that is not the arrangement of BPFs to all train platforms via transfer floors. As the focus changes to the organisation of space across levels, the intermodal diagram is three-dimensional, or rather, psudo-three dimensional as an axonometric diagram.

From the arrangement diagrams, one can visualise how to circulate through the network of spaces connecting all BPFs to all train platforms. The following subsections deal with a few factors extracted within the axonometric diagrams, where it was found that there are various factors that inform how spatial composition affects circulation. These are the (A) positional relationship, (B) the train platforms setup, (C) the categories of link between spaces, and their relation amongst them. In essence, the platforms, being the main component of a station, and its spatial configuration, ultimately affects how everything else can be positioned and how circulation can take place along the transfer floor.

4.2.1. Segmentation

Moving on from the multimodal composition diagrams, intermodal configuration diagrams filter out all floors outside the BT intermodality, and the diagram focuses on the relative position relationship between BPFs and train platforms via transfer floors. This change causes the number of floors considered to reduce greatly. An example from MM to IM where the number of relevant floors is reduced from 17 to 7 floors can be seen in the figure below.

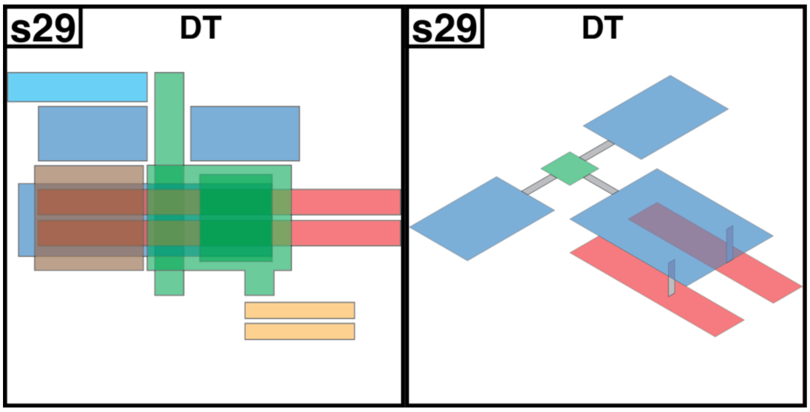


Figure 4.4. *s29, Delft with BPFs 040, 041, and 042*

Taken directly from the multimodal station, the number of floors that only include the BT intermodality is reduced and shows 226 train floors, 136 bicycle floors, and 157 transfer floors, totalling 519 floors.

Table 4.3. *Total floors in intermodal configurations*

Floor Cat.	Tn	Be	T	Total Floors
freq.	225	136	157	518

These floors can be further analysed in their numbers across the cases. For platforms, the number of platforms across the 95 stations range from 1 to 8 platforms. Most cases were found to have 1-3 platforms. Among them, stations with four or more platforms are rare, with one or two cases. For the BPFs, it was found that most stations have 1 and 2 facilities. Stations with 3 BPFs total in 5 cases, 4 with 4 BPFs, and 1 with 5 (s62, Leiden Centraal). For transfer floors, most cases have one or two transfer floors, were cases with 3 are 9, and only one case for both 4 and 5 transfer floors.

Table 4.4. *Number of train, bicycle, and transfer floors across cases*

Train	1	2	3	4	5	6	7	8	Total	Bicycle	1	2	3	4	5	Total	Transfer	0	1	2	3	4	5	Total
freq.	18	46	23	2	2	1	2	1	95	freq.	70	15	5	4	1	95	freq.	2	44	38	8	2	1	95
total	18	92	69	8	10	6	14	8	225	total	70	30	15	16	5	136	total	0	44	76	24	8	5	157

Although this table show the recurrence of the number of floors per category per station, there isn't much that can be gathered from this simple operation. This is more of a thing to see the distribution of the ranges for each floor category. This is to see that the one with more floors are more isolated cases than the norm, for which other aspect might come into play with regard to why they have so many floors.

4.2.2. Arrangement

After looking at each floor category separately, we now look at how they relate to each other within the BT intermodal space. From the diagrams, it was found they can be reviewed with regards to the ratio and positional relationship between BPFs and platforms in each station, as well as the types of transfer floors and their combinations.

Although there are multiple levels in these diagrams, the levels are not important here, but the relation among parts to the whole across levels. When looking at the BT intermodal configuration, the main components are the BPFs and the train platforms. From the diagrams, it was found that the most common ratios are 2:1 (37), 1:1 (17) and 3:1 (15). This is of course an incomplete image, as cases with higher number of platforms are serviced by more BPFs, just not those in scope. As such, this limited account serves to say how many enclosed facilities are found according to stations with a specific number of platforms.

Table 4.5. *Train platform to BPF ratio*

BPF / Platform	1	2	3	4	5	Total
1	17	1	-	-	-	18
2	37	6	3	-	-	46
3	15	4	2	1	1	23
4	1	1	-	-	-	2
5	1	1	-	-	-	2
6	-	-	-	1	-	1
7	1	-	-	1	-	2
8	-	-	-	1	-	1
Total						95

Among these ratios, it was found that in most cases the vertical positional relation between all facilities and platforms are constant, meaning all BPFs are located at the ground floor when all platforms are elevated. Four distinct categories were found: flat, where both all BPFs and platforms are positioned at the same level (e.g., ground floor (0)), upwards (all BPFs are one or more levels under the platforms; downwards (all BPFs are one or more levels over the platforms); and mixed (one or more BPFs and or one or more platforms are positioned at different levels). For mixed, examples include when BPFs are at different levels, but all platforms are at same level (s11, Amsterdam Centraal); and when all BPFs are at the same level but platforms are not (s14, Amsterdam Sloterdijk). Figure 4.7. shows the distribution of the positional relationship across the stations, with the most common being an upwards relationship.

Table 4.6. *Vertical positional relation between BPFs and Train Platforms at station*

Positional Relation	Up	Flat	Down	Mixed
freq.	55	26	4	9

At this level of abstraction, it may seem too complex to observe the relation among the three floor categories while taking account of their arrangement in space. However, the categorisation of transfer floors shows that there are certain patterns that lead to specific configurations. These patterns could be related to their function along the way, but in this analysis, are found to be derived from how they connect to other spaces. As such, the compilation of transfer floors suggests the following. They consist of open spaces in front of the station (station square), a sidewalk before a road or on the station site, a corridor, a stairway landing, and on a few occasions, a platform or a BPF as a transfer floor. In this case, platforms are not considered because at least one platform is accessible without needing it to access another. In the case of the BPF as transfer floor (s29, Delft), this is included because in the least number of floors possible, the other BPFs (041, 042) can't access the platforms without going through the BPF as transfer floor (040).

Table 4.7. *Intermodal arrangement transfer floor categories distribution and combinations*

pos. / cat.	1	2	3	4	5	Total
C	18	35	3	1	-	57
S	44	7	5	-	-	56
W	29	5	3	2	1	40
L	2	1	-	-	-	3
B	-	1	-	-	-	1

Their differences are described as follows**.** Corridor: the corridor is the through which, in most cases, a user can access any and all of the train platforms. the corridor can be a passage at ground level, a tunnel underground, or elevated overpass. The corridor is always positioned over or under the train platforms, and is segregated for passengers. Square: although there is initially a distinction between a square (open) and a hall or concourse (enclosed), focusing on the floor shows that they both are squares before a corridor. Sidewalk: although similar to square, sidewalk tends to contain both square and corridor without spatially defining them. The distinction is made to note at the orientation of the space, which tends to face no station building, or something else. Sidewalk in many cases also has a bicycle lane or car road next to it, in contrast to a corridor, which is segregated for pedestrians only. Having a sidewalk as corridor is a common design for cases with elevated platforms. There is one case where a bicycle lane is next to a corridor, but is segregated (s26, Breda). Landing: The landing is a transitional floor between a stairway and another floor. For the 3 cases in this study (s18, S33, s91), the landing floor is a floor created by introducing another level (s91, s18), or having a dead end that requires change in level to continue (s33). BPF: the BPF as a transfer floor occurs in one case (s29, Delft), where for 2 of the three BPFs (041, 042) it is necessary to go through a BPF (040).

The definitions of these transfer floor categories also have to do with the combination of transfer floors across the cases. As seen in Figure 4.7., most transfer floors are the first or second transfer floor. Cases with 3 or more are rare, and the cases where Square is a third transfer floor is because the station has one square on each side of the platforms. The most common combination of 2 transfer floors is S-C, or Square-Corridor (29/38). This is the case where a BPF faces the square and then there's a change in level to a corridor to access the platforms. This distinguishes itself from cases where W, S, or C are the one transfer floor (W(18), S(11), C(15)), where there can be a change in level between the BPF and transfer floor and the transfer floor and platforms, but the BPF faces the transfer floor that has access to the platforms.

4.2.3. Disposition

While it is not likely that there's a direct correlation between the number of BPFs or platforms and the number of transfer floors, the above shows that there are categories within each floor type that contributes to a specific configuration. One particular aspect is that of how platforms are arranged in relation to the train tracks. The orientation of the train tracks creates an axis from which all station components are added to and hence create a spatial configuration. Among the platforms, they can be configured in different ways. Across the stations, it was found that the platform setups had configurations of sides, islands, terminals, and their combinations. The figure below shows the setups.

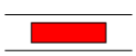
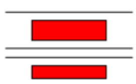
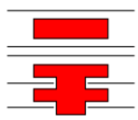
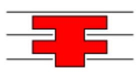
Island(s)	Side(s)	Side(s) + Island(s)	Terminal + Island(s)	Through-Terminal	Terminal
					
[40]	[14]	[31]	[4]	[3]	[4]

Figure 4.5. *Platform setup types. (black lines represent train tracks)*

Based on the information above, the BT intermodal configurations can be understood according to the disposition offered by the platform setup. Because at this level we look at all BPFs to all train platforms, finding patterns across the three floor categories is rather difficult, especially considering the spatial configuration. However, depending on what platform setup is used, it can hint to possible configurations for both BPFs and the transfer floors to connect them. Both vertical and horizontal position can be affected by the platform setup. For example, if we take the most recurring setup, islands (40/95), and observe the different configurations concerning 1 BPF, 1 transfer floor and 1 train platform, we find that what may remain fixed is the platform, and as such, the other floors will be configured in a similar manner to solve the same problem, to connect the BPFs to the platforms via the transfer floor.

In Figure 4.6, it is observed that as the island platform is fixed, the other components can be arranged in different ways around it, where the cases in this study showed two different variations, with the linear arrangement towards the platforms, and with the BPF being position on a side.

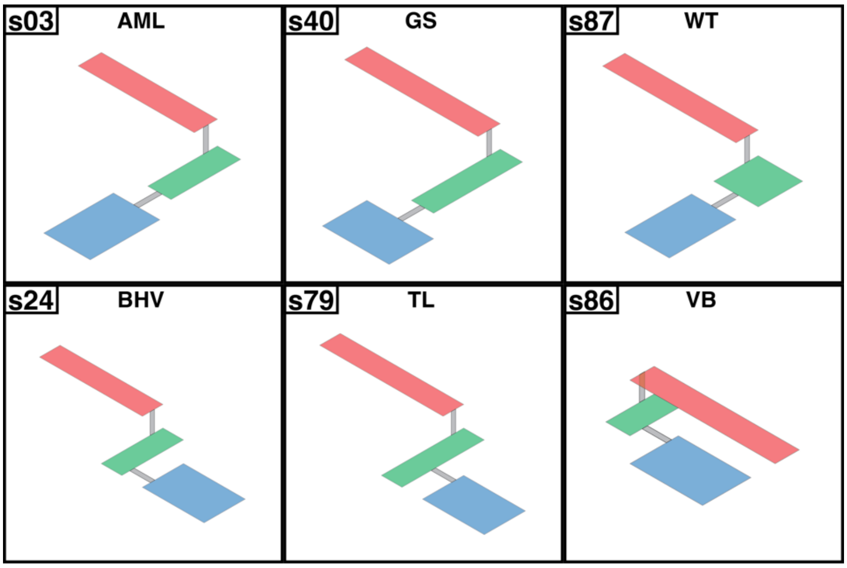


Figure 4.6. *Cases with islands platform setup with 3 floors*

To further explain how platform setup affects how every component is positioned is to look at how Horizontal position being affected by platform setup. In the case of side+island, where on one side of the station, the side platform directly connected to the station square. Here, a BPF could be linked to the platform and then require a transfer floor, under, over, or across the tracks. However, it was found that most cases with this setup included two transfer floors in connecting BPFs to the train platforms. As seen in the figure below, while all cases are unique in their arrangement, they are all dealing with the same problem of connecting the BPF to a side platform and an island. In the last case (s84, Venlo), the transfer floor could have been omitted if the corridor connected to the platform directly.

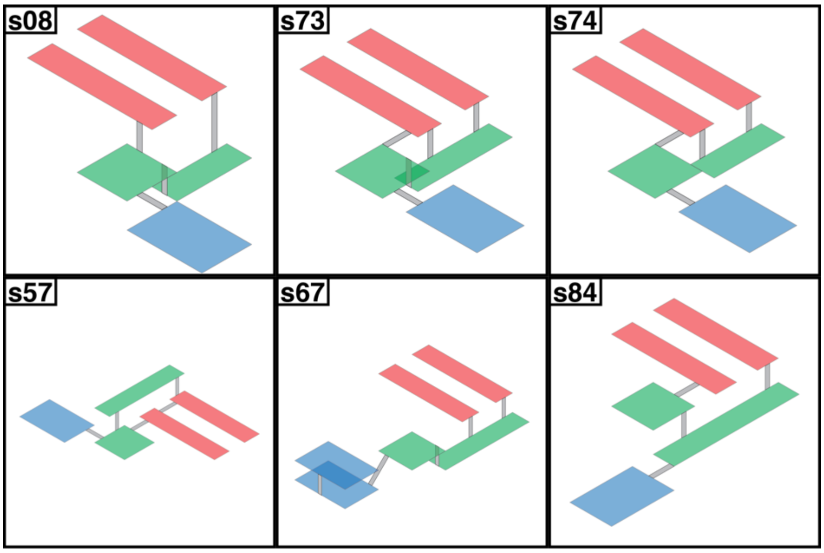


Figure 4.7. *Cases with side+island platform setup with 5 floors*

Therefore, these results point to the idea that the BT intermodality of a station and its spatial configuration relies mostly on the platform setup. Although it is ultimately up to the site context and the available space to implement a BPF and the necessary transfer floors to the platforms, this categorisation of configurations make it possible to compare cases that have similar design problems, as is the obstruction to circulation caused by infrastructure such as the train tracks.

4.3. Internal Circulation Grade

Following the BP intermodal configuration, the next step was to change the level of abstraction from all BPFs to all platforms and focus on the relationship between one BPF and all the platforms. the relationship is seen as the internal circulation, first from BPF to all platforms, and secondly, from BPF to the farthest platform from it. For circulation, a graph diagram is used, on the one hand, looking at the articulation across level to the farthest platforms, and then abstracted further, without verticality, to pinpoint the pattern of the articulation.

4.3.1. Articulation

As seen in the figure below, the intermodal arrangement diagram is broken down and abstracted to articulation graphs that show the path from each BPF to all platforms. In this example, it can be seen how each train floor (square) represents a group of platforms accessible from the same preceding floor. 068 and 069 have the same access to all 3 platforms via the corridor, while 070 does so as well, but can reach the 3rd platform directly without going through the corridor. This is due to the BPF having an entry to the platform via its second level.

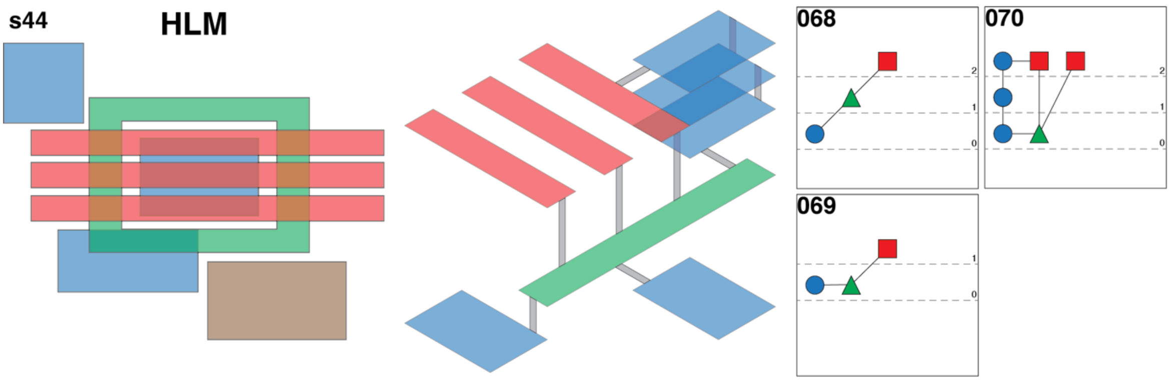


Figure 4.8. *Abstraction from composition diagram to articulation graphs (s44, Haarlem)*

At this level of abstraction, two things that were decided upon before can be better explained here. They are the types of horizontal links, as opposed to the vertical ones (change of level), and the distinction in BPFs with regards to their number of levels and entrances.

Because the links were determined mainly to decipher how to get from the BPFs to platforms, the idea here is that the separations, defined by change in level, were also met by horizontal barriers. As such, there is a distinction of links that connect the floors in the intermodal arrangement. For links, it was found that four things caused horizontal segmentation by function, orientation, road, and train tracks.

Function segmentation is simply what the floor is used for, this category is not quantify, as it occurs in every case where the BPF is adjacent a transfer floor or train platform when the other link types are not present. In the case of orientation, it refers to the exit of the BPF not being oriented immediately towards the platform, alongside it, or in the opposite direction, or at a distance, causing a transfer floor in between. Roads and train tracks make the segmentation obvious as a break due to infrastructure, lowering into road and train tracks to get across to next floor.

Table 4.8. *Frequence of horizontal links*

Horizontal Link	(R)oad	(T)racks	(O)rientation	Total Floors
freq.	9	9	24	42

With orientation being the most recurring horizontal link outside function in 24 BT spaces (136), it was found that this link type was present across 14 different articulation patterns. One particular pattern, with 6 cases, shows a similar outcome of articulation due to the orientation.

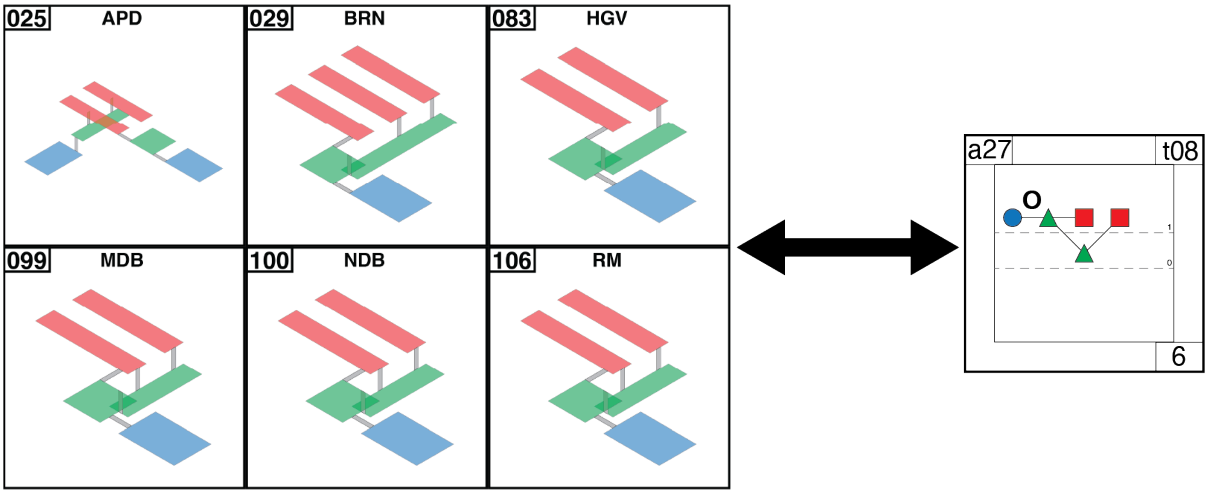


Figure 4.9. *Articulation pattern 27 with all cases having an orientation link between a BPF and a transfer floor*

Another thing we found was that BPFs affected the articulation with regards their number of floors and number of entrances. Although most facilities have only one level (123/136), it was found that there are several facilities that have two and three levels. While some could be understood as two adjoined facilities due to different materiality or enclosure (e.g., open facility over an underground facility), they were considered one in the same where they share a single point of access for the bicycles. For the number of entrances, most have one entrance (125/136), but two entrances are possible regardless of number of levels. The most common to have two entrances were two level BPFs (7/10).

Table 4.9. *BPFs number of entrances to levels*

Levels / Entrances	1	2	3	Total
1	103	18	4	125
2	2	7	2	11
Total	105	25	6	136

Because having multiple entrances could improve the circulation to one or more train platforms from the BPF, the presence of multiple levels and levels in the BPF created articulations that could have direct access to a platform. This includes 8 cases that end up having their own articulation patterns, as seen in Figure 4.10.

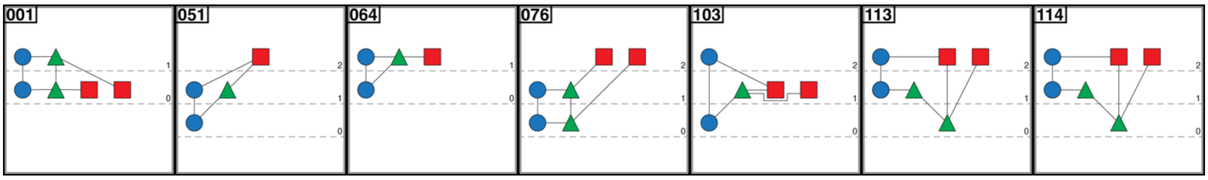


Figure 4.10. *Articulation patterns of BT floors with BPFs that have 2 levels and 2 entrances*

Through this reading of the diagrams, along with the categorisation of BPFs and links, the articulation graph was extracted for each BT space, which was structured into 53 distinct patterns. What remains is how to organise the articulations above, how are can they be structured in a way that tell us how some a more similar than others, or how the articulation work better in one case than the other despite the same number of floors.

4.3.2. Trajectory

From looking at the 54 distinct articulation patterns, it was found that many were variations of a same trajectory. Trajectory's difference with articulation is that trajectory filters out the change in levels and presents only the number of spaces between a BPF and a last platform or platform group, hence reducing the patterns from 56 to 13. Having a pattern then makes it possible to rearrange the articulation patterns within the trajectory pattern. In the figure below, this is done for all articulation patterns with one transfer floor between the BPF and all train platforms. The articulation patterns are arranged according to the change of level direction (flat/up/down), the number of changes of level (0-4), and number of levels (1-5).

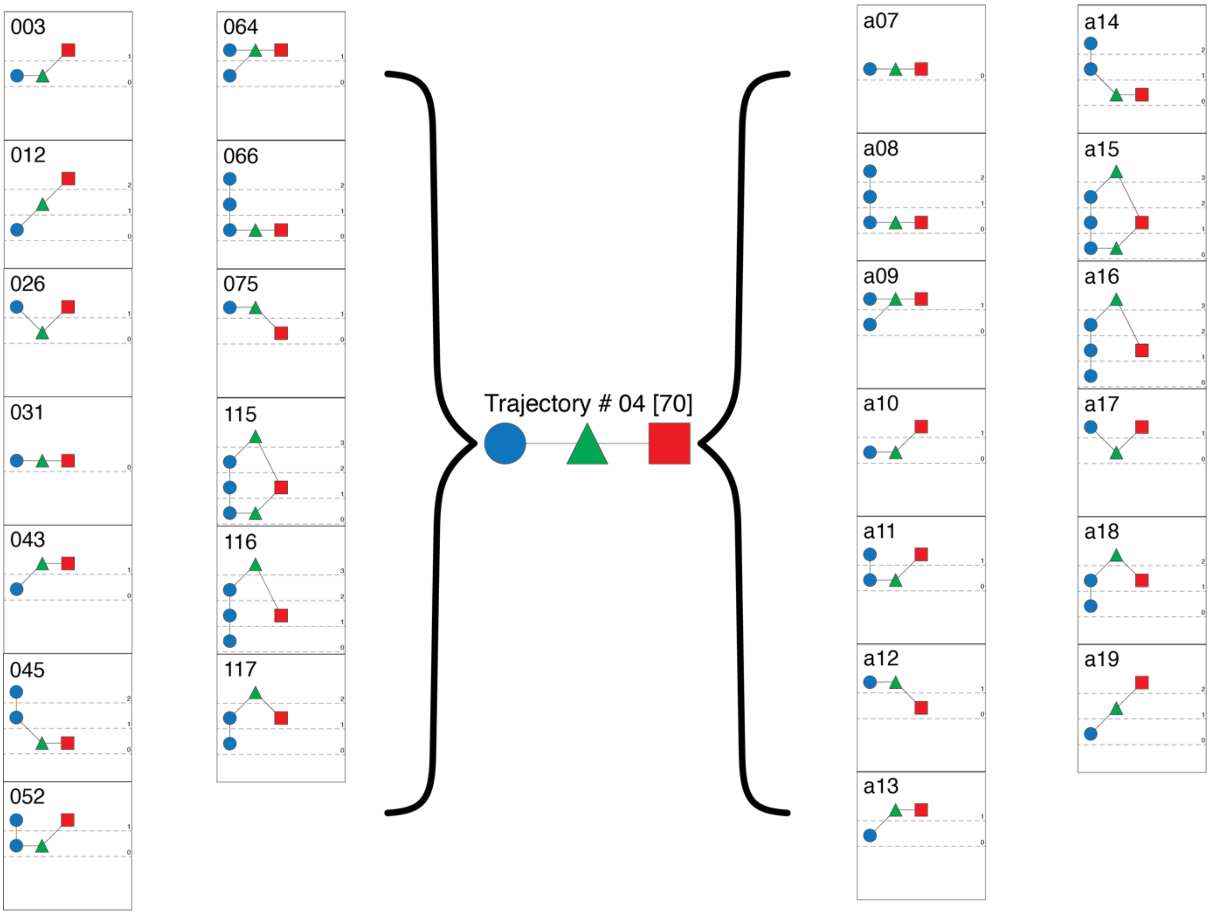
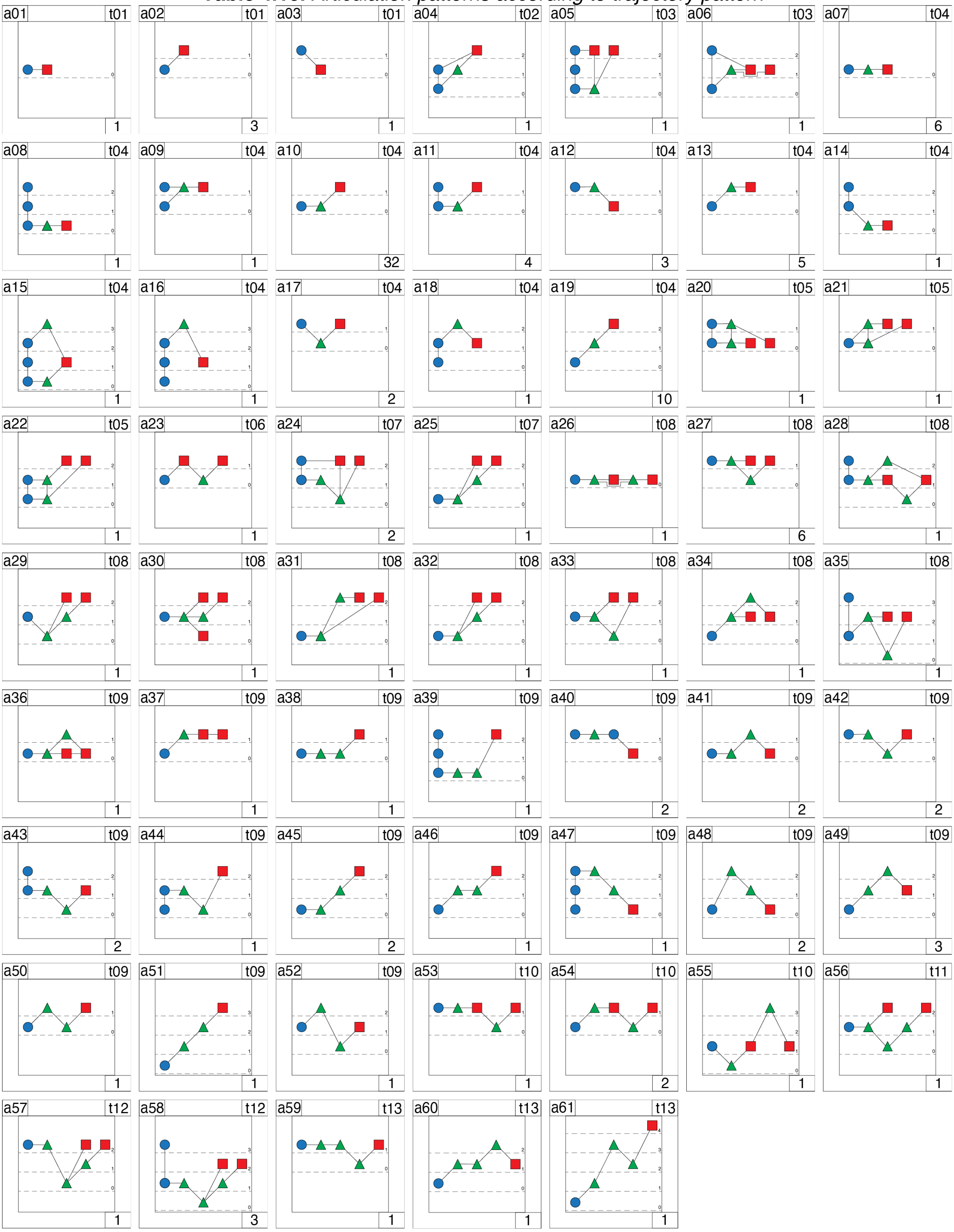


Figure 4.11. *Abstraction from articulation to trajectory towards structure.*

This reduction also makes it possible to organise the articulation patterns according to the trajectory pattern. The table below shows the overview of articulation patterns per trajectory pattern. It can be observed that there are 13 trajectory patterns and 61 articulation patterns. Among the 61, the majority have a single case (42/61).

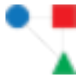
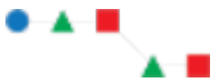
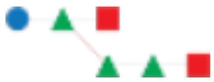
Table 4.10. *Articulation patterns according to trajectory pattern*



4.3.3. Type as Metric

The above make a case for the inventory of all existing ways to connect BPFs to train platforms at train stations in the Netherlands. However, this categorisation is still too granular to readily assess the performance of BT floor. Following the articulation pattern via the trajectory, it becomes possible to abstract the trajectory patterns to a letter, which represents the performance of circulation within each BT floor within the BT intermodality of a multimodal station. Therefore, a final abstraction of the trajectory patterns become a grade, from t01 with zero transfer floors to t13 with three transfer floors in a ranking system.

Table 4.11. *Internal circulation grade overview*

Trajectory	Graph	Total Floors	Transfer Floors		Articulation	Cases	Grade
			min	max			
t01		2	0	0	3	5	A [5]
t02		3	0	1	1	1	B [75]
t03		4	0	1	2	2	
t04		3	1	1	13	69	
t05		5	1	1	3	3	
t06		4	0	2	1	1	C [43]
t07		5	0	2	2	3	
t08		5	1	2	10	15	
t09		4	2	2	16	24	
t10		5	1	3	4	5	D [13]
t11		6	1	3	1	1	
t12		6	2	3	2	4	
t13		5	3	3	3	3	

The table above gives an overview of the circulation performance of BT floors at Dutch train stations. It was found that over 50 percent of all cases have a circulation grade of B, meaning that in many cases, there is only one transfer floor between the BPF and the farthest train platform. Moreover, is can be seen that trajectory 4 (t04) was the most common with 70 cases, where all platforms are equally accessible from the transfer floor. The same can be said for trajectory 9 (t09) where all platforms are accessible from the second transfer floor, with 24 cases. Cases with grade D remain exemplary to understand what might lead to a lower circulation performance.

The grades (A-D) become the last level of abstraction to categorise the BT floors according to their internal circulation performance. Unlike other categorisations previously used, such as BPF types, here there is a metric that synthesises many factors that deal with the spatial relationship between a BPF and the train platforms at the train station. Using the grades, the cases can be better understood for what their similarities and differences are. One example of this would be to use the grade as a constant among various cases. Here, the grade can provide all possible variation of the type, providing all potential trajectories, articulations, configurations and compositions as precedent as well as hinting to what is possible.

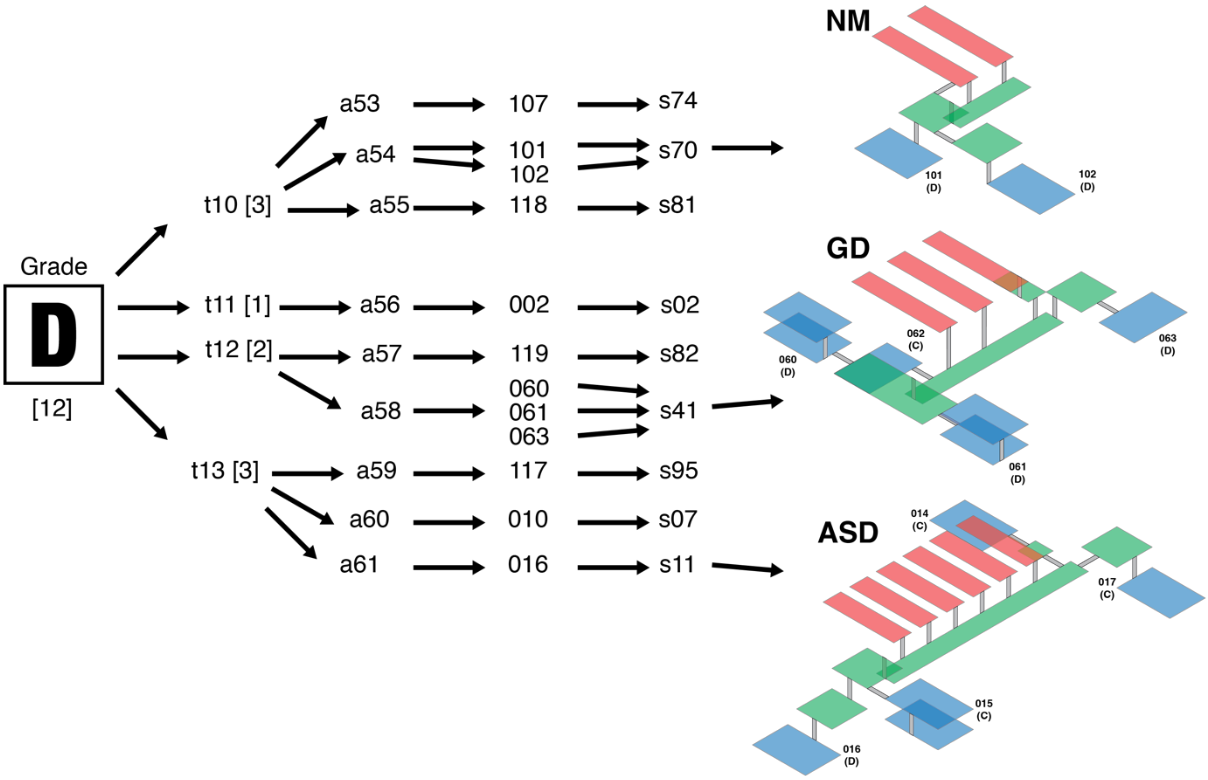


Figure 4.12. *Grade as type*

In the figure above, it can be seen how from grade D splits into four trajectory patterns, nine articulations, 12 configurations and compositions. From these 12 cases, some similarities might appear in spatial configurations, although there is no clear pattern across them other than the number of floors between a BPF and the farthest platform. However, putting them together signal to what might make them all have this grade, such as the addition of a landing transfer floor (s41, GD, 060, 061, 063), or the segmentation of transfer floor due to an intersecting road or orientation (s70, NM, 101, 102). These impasses could very well be a result of the spatial configuration and composition. Looking closer at the configuration, it can also be seen that other BPFs might be better positioned to have a higher grade, as seen for 062 in GD, and all BPFs at ASD except 016.

Another example is when the grade is positioned as the potential improvement when confronted with other cases. This means that via grade, cases with similar spatial characteristics can be compared as to what would it take to improve a case from D to C, B, or A. The cases positioned together would typically not make much sense due to their differences under other categorisations (class, urban/rural), but would be understood as within one group relating both in spatial configuration and grade.

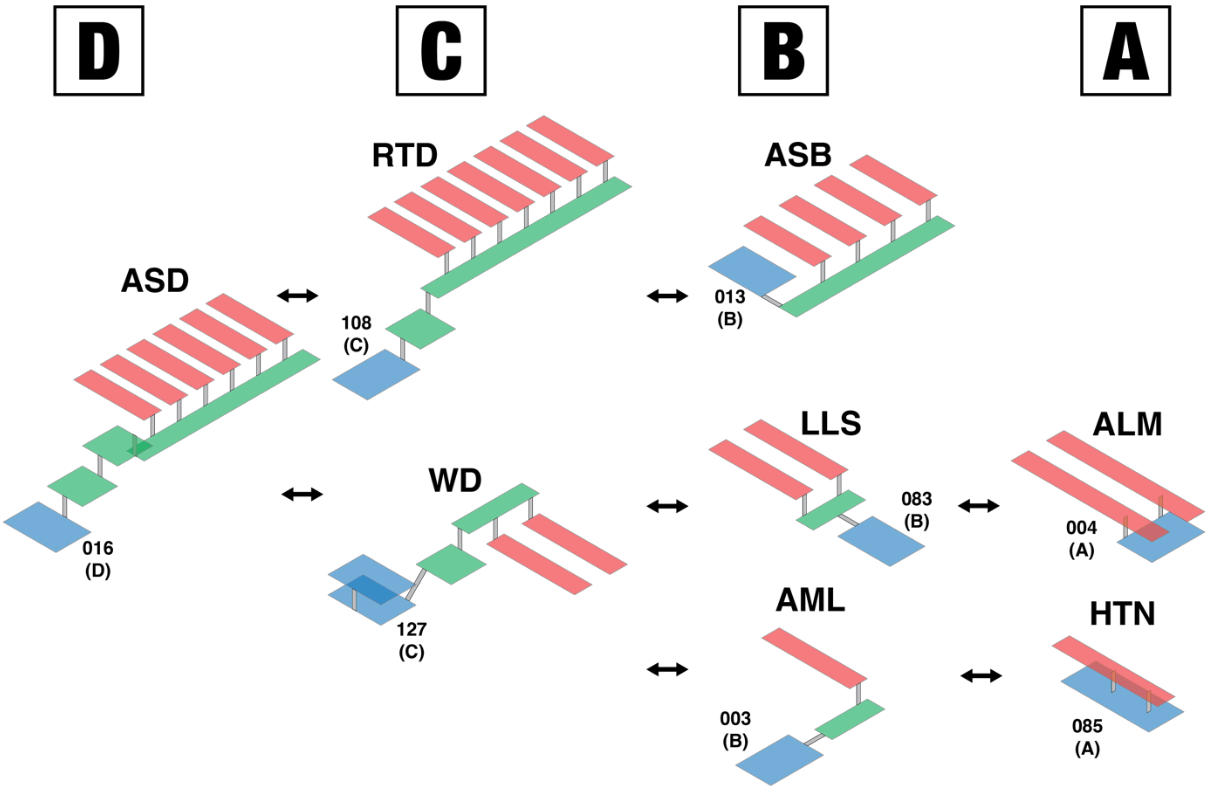


Figure 4.13. *Grade informs circulation improvement according to spatial arrangement*

Using a case from the previous example, 016 can be positioned along other BPFs that have similar configuration but result in different articulation. This can be seen in the figure below, where the type is used a grade in that the range of options are related by being related to each other through the change in grade or performance. This relation can provide insight as to what might need to be done to improve the grade of BPF within a specific configuration.

To conclude, the relationship between the BPFs and train platforms at the train station can be understood across scales through the abstraction from multimodal spatial composition to circulation grades and everything in between. Because every resulting groupings feed into or from another, the resulting categorisations provide various mechanisms to better understand the relationship among the cases studied. When considered in reverse, from the grades towards the multimodal composition, the categorisations potentialize possible spatial strategies to design spatial composition with a circulation grade as the driver. This new capacity can potentially improve intermodal combinations, including, but not limited to BT intermodality.

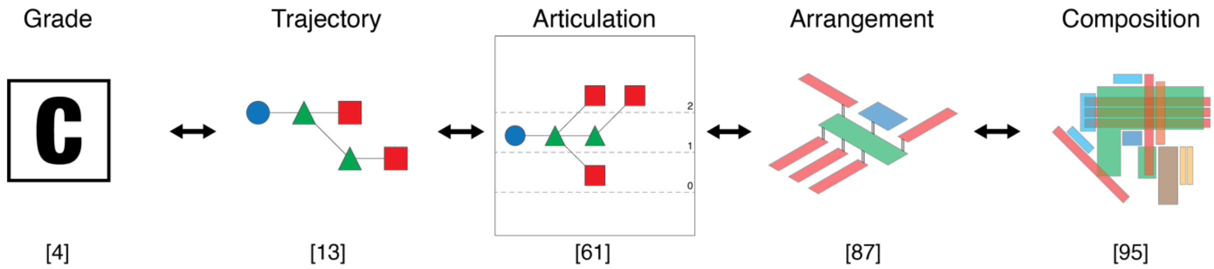


Figure 4.14. *Analysis results categorisations overview*

Chapter 5: Conclusion

At the beginning of this research, the aim was to better understand the transfer space and asked questions to be answered. This resulted in the exploration of literature via three concepts in order to inform how the space might be defined and what methods could be used to analyse it. The proposed method was spatial composition, with the floor as the unit of analysis and circulation as the compositional principle. The analysis resulted in the internal circulation assessment of 136 BT intermodal spaces across 95 train stations to better understand their effect on the circulation between the enclosed BPFs and train platforms at the train stations.

The insights from this research are discussed in this chapter. First, the main findings of this research are provided in Section 5.1. by focusing on the insights from each chapter. In Section 5.2., the methods, limitation and reflection of the research are discussed. Section 5.3. elaborated on the recommendations for practice and future research.

5.1. Main Findings

Throughout this study, it could be said that everything touched upon was unstable from the beginning, where nothing is entirely valid due to the varying number of interpretations of everything. However, as the study went on, or rather, the way the research was set up from the start was to find the common in variation. While this was not the question or sub-questions, it guided the outcome of this research. Although there are many findings stemming from trying to answer the research question, the main insights can be summarised by focusing on one aspect of each of the chapters. These can be understood as a finding on the topic (transfer space), the methodology (spatial composition) and analysis (circulation grade). Whether directly or indirectly linked to the research answer, the implicitness of transfer space (hidden in plain sight), or scale covering these two, the compositional principle of floor and circulation, and types giving rhetoric to space, have consequently theorised the transfer space and its measurement and provided this research with a conclusion.

5.1.1. Scope through Scale

The first major insight from this research has been the clarification of the topic, the transfer space between BPFs and train platforms at a station through the concepts BT intermodality, multimodal station and internal circulation. Upon reviewing all the literature across these concepts and synthesising it, it was possible to make explicit the fundamental space that is implicit in all things related to BT combination by positioning it within the larger research context, which in turn provided the categorisation of research topics and their span of space according to scale. Hence, while there are many ways to describe and evaluate it in the three concepts, the transfer space remains a constant across concepts despite their goals and perspectives.

Moreover, it was found that the transfer space being a missing link within literature is due to the framing of the transportation system as a multi-layered network. From the literature review, it is evident that the station can be defined as a network to analyse the relationship of nodes within the station as internal circulation. However, prior to this study, the relation between layers is recognised, but does not establish that the station and its spaces, as a lower-level layer of the system, which affects other layers, such as traffic (incoming trains) or transport (service line through station) layers. In van Nes (2002), The station in a multimodal transport network is seen as a node within a network of stations to access the system of transport services. A station that serves two transport services in multimodal in nature. An example of this is a station in a transport network map where a circle is bigger or multi-coloured to represent housing multiple lines within the node. What this research contributed to this layered model is to split this node, meaning the station itself is a network, with nodes as access points to specific modes, and at a lower level, the nodes become the floors where people walk to move between modes to access them. Within the multimodal transport network, the multimodal station, the transfer point, and its access nodes, represents the lowest layer of the layer model of a transportation system. As shown in Figure 5.1., for traffic or transport services to be possible across modes, the space to facilitate them is necessary.

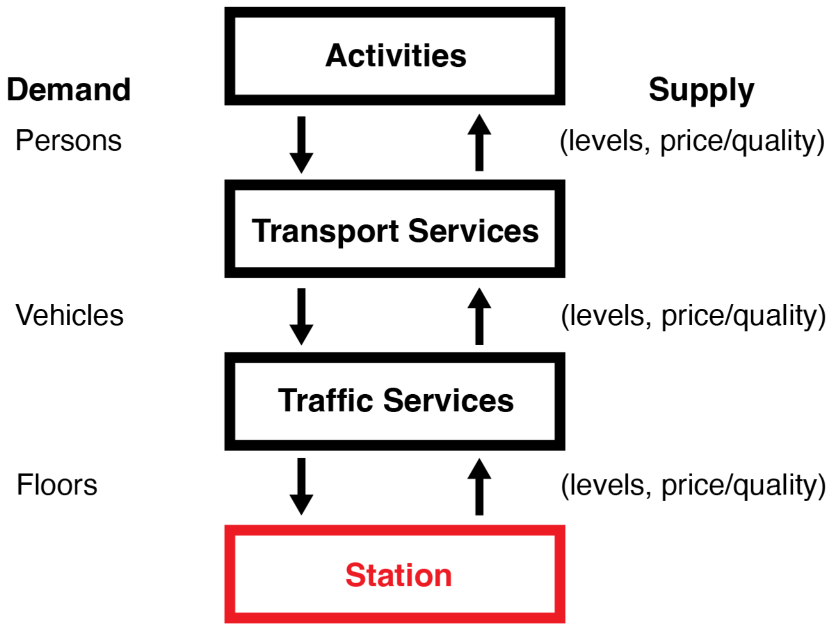


Figure 5.1. *Layer model of the transportation system (adapted from van Nes (2002), which is adapted from Schoemaker et al. (1999))*

5.1.2. The Abstraction of a Composite Object

Moving on from its place in the field of research, the second finding of this research was dealing with how to represent the transfer space within an intermodality within a multimodal station without a precedent methodology. In this case, spatial composition resulted to be a perfect fit because the proposed methodology was guided by the first finding (scale and low-level layer network), which ended up being one that can frame across and in between scales and is represented in graphs. Floor is set as the unit of analysis, which can exist at various scales, not specific to one intermodality, and therefore the common part present in any station regardless of built space. As a surface for circulation, circulation was able to frame the space between endpoints needed for analysis and became the justification for the data used with regards to survey the site. As such, the methodology is robust enough to be replicable and be applicable even with poor data. It becomes possible to abstract as long as there is a station and two modes within the area functioning for transportation.

The second thought on the finding (method fitting previous finding) was the epistemological process that was to try to translate the act of seeing a place and deciphering how to segment it and compose it from a series of distinct objects. This was difficult to put into words, as the process, from an architectural perspective, is inherent and therefore not presented as process in literature. Using spatial composition, the segmentation/integration process of parts and whole was instrumental to develop the methodology and the results, where the aim to find type informed how the composite object could be described and produced. Although spatial composition can be generalised to a process of finding the intelligibility of a space, the fact this term has been developed as a methodology with extensive previous research on a plethora of composite objects, it made it a very reliable and robust framework from which to assess the transfer space in a multimodal station. In a way, because this framework can include whatever is in space depending on focus, it can readily be used to capture spaces at transportation nodes previously omitted due to their complexity and offering a common language from which to analyse space across cases. Actually, the problem here was that although previous abstractions of space exist, they lacked a behind-the-scenes explanation as to how they got to that composition, or why they included/excluded details. Using this methodology, the process essentially requires the explanation or justification of what is the unit of analysis and compositional principle as a requirement, not just a constraint (e.g. geographical or operational demarcation).

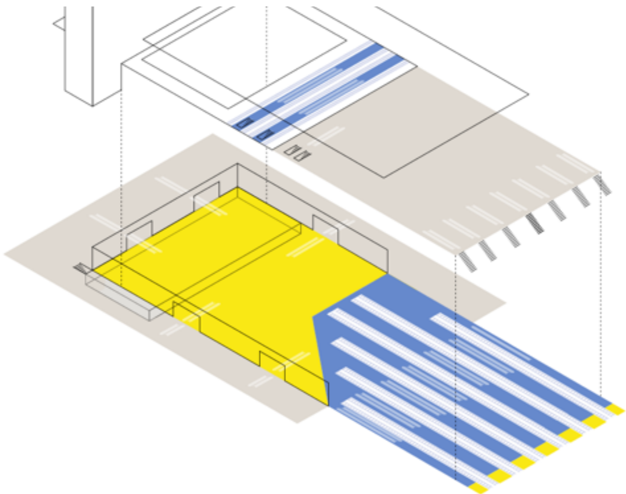


Figure 5.2. *Den Haag Centraal is categorised as a multimodal hub, yet not all other modes are included in its diagram. Source: Bureau Spoorbouwmeester, 2012*

5.1.3. Circulation as Compositional Principle

Once the station can be abstracted, segmented and analysed for circulation, the third finding in this research was that it was found that circulation as a metric as well as a compositional principle, was successful in working both to narrow and expand what factors should be considered at different levels of abstraction. While circulation grade is ultimately the simplest way to describe the performance of a BT intermodal space, the composition, arrangement, articulation and trajectory from which it derives, they each are able to construct a category to consider possible combinatorial logic of parts. In doing so, it was found that the use of floors explains or elaborates on the verticality at stations necessary to segregate the railways, where most, if not all, cases require passengers to go over or under the tracks to access the platforms. In the case of terminal stations, it should be easier to ensure good circulation grade, as the segregation is not present as long as the BPF is positioned in front of the floor from which all platforms stem (e.g. Vlissingen and Den Haag Centraal). This kind of insights are possible when looking at recurring patterns in space, where circulation as a compositional principle works across scale and across levels of abstraction for the purpose of describing and producing the transfer space of an intermodality within a multimodal station.

The second point of this finding (design factors across levels of abstraction) is that the compositional principle is not unlike the notion of "BPF as entrance to the station". Mentioned as a design suggestion for BPFs at stations in a white document describing the station quarter (stationskwartier), the document suggests that every new station entrance is a new bicycle parking facility (Nieuwe stationsingang = nieuwe fietsparking). While this whole research delves on spotting the presence of the transfer space, it is ultimately the omission of transfer space that is the design goal, as the best cases are those where the platforms can be directly from the BPF, acting as an entrance to the station for train-cyclists (e.g. Vlissingen, Delft, and Houten). Therefore, this study concludes that the BPF can and should be positioned as an entrance to all train platforms.

Figure 5.3. *New station entrance = new BPF. Source: Bureau Spoorboumeester, 2019*

5.2. Discussion

In the discussion, the idea is to internalise what the findings mean. This part consists of reflections on the limitations of the research, reflections on the methods used in the research, and reflections on the research in general. A model, as a simplification of reality, stems from what can be reduced and what may not be describable. In a way, this study is a model, an attempt to solve a problem with specific tools at a specific scope. As such, both the constraint imposed by time and data available give fruit to the resulting report. In this sense, it could be seen how although there are many decisions and assumptions made to carry out this research, at the end of the day, its finitude is controlled by time, effort, and data available.

5.2.1. Limitations of Research

The limitations of this research stem from the novelty of how the problem is framed, which put into question **data availability** with regards to previous research and spatial information on the stations, the BPFs, and their relationship. On the one hand, there are a lot of studies that deal with bicycle-train relationship, but there wasn't a specific branch that dealt with the transfer space specifically. On the other hand, there is the presence of BPFs at 95 train stations in the Netherlands, but no written inventory on the total number of facilities and their position in relation to the station. These limitations were therefore turned as a research objective, which was to look at all the previous research to find the recurring information of the topic on paper, and to look at all existing infrastructure to find the recurring information of the space at stations. The decision to cover all literature manually was met with constant expansion of sources upon reaching the bibliography of each article to cross-reference with existing inventory and the coverage of multiple languages what as much of assistance as to delay placing them within the whole body of knowledge when there was no cross reference to other documents. The decision to cover all stations was further complicated due the data unreliability and temporality of station online maps (subject to change due to works or photograph updates or lack of), which demanded corrections to analysis or expansion of the sample.

This study is not limited in the rigour to **structure** everything tightly within one totalising system where everything fits accordingly around the research topic. This was most definitely forced as a way to organise what at many moments during the investigation would stir off on a tangent due to potential exceptions to the rule. This is exemplified in using the literature review to inform the methodology to inform the results. To the author's knowledge, the resulting research framework was more of a straightjacket where all conclusions led to the same structure rather than planned from the onset. It is therefore possible that some sources are used to expand on making a point, although said source is not primary focus on the topic to support. Nonetheless, this is why a multitude of sources to support a point by showing recurrence across source of different disciplines was applied. A la ouroboros, the structure of the research was probably set for by the ideation of finding type throughout the study. As expressed in de Bruijn (2012), one develops an approach during the investigation and hopes it somehow squares out a circle.

One other limitation that ate away at my brain was the bold move to talk about **voids and circulation** between disciplines without common language. I consider this a limitation of the research because this felt so difficult to synthesise into the thesis with so little literature pointing to what I meant by both of these things. Again, the thoroughness of pulling sources from so many places has been an honest attempt to ascertain the meaning of what is meant by both things. For voids, finding out that eastern art and architecture saw voids as an intentional space was the first step to find out how to talk about it, even if it stemmed from the Kyoto school of philosophy on emptiness (Baek, 2008). Particularly with regards to circulation, the movement-space relationship from the perspectives of transport, architecture, and transport-architecture, was already an analytical procedure within what should be a compilation of related articles, which were selected on the basis of how they could support the definitions for each discipline. In the end, one lands at certain definition that can be implied from the compilation in each instance, it is not apparent by simply putting the literature next to each other, as terminology and focus of each document varies, such as focusing on queueing model innovation, but including circulation as a factor.

5.2.2. Reflection on Methods

Stemming from the limitation on the research, the ambition to use **type as the organising principle** to find what was constant despite variation in this investigation was a nightmare. I have no idea if type has been used before this openly for explorative research that does not simply precede a design proposal, but I think this was more positive than negative outcome. I guess this is where it feels quasi-academic and not fully academic, almost like auto-theory. The lack of pre-established methods proved to show for inefficiency to the next degree. For example, all, the literature review, methodology and analysis results were a masticating/ruminating cycle where all pieces were suspended and informed each other through iterations removing what was not relevant across. Lack of consensus seems like an unwillingness to establish terms or restrain from using them interchangeably or having other definition if talking about moving people or goods (e.g., intermodal, co-modal, multimodal, transmodal, intramodal in public transport or transit and freight or logistics).

Moreover, existing methodologies for type are also not 100% similar to what was applied here. The inability to trace the proposed methodology of type directly to previous research was infuriating. The positive thing was to find that spatial composition solved four issues: it frames composite objects, it could be used to analyse void-space, and it is deployed towards extracting types out of the framed object, and it could abstract the parts-whole as a network graph. Although this is super positive, there is virtually no other study with which to point as a reference to what was applied here. In that sense, there was little awareness of what could be the best approach to the analysis framework, so, again, the constant reiteration of everything led to formulating the methods as described here.

Seeing as there was no previous method to this thing, there were a million ways to segment the station into parts. For a long time, the segmentation was made by rooms, meaning a roof or wall would make a separation, but then the segmentation could be too many space that could be one, or the difficulty of expectations, where a roof or wall could be inferred at a space depending on what was considered. Therefore, floor as a unit ended up being simpler and covered all cases, becoming a constant by avoiding exceptions and resulted in giving better outcomes than the alternative. The other major reflection on the analysis method has to do with the author's capacity for **architectural representation**. The first encounter with the idea of analysing a group of composite objects, as is the BT intermodality within the multimodal station came from the book Made in Tokyo (Kaijima et al. 2001), by the same authors that developed the spatial composition theory. This book provided a perfect framework to represent the stations, even if the scope was completely different, where ugly architecture made of two or more objects, such as a cement factory/dormitory, or a graveyard/shooting range, all considered environmental units. As the complexity of the drawing exceeded my capacity as a draftsman, the integration of the abstraction of architecture as network graph was not only a justification to simplify the representation, but also helped to better understand why it is so common across disciplines and scales.

5.2.3. Reflection on Research

The lack of common language, methodologies, or measurements for the transfer space would in any other instance proved too ambitious of a task. Looking back, it is obvious why this scale was implicit, it is difficult to talk about non-places, talk about them within places between disciplines in a research field without established terminology.

There is a version of this where I could simply focus on identifying and locating the BPFs at train stations and measure them according to Euclidian distance (straight line between two point). However, this avoid the question of how there is a space between them that is not address and is simply represented by the number of meters, which may in practice not be a straight line horizontally or vertically, which alters the time it take to walk it and further blurs what the metric actually measures.

One way I read the literature review today is as “the reasons why no one has ever dared to look into the spatial dimension of this problem”. In my mind, I would previously think this thesis was a stupid idea because I was covering something so obvious, where I, for the longest time, would not accept that it hadn't been covered and this is essentially why I started looking at literature in other languages, and covering something too ordinary or moribund or redundant or one of these words to talk about something that is leftover, after-thought, liminal.

The question at the centre of this investigation was to try to think how people come up with space. However, what became exciting with using type and delving into architectural theory, I earned an education on the operation of writing the redundant and elevating it to the status of architecture. This means that while architecture is generally concerned with projects that came from the intellect of authors, works of art, built space or un-built space was also part of the environment could and should be talked about.

I recognise that ambition to align everything, which maybe was not necessary to find the proposed solution, but it structured what I filtered out to come up with a methodology and position the topic within the larger body of knowledge. I think my last reflection on this project are two things. First, the kind of question this research poses has one way of solving it found in this study, which can serve as a point of reference to other investigations. Secondly, In the sudden rise of General AI, this study can be read as a proto-AI attempt to synthesise a LLM (Large Language Model) from literature and infrastructure to give back four letters: A, B, C, and D. This thought offers two insights: I could have waited for AI to get better to skip having to wrangle literature and spatial data myself, or this thing could be cooked up to be a way to write typological research algorithm programs, something approaching OSMnx, carrying out street network analysis in any street grid available in OpenStreetMaps (Boeing, 2017).

5.3. Recommendations

Although this was completely unnecessary, the innovation in the research approach has resulted in precedent to use type in intermodality, composition in English academic studies on stations, and a quasi-multi-language exploration scoping review methodology. We can find solace in the fact that these useless things we created here can be of some use for research and practice.

5.3.1. Terminology

This study has provided a couple of diagrams to the larger body of knowledge to position topics across scales of space and layers of a transport network. Hopefully, scale and hierarchy can be principles that make research topic distinct, at least to the point that research within each talk about the same thing. Maybe in this way, harmonisation is possible if everyone figures out, they are talking about the exact same things and approximate a common language. Finding distinct topics and overlaps in subject matter across disciplines while all dealing with a scale of space is a noble pursuit to ground boundaries and connections within literature for single discipline, interdisciplinary, multidisciplinary, and transdisciplinary studies.

5.3.2. Further Research

There are three applications of the outcome of this research for future endeavours: correlating the circulation grade to previous research measures, replicating station composition to other case studies ranging in location, multimodality, and intermodality, and alternative uses of station composition to understand other units of analysis, the evolution of stations and the enrichment of spatial data for circulation analysis. Circulation as a metric that grade the performance of a transfer space with regards to ease of transfer could be coupled with indicators in other studies to see if there is correlation of grade to user preferences and interventions at the station over time. One example is the correlation of grade to station type in terms of size/complexity (small, medium, large), where it could be assessed if survey participants stated smaller station have better BPFs is correlated with smaller stations having less transfer space and therefore having a better grade on average (Martens, 2007). Another example is the correlation of grade to BPF implementation could be assess according to the before and after change in grade to the modal split share of bicycle as access/egress for said station. Moreover, the distinction of grade per BPF could potentially pursue operators to measure modal share per facility rather than the station in general. Additionally, grade could be assessed for correlation with bicycle parking policies, looking at whether circulation has improved with increasing capacity. This could expand on the interrelation among capacity, cover, and circulation, where maybe increase in circulation may result in worse circulation, due to picking a larger space often farther from the train platforms at the station site.

The way the analysis framework was developed, there is potential for it to be applied in the Dutch context for the circulation grade of other BPFs (e.g. open facilities (676/810)), evaluate multimodality of other stations (306/400), or look at other intermodalities at stations (> 400) (e.g., train-bus, bus-tram, tram-train, train-ferry, bicycle-tram, bicycle-bus, etc.). Its replicability, due to the unit of analysis, can also be applied in other contexts, including stations in Germany, Denmark, Spain, China, Japan, or USA. Moreover, the analysis framework could also be applied to different framed objects, such as car-parking at a mall, bicycle parking at a point of interest (e.g., beach boardwalk, public building, event entrance). Also, the analysis framework could be applied for the circulation of other users, such as wheelchair users or parents with trolleys, who are also travellers for all spaces mentioned here.

Regarding the research approach, further research using this approach, in my honest opinion, calls for two specific subjects: the genealogy of the multimodal station, and a walking data specification for the station. These are alternative uses of the research approach, but they seem to fit with the approach because it's a tricky task. For the genealogy, the approach implies studying the station using composition to trace back the genesis of the multimodal station and extract the history and evolution through its spatial composition. This precedent analysis is like a literature review, but with buildings, to be able to trace evolution of BPFS at station or multimodal station using spatial composition, such as revisiting the variation of standardisation of post war stations in the Netherlands (Lansink, 1998).

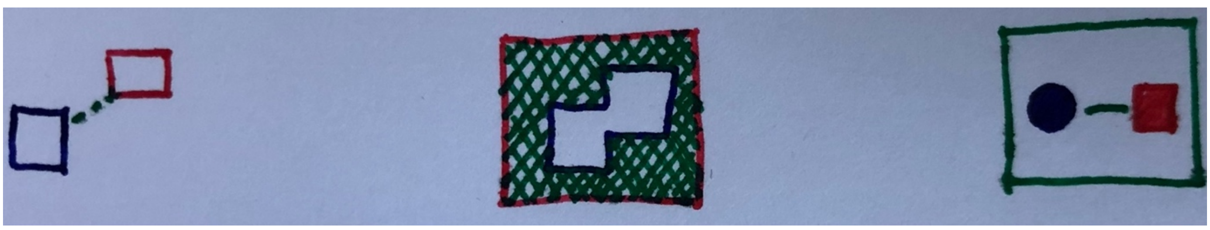
With the data specification, I would make a case for the Walking Space Network Data Specification (WSNDS). This term was introduced in one of the studies of internal circulation from a Transport-Architecture perspective, which had a spatial network for each Tokyo station analysed in the study (Arai et al. 2022; MLIT, 2017). The application of the approach would investigate this specification as a micro scale of GTFS (General Transit Feed Specification), which defines a common data format for public transportation schedules and associated geographic information. In this case, the existence of such data standard would mean a route planner such as Google Maps would be able to display the segmentation of the walking segment from a bus stop to a train platform when transferring in a trip. As such, the data specification could help both to better describe, evaluate, produce and modify spaces at the station to improve circulation for every traveller. One possible application of such standard would then be to correlate circulation grade to time, distance, and dimensions of the space within micro simulation model of the BT space within a multimodal station.

5.3.3. Policy and Design Precedent

Not all facilities are created the same way and the station's spatial context matters. Despite these constraints, this research provides a framework to evaluate accordingly and propose design strategies. Therefore, rather than doing their homework, this study can serve as a precedent for both.

In policy, the theorisation and evaluation of the transfer space can be a justification for clearer communication of objectives at different scales and provide an evaluation tool. Additionally, it could be interesting for policy to look at the visibility of spatial data for a composite object such as a multimodal station from the point view of the comfort for its population, in the sense that the google maps should include these spaces as part of a whole, despite being separate objects, because they function in tandem and are considered when making a decision to make a trip for a traveller. This can be said to be a political stance, where a place can be both a whole and a part of bigger whole.

For design, justification for organisation of space in relation to design goal (ease of use or seamlessness) and its measure. The idea of precedent works for policy as a systematic review to a consensus on what ultimately is what's needed to improve the BT combination, and for design, it represents the precedent analysis at the beginning of any design proposal for a new BPF by a designer, which is to look at previous examples of BPF implementation and use their design to influence design choices for their proposal. Derived through type, the solution is not a model, but an instrument to interpret what remains and what is redundant; not a metric, but an instrument to both specify needs and generalise outlook, a productive universal (Kockelkorn & Zschocke, 2019).



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Appendix A: Literature Review

A.1. Literature Review Approach

Approach Ideation

For this study, the literature review proves to be bothersome because there isn't really something to depart from: where a literature review compiles sources to both validate research topic and methods to depart from, this review is closer to a scoping review, which compiles literature according to keywords or concepts that may include the term in in question, the transfer floor. From this literature review, the transfer floor can be made explicit as well as how it has been studied in the past or why not.

The literature review is therefore deployed "around" the term. This is done by using concepts that may encapsulate or include the term implicitly. The concepts, rather than being set from the start, were formulated upon various iterations of searching for literature, which is explained below and is reflected in how the main body is structured. The resulting concepts applied are based on different scales that may be dealing with the term, such as the multimodal station, BT intermodality, and internal circulation. As such, rather than validating the term as an established subject matter, the concepts represent an anti-hypothesis to demonstrate it has yet to be studied and derive why this may be the case. Put another way, the concepts are applied to make explicit a void in the literature, a liminal space, the transfer floor.

Following this logic, rather than using an established approach to literature review, such as systematic review or scoping review (Munn et al. 2018) or bibliometrics (Delgado-Vinas et al. 2022) it was assumed that this review required closer reading due to the number of interpretations per concept. Close reading to locate a word or an intention to cover a cover, not just the keyword. Due to limitations found in the interpretations changing between English and Dutch sources, sources in other languages were also considered in the languages such as Japanese, Mandarin, Korean, Arabic, English, Spanish, French, and Italian. Japanese is also the bulk of literature used for the methodology.

This resulted in the compilation of many more documents that were included in this report. To organise the documents by keywords, a network was established using the note-taking software Obsidian. This software was used both as a bibliography management software and to visualise the connection amongst documents reviewed. Although many sources were not used in report, their compilation/grouping helped distinguish variation within a topic and filtered out what was out of scope. The figure below captures the total number of documents considers in a network graph for the Obsidian vault (folder).

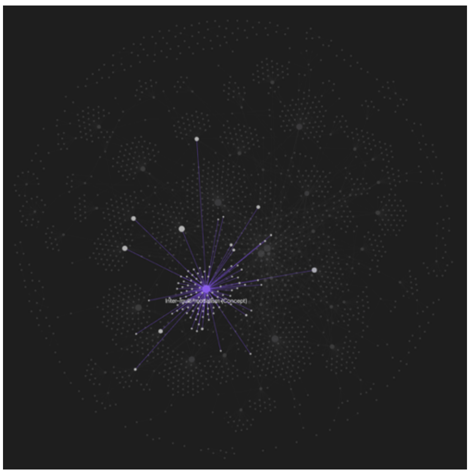


Figure. A.1.1. *Literature review network graph in Obsidian*

This appendix is divided by the concepts used. As previously mentioned, the literature review approach was devised as the literature search changed keywords in order to narrow down the scope of what documents to search for and review. The following paragraphs give a brief explanation of how the search strategy was carried out, as well as how the method was structured with the intention to group the documents reviewed to provide a structure to the main body when talking about each concept, as well as keeping a thread between the different concepts. The subsequent sub-appendices A.2. – A.4. give a detailed account of how the documents were filtered and how they informed the synthesis of each concept via the use of tables to filter documents and diagrams to synthesise the meaning of the concept and its relation to the transfer floor.

Search Strategy

The review of literature started with the exploration of the bicycle-train connection concept. The search query for bicycle-train connection included the following terms and all possible variations of the terms and combinations: “bicycle parking facilities”, “stations”, “public transport”, “intermodal”, “multimodal”, “train platforms”, “layout”, “configuration”, “circulation”, “quality”, “level of service”. During the review of literature, it was found that there is a fair amount of systematic review academic articles on bicycle-train connection over time under the terms “bicycle-train combination”, and “bicycle-rail integration”. In addition to these, it was also found that many literature reviews within MSc theses and PhD dissertation have carried out systematic reviews on the subject before. The results of this review consist of positioning the research problem within the existing body of knowledge through the categorisation of spatial scales and its factors. The categorisation of spatial scales enables to narrow down the research related to the scale of this research, and the scale’s factors provide a better understanding of previous research at that scale.

This was followed by the exploration of the multimodal station. Because the train mode tends to be considered the backbone of any public transport network, it was assumed that more likely than not, the multimodal station is, roughly speaking, a train station with service to other modes. As such, both academic and grey documents on the multimodal and train station were reviewed. Evidently, many studies on complex train stations were named multimodal stations, and multimodal station without this notion could be more abstract, where “multimodal” combined with other words would deal with very different subjects, such as multimodal hubs on a street intersection, mobility as a service (MaaS), and the inclusion of offices around the station area (transit-oriented-development, TOD). As such, an emphasis on architectural perspective of the multimodal (train) station was made. The results of this review consist of an overview of existing academic literature on the analysis of the multimodal station, and an overview of the practice of the physical planning of a multimodal station.

The last part of the literature consists of the exploration of intermodal circulation. Although this term’s combination of words is not found in the existing body of language, related terms such as “flow”, “flow line”, “route”, “path”, “circulation area”, “intermodality”, “order”, “array”, “sequence”, “pedestrian flow”, “pedestrian traffic”, “station system” and “circulation diagram” were used. Because the circulation term is borrowed from the discipline of architecture, the documents reviewed in this section are focused on the representation of circulation in space. As such, the academic literature delves into the concept of architectural circulation and its relation to the organisation of space. For grey literature, industry documents are reviewed to establish how the relationship between modes is spatially understood. The results of this concept consist of the contextualisation of the architectural definition of circulation within the multimodal station and the industry’s description of how intermodality is set as a sequence from one mode to another within the multimodal station.

Method

As a way to put the literature search into evidence and filter though the documents to see what’s useful and what might be out of scope, tables were created to place multiple documents and compare them in one place. The intention of formulating tables that help narrow down the focus by comparing across the documents what is similar, different, inside and outside the scope by looking at the factors within the selection of documents them self, the body.

The general idea of this tables is as follows: or the structure within each concept:

- Item number
- Author and year
- Document category
- Document sub-category
- Field
- Sub-field
- Subject Matter
- Presence of keyword relating to concept considered

Applied to the concept, the tables can be described as follows:

- The BT intermodality table is focused on the presence of transfer space in a BT document and whether it has scale (which) or is scaleless.

- The Multimodal station table considers papers that deal with a station building or site (scale-FUL), then what name for multimodal station, and then distinguish focus on the function (place/node) and form (segmentation, outline, arrangement)

- The internal circulation table considers two things, first documents according to discipline, and method. Secondly it gives an explanation of why the chosen are chosen, which is to say they best represent what you are getting at. This table is an opportunity to include all the various sources you looked at (e.g. hospitals and museums) to inform your decision.

Their output is then explain using the figure that corresponds to synthesise their section. Through these diagrams, it was found that they both informed the next concept and that at the end, they translated to the spatial framework applied to develop the study's methodology.

Sources:
Munn, Z., Peters, M. D., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC medical research methodology, 18*, 1-7.

Delgado-Viñas, C., & Gómez-Moreno, M. L. (2022). The interaction between urban and rural areas: An updated paradigmatic, methodological and bibliographic review. *Land, 11*(8), 1298.

A.2. BT Intermodality

Rather than dealing with the search strategy for BT intermodality, this appendix is more focused on the processing of the literature compiled. The following paragraphs explain the logic of the table to be presented below, as well as the constraints, such as where and when to stop compiling, and what to check in documents. The point of departure for a literature review on BT intermodality was to look all the systematic reviews that look at the relationship between bicycles and trains. The total reviews are shown in the table below with a brief description of its contents and the total number of articles reviewed.

Table A.2.1. *BT intermodality systematic reviews*

#	Author and Year	Title	Articles reviewed	Utility	Relevant term
1	heinen & buhler. 2019	Heinen, E., & Buehler, R. (2019). Bicycle parking: a systematic review of scientific literature on parking behaviour, parking preferences, and their influence on cycling and travel behaviour.	94	Insights	Users prefer more capacity, proximity and better quality than the opposite
2	weliwitiya, h. 2020	Weliwitiya, H. (2020). Bicycle train intermodality: Exploring mode choice decisions and mode shift potential	50	Factor categories and field umbrella term	Station environment, parking integration factors, and BT intermodality
3	hagen & rynning. 2021	Hagen, O. H., & Rynning, M. K. (2021). Promoting cycling through urban planning and development: a qualitative assessment of bikeability.	Not specified	Attribute categories	Accessibility by public transport (PT)
4	hoksam, s. 2021	Hoskam, S. (2021). The willingness to pay of various types of bike parking-users at train stations for different types of facilities and stations.	Not specified	Factor categories	Parking facility layout characteristics
5	egan et al. 2023	Egan, R., Dowling, C. M., & Caulfield, B. (2023). Exploring the elements of effective public cycle parking: A literature review.	24	Factor categories	Accessibility, Proximity and Integration
6	kosimidis & muller. 2023	Kosmidis, I., & Müller-Eie, D. (2023). The synergy of bicycles and public transport: a systematic literature review.	298	Factor categories	Quality of interchanges and provided facilities

These reviews give us some ideas of how the review can be organised and where to draw the line by looking at what their tables are categorising. As such, the format is adapted for this study, and it is found to be the first filter that will affect all review for literature of the subsequent concepts. However, the reviews lack a specification of what actually matters, but derive insights from an array of solutions. Among those solutions, increasing proximity between parking facilities and stations is mentioned, but not from a physical perspective, such as pointing to the train platform as the endpoint on the train side. Moreover, there is conflicting use of the terms intermodality and integration. In the next table, various documents were reviewed to get a better distinction between the terms “combination, integration and intermodality” by establishing scale categories.

BT Intermodality Literature

From these systematic reviews, it was considered then to look at specific documents and look at how the bulk of literature could be categorised in order to filter the documents that may provide answers to the problem that is the transfer floor and possible methods to analyse it. The BT intermodality table is focused on the presence of transfer space in a BT document and whether it has s (which) or is scaleless. To accomplish this, the table created included columns that distinguish the field from the sub field, on whether the transfer floor is mentioned. While doing this, it became possible to distinguish BT intermodality as a research field from integration and combination based on scale, as well as to narrow down through integration to physical one, and within that one, BPF integration factors. Therefore, the table below gives an overview of literature that is most closely related to the subject matter at hand, even though it does not tackle the transfer floor. The documents are ordered by year, as the most recent documents will probably include the previous in their bibliography.

Table A.2.2. *BT Intermodality adjacent literature*

#	Author and Year	Title	Doc Type	BT Field	Subject Matter	Method	Scale	Mention of Transfer Floor
1	Brons et al. 2009	Brons, M., Givoni, M., & Rietveld, P. (2009). Access to railway stations and its potential in increasing rail use. Transportation Research Part A: Policy and Practice, 43(2), 136-149.	Academic article	Integration	Access/egress mode to stations	User Survey	Origin-Access	No
2	Pucher & Buehler, 2009	Pucher, J., and R. Buehler. Integrating Bicycling and Public Transport in North America. Journal of Public Transportation, Vol. 12, No. 3, 2009, pp. 79–104.	Academic article	Combination	BT integration measures	Literature Review	Origin-Destination	No
3	Pan et al. 2010	Pan, H., Shen, Q., & Xue, S. (2010). Intermodal transfer between bicycles and rail transit in Shanghai, China. Transportation Research Record, 2144(1), 181-188.	Academic article	Integration	BT intermodal transfer	User Survey	Origin-Access	No
4	Scheltema, E. 2012	Scheltema, E. B. (2012). ReCYCLE City: Strengthening the bikeability from home to the Dutch railway station.	MSc thesis	Integration	BT Integration origin-access	Route Analysis	Origin-Access	No
5	Arbis et al. 2016	Arbis, D., Rashidi, T. H., Dixit, V. V., & Vandebona, U. (2016). Analysis and planning of bicycle parking for public transport stations. International journal of sustainable transportation, 10(6), 495-504.	Academic article	Intermodality	Bicycle Parking distance to station entrance	Observation	Access Station	No
6	Hernandez et al. 2016	Hernandez, S., Monzon, A., & De Oña, R. (2016). Urban transport interchanges: A methodology for evaluating perceived quality. Transportation Research Part A: Policy and Practice, 84, 31-43.	Academic article	Integration	Transport interchange quality	User Survey	Origin-Access	No
7	Kager et al. 2016	Kager, R., Bertolini, L., & Te Brömmelstroet, M. (2016). Characterisation of and reflections on the synergy of bicycles and public transport. Transportation Research Part A: Policy and Practice, 85, 208-219.	Academic article	Combination	BT mode	Conceptual Analysis	Origin-Destination	No
8	Geurs et al. 2016	Geurs, K. T., La Paix, L., & Van Weperen, S. (2016). A multi-modal network approach to model public transport accessibility impacts of bicycle-train integration policies. European transport research review, 8(4), 1-15.	Academic article	Intermodality	BT accessibility	Model	Access Station	No

#	Author and Year	Title	Doc Type	BT Field	Subject Matter	Method	Scale	Mention of Transfer Floor
9	Leferink, t. 2017	Leferink, T. S. (2017). Why Cycle To The Railway Station?: A station scanner based on factors that influence bicycle-rail use. With a study on stakeholders in Scotland.	MSc thesis	Combination	BT intermodal transfer	User Survey	Origin-Destination	No
10	Sjoo & Skoldberg. 2019	Sjöö, A., & Sköldberg, L. (2019). A Study of Multimodality with Focus on the Combination of Bicycles and Trains-Technical Solutions Combined with Mobility Management and Nudging for an Effective Bicycle-Train System in Region Västra Götaland.	Academic article	Combination	BT mode	User Survey	Origin-Destination	No
11	Dolders & Reiling. 2020	Dolders & Reiling (2020). OV-KNOOPPUNTEN + FIETS: Doorsnede van de 'fiets+OV' opgaves richting 2040.	Feasibility study	Integration	BT integration spatial analysis	Site Analysis	Origin-Access	No
12	Weliwitiya, h. 2020	Weliwitiya, H. (2020). Bicycle train intermodality: Exploring mode choice decisions and mode shift potential	PhD dissertation	Integration	Parking feature satisfaction	User Survey	Origin-Access	No
13	Hoksam, s. 2021	Hoskam, S. (2021). The willingness to pay of various types of bike parking-users at train stations for different types of facilities and stations.	MSc thesis	Integration	BT intermodal transfer	User Survey	Origin-Access	No
14	Jonkeren et al. 2021	Jonkeren, O., Kager, R., Harms, L., & Te Brömmelstroet, M. (2021). The bicycle-train travellers in the Netherlands: personal profiles and travel choices. Transportation, 48(1), 455-476.	Academic article	Integration	BT traveler profile	User Survey	Origin-Access	No
15	Pazzini et al. 2023	Pazzini, M., Lantieri, C., Zoli, A., Simone, A., & Imine, H. (2023). Evaluation of Railway Station Infrastructure to Facilitate Bike–Train Intermodality. Sustainability, 15(4), 3525.	Academic article	Integration	BT intermodal transfer	User Survey	Origin-Access	No
16	Beidenhauser, C. 2024	Beidenhauser, C. (2024). Bike–Train Integration. The Role of Bicycle Parking in Promoting Sustainable Transportation along Norway's Jæren Line (Master's thesis, UiT Norges arktiske universitet).	MSc thesis	Integration	Bicycle Parking typology	Literature Review	Origin-Access	No

From reviewing literature on BT intermodality, it then became possible to distinguish scales and topics covered within each scale. This insight corresponds to Figures 2.1. and 2.2. in Chapter 2.

A.3. Multimodal Station

For the multimodal station, there was initially two issues: a) not all multimodal stations are called multimodal and most larger train stations or bus stations are multimodal but not defined as such, b) multimodal station as a place has yet to be defined according to its components, so as to rely on the segmentation of train stations to be able to extract components of a multimodal station. As such, the search of literature on multimodal stations became a search for breakdown of stations in general. The following table shows the results of this search, where literature from various countries define the station either by function or by form, which various categories and often lacking a clear definition for the transfer floor. In the only case where the multimodal station is named as such [7], it represents a type of station that has more modal facilities than other types. In this case the approach domain is defined as all the common space between modes.

Table A.3.1. *Multimodal station literature*

#	Author and Year	Year	Country	Title	Doc Type	Function or Form	Station Categories	Segmentation	Scale	Mention of Transfer Floor	Multimodal Station Term
9	Kandee, S. 2004	2004	N/A	Kandee, S. (2004). Intermodal concept in railway station design. Transportation facilities and the design railway station.	Academic article	Function	None	Areas	Island	Concourse	Intermodal Station
5	Prorail. 2005	2005	NL	ProRail (2005). Basisstation 2005, deel A en B: Functionele normen en richtlijnen voor treinstations.	Industry guidelines	Function	None	Functions	Island	Front-function	Railway Station
3	Zemp et al. 2011	2011	CH	Zemp, S., Stauffacher, M., Lang, D. J., & Scholz, R. W. (2011). Classifying railway stations for strategic transport and land use planning: Context matters!. Journal of transport geography, 19(4), 670-679.	Academic article	Function	7 Classes	None	Urban Area	No	Railway Station
10	Lehmann, T. (2011)	2011	DE	Lehmann, T. (2011). Der Bahnhof der Zukunft–Alternativen zum traditionellen Bahnhofsempfangsgebäudel Entwicklung eines modularen Entréesystems für kleine und mittlere Bahnhöfe.	Industry guidelines	Function	6 Categories	Zones	Island	Station Plaza	Railway Station
7	Bureau Spoorbouwmeester, 2012	2012	NL	Bureau Spoorbouwmeester (2012). Het Stationsconcept:Visie en toepassing. Bureau Spoorbouwmeester. Utrecht.	Industry guidelines	Form	6 Types	Domains	Island	Approach Domain	Multimodal Station

#	Author and Year	Year	Cou ntry	Title	Doc Type	Function or Form	Station Categories	Segmentation	Scale	Mention of Transfer Floor	Multimodal Station Term
8	van Hagen & Exel. 2014	2014	NL	Van Hagen, M., & Exel, M. (2014). De reiziger centraal - De reiziger kiest de weg van de minste weerstand.	Industry guidelines	Function	6 Types	None	Urban Area	No	Station
1	Networkrail. 2021	2021	UK	NetworkRail (2021). Station Design Guidance Design Manual NR/GN/CIV/100/02 March 2021.	Industry guidelines	Function	6 Categories	Stages	Island	Approach Stage	Interchang e
6	Amtrak. 2022	2022	US	Amtrak. (2022). The Amtrak Station Planning and Development Guidelines.	Industry guidelines	Form	5 Typologies	Program Components	Building	Circulation Component	Large Stations
2	Weustenenk & Mingardo, 2023	2023	NL	Weustenenk, A. G., & Mingardo, G. (2023). Towards a typology of mobility hubs. Journal of Transport Geography, 106, 103514.	Academic article	Function	6 Categories	None	None	No	Hub
4	Prorail. 2023	2023	NL	ProRail (2023). Network Statement 2024	Annual Report	Form	5 Classes	Zones	Island	Front-zone	None

While the intention here was initially to distinguish the definitions according to scale, it proved difficult to do so when the terms used are so different or are not dealing directly with a multimodal station. This eliminates the need to check by name of multimodal station, and instead focus on the circulation of paths. It was found that in many cases circulation path/route is seen as the way to get from point A to B.

A.4. Internal Circulation

Although it is not very clear in this appendix, the literature used to narrow down the definition of internal circulation stemmed from the use of the term in [19]. From this term, it was possible to focus on those studies where the circulation, or flow was measured within the boundaries of the station. As such, most studies focus on a more granular scale (e.g. stairway or ticket gate). However, it is through this review of literature that it was possible to improve what to filter what to search.

This appendix includes two tables. one gives an overview of all the studies that were considered with regards to the internal circulation of a station, preferably multimodal, although almost none applied. The second provides an overview of all the studies reviewed that gave a comprehensive understanding that circulation can and tends to be captured and communicated via network graphs. Together, they trace the manner in which this study structured the text on the main body and derived its conclusions on the concept.

Table A.4.1. *Internal circulation literature*

#	Author and Year	Title	Doc Type	Field	Scale	Circulation	Transfer Floor	Method
1	Khattak et al. 2018a	Khattak, A., Yangsheng, J., & Hussain, A. (2018). Design of passengers' circulation areas at the transfer station: An automated hybrid simulation-differential evolution framework. Simulation Modelling Practice and Theory, 87, 293-310.	Academic Article	Transport	Station Building	Walking speed	Passageways and stairways	Queue Model
2	Khattak et al. 2018b	Khattak, A., Yangsheng, J., & Abid, M. M. (2018). Optimal configuration of the metro rail transit station service facilities by integrated simulation-optimization method using passengers' flow fluctuation. Arabian Journal for Science and Engineering, 43, 5499-5516.	Academic Article	Transport	Station Concourse	Pedestrians/second	Ticket and elevator facilities	Queue Model
3	Zhu et al. 2017	Zhu, J., Hu, L., Jiang, Y., & Khattak, A. (2017). Circulation network design for urban rail transit station using a PH (n)/PH (n)/C/C queuing network model. European Journal of Operational Research, 260(3), 1043-1068.	Academic Article	Transport	Station Building	Pedestrians/second	Corridors and stairways	Queue Model
4	Ahn et al. 2017	Ahn, Y., Kowada, T., Tsukaguchi, H., & Vandebona, U. (2017). Estimation of passenger flow for planning and management of railway stations. Transportation Research Procedia, 25, 315-330.	Academic Article	Transport	Station Building	Pedestriian movements per direction	Concourse and platforms	Traffic Simulation

#	Author and Year	Title	Doc Type	Field	Scale	Circulation	Transfer Floor	Method
5	Haghani et al. 2019	Haghani, M., Sarvi, M., & Shahhoseini, Z. (2019). When 'push'does not come to 'shove': Revisiting 'faster is slower'in collective egress of human crowds. Transportation research part A: policy and practice, 122, 51-69.	Academic Article	Transport	Threshold	Pedestrians/m2	N/A	Evacuation Experiment
6	Dell'Asin & Hool. 2018	Dell'Asin, G., & Hool, J. (2018). Pedestrian patterns at railway platforms during boarding: evidence from a case study in switzerland. Journal of Advanced Transportation, 2018, 1-11.	Academic Article	Transport	Station Platform	Passenger path	Platform	Queue Model
7	Yamada & Utaka. 2023	Yamada, T., & Utaka, M. (2023). Evaluating ticket gate directional restrictions using simulations of pedestrian flow considering stationary people in a railroad station concourse. Journal of Asian Architecture and Building Engineering, 22(4), 2058-2073.	Academic Article	Transport	Station Concourse	Observed passenger path	N/A	Simulation
8	Jiten et al. 2016	Jiten, S., Gaurang, J., Purnima, P., & Arkatkar, S. (2016). Effect of stairway width on pedestrian flow characteristics at railway stations. Transportation Letters, 8(2), 98-112.	Academic Article	Transport	Station Stairway	Passenger/m2	N/A	Site Experiment
9	Shen et al. 2024	Shen, Y., Yang, H., Ren, G., & Ran, B. (2024). Model cascading overload failure and dynamic vulnerability analysis of facility network of metro station. Reliability Engineering & System Safety, 242, 109711.	Academic Article	Transport	Metro Station	Passenger passing rate	Transfer facilities	Cascading Overload Failure Model
10	Starmans et al. 2014	Starmans, M., Verhoeff, L., & van den Heuvel, J. (2014). Passenger transfer chain analysis for reallocation of heritage space at Amsterdam Central station. Transportation Research Procedia, 2, 651-659.	Academic Article	Transport	Station Building	Passenger arrivals based on train schedule	Corridors	Passenger Transfer Chain Analysis
11	Khattak et al. 2019	Khattak, A., Yangsheng, J., & Abid, M. M. (2019). Assessment of Passengers' Transfer Zones in the Transit Centers: A PH-Based State-Dependent Discrete-Event Simulation Framework. Arabian Journal for Science and Engineering, 44, 4491-4508.	Academic Article	Transport	Station Building	Walking speed	Passageways and stairways	Queue Model
12	Xianyu, 2017	Xianyu, W. (2017). A simulation model for evaluating facilities' adaptability in the fare collection area of subway stations. Journal of Rail Transport Planning & Management, 6(4), 331-345.	Academic Article	Transport	Station Concourse	Passenger speed	Concourse and ticket gates	Queue Model
13	Banos & Charpentier. 2010	Banos, A., & Charpentier, A. (2010). Simulating pedestrian movement in dynamic environments. Cybergeo: European Journal of Geography, (499), 1-17.	Academic Article	Transport	Station Concourse	Passenger path	Concourse and ticket gates	Agent-based Model

#	Author and Year	Title	Doc Type	Field	Scale	Circulation	Transfer Floor	Method
14	Eldakdoky, 2016	Eldakdoky, S. (2016). A study of equitable accessibility and passengers flow in future stations of Cairo Metro. JES. Journal of Engineering Sciences, 44(4), 403-417.	Academic Article	Transport	Station Concourse	Passenger/m2	Service facilities	Flow-density analysis
15	Hu et al. 2015	Hu, L., Jiang, Y., Zhu, J., & Chen, Y. (2015). A PH/PH (n)/C/C state-dependent queuing model for metro station corridor width design.	Academic Article	Transport	Station Corridor	Passenger/m2	N/A	Queue Model
16	Khattak et al. 2017	Khattak, A., Jiang, Y., Zhu, J., & Hu, L. (2017). A new simulation-optimization approach for the circulation facilities design at urban rail transit station. Archives of Transport, 43.	Academic Article	Transport	Station Concourse	Passengers/second	Passageways and stairways	Queue Model
17	Khattak & Hussain. 2021	Khattak, A., & Hussain, A. (2021). Hybrid DES-PSO framework for the design of commuters' circulation space at multimodal transport interchange. Mathematics and Computers in Simulation, 180, 205-229.	Academic Article	Transport	Station Concourse	Pedestrian/m2	Passageways and stairways	Queue Model
18	Loukaitou et al. 2015	Loukaitou-Sideris, A., Taylor, B. D., & Voulgaris, C. T. (2015). Passenger Flows in Underground Railway Stations and Platforms, MTI Report 12-43.	Academic Article	Transport	Station Building	Passengers/m2	Walkways and Stairways	Simulation
19	Xu et al. 2014	Xu, X. Y., Liu, J., Li, H. Y., & Hu, J. Q. (2014). Analysis of subway station capacity with the use of queueing theory. Transportation research part C: emerging technologies, 38, 28-43.	Academic Article	Transport	Station Sie	Passengers/m2	Walkways and Stairways	Queue Model
20	Paksukcharern, 2003	Paksukcharern Thammaruangsri, K. (2003). Node and Place, a study on the spatial process of railway terminus area redevelopment in central London.	PhD Dissertation	Architecture	Station Site	Movement pattern	Internal space	Space-Syntax
21	da Conceicao, 2015	da Conceição, A. L. M. (2015). From city's station to station city: An integrative spatial approach to the (re) development of station areas. A+ BEI Architecture and the Built Environment, (1), 1-252.	PhD Dissertation	Architecture	Station Area	Link possibilities	Pedestrian space	Site Analysis
22	van Weerdenburg, 2022	van Weerdenburg, M. (2022). Transportation Hubs as Public Space: Transforming the public space surrounding Brussels-South Railway Station	MSc Thesis	Architecture	Station Site	Access route	Walkways	Site Analysis
23	Inamochi, 2015.	Inamochi, R. (2015). Spatial characteristics of modern city Tokyo seen from the composite form of station buildings and surrounding environments.	PhD Dissertation	Architecture	Station Area	Visual continuity	Planes	Spatial Composition Analysis
24	Schipper, 2024	Schipper, B. (2024). Night Train Hub Berlin: Connecting Berlin with the rest of Europe.	MSc Thesis	Architecture	Station Site	Circulation area	N/A	Comparative Analysis

#	Author and Year	Title	Doc Type	Field	Scale	Circulation	Transfer Floor	Method
25	Liu, 2023	Liu, X. (2023). Reconnecting: Multi-modal Transfer Station at Warsaw Street.	MSc Thesis	Architecture	Station Site	Transfer route	In between space/passage	Site Analysis
26	Sadhukhan et al. 2018	Sadhukhan, S., Banerjee, U. K., & Maitra, B. (2018). Preference heterogeneity towards the importance of transfer facility attributes at metro stations in Kolkata. Travel Behaviour and Society, 12, 72-83.	Academic Article	Architecture	Station Area	N/A	Pedestrian crossing, environment, and pathway	User Survey
27	Li et al. 2024	Li, Z., Lu, Y., Zhuang, Y., & Yang, L. (2024). Influencing factors of spatial vitality in underground space around railway stations: A case study in Shanghai. Tunnelling and Underground Space Technology, 147, 105730.	Academic Article	Architecture	Station Quarter	Pedestrian flow data	Underground passages	Space-syntax
28	Arai et al. 2022	Arai, Y., Kusakabe, T., Niwa, Y., & Honma, K. (2022). Evaluation of wheelchair accessibility in train stations using a spatial network. Asian Transport Studies, 8, 100067.	Academic Article	Transport-Architecture	Station	Path length	Path network	Network Analysis
29	Siblesz, 2021	Siblesz, J. (2021). The Integrated Station: A transfer quality assessment model for multimodal stations.	MSc Thesis	Transport-Architecture	Station Site	Transfer flow	Transfer distance	MCA Model

Upon looking back at all these studies, it was evident that many share a way of conveying circulation, an image to communicate movement through a space, this image was a network graph. While the main body text parses the relationship of circulation with network graphs in both the beginning and end of section 2.4., the literature compiled to give a general explanation of both guided how the literature from both fields and between was structured. Because these source are outside of scope, as in not dealing circulation in stations, but circulation in other spaces or in general, this second table is a compilation on the concept to anyone interested in circulation in general from a spatial perspective.

Table.A.4.2. *General circulation literature*

#	Author and Year	Year	Title	Doc Type	Field	Subject Matter	Scale	Graph
1	van Nes, 2002	2002	van Nes, R. (2002) Design of Multimodal Transport Networks.	PhD Dissertation	Transport	Transport Network	Multimodal transport network	Hierarchical networks
2	Hillier, 2007	2007	Hillier, B. (2007). Space is the machine: a configurational theory of architecture. Space Syntax.	PhD Dissertation	Architecture	Spatial Analysis	Building	Room network
3	Natapov et al. 2020	2020	Natapov, A., Kuliga, S., Dalton, R. C., & Hölscher, C. (2020). Linking building-circulation typology and wayfinding: design, spatial analysis, and anticipated wayfinding difficulty of circulation types. Architectural Science Review, 63(1), 34-46.	Academic Article	Architecture	Circulation Typology	Building	Room network

4	Pan et al. 2023	2024	Pan, H., Yang, L., Liang, Z., & Yang, H. (2024). New Exact Algorithm for the integrated train timetabling and rolling stock circulation planning problem with stochastic demand. European Journal of Operational Research, 316(3), 906-929.	Academic Article	Transport	Circulation Planning	Transit service line	Time-space network with stations
5	Kaijima et al. 1997	1997	Kaijima, M. Sakamoto, K. and Tsukamoto, Y. (1997). The Connection of Rooms in Circulation Path, A Study on Spatial composition in Circulation Path in Japanese Contemporary Architecture	Academic Article	Architecture	Circulation Path	Building	Room network
6,9	Emmons, 2005	2005	Emmons, P. (2005). Intimate Circulations: representing flow in house and city. AA files, (51), 48-57.	Academic Article	Architecture	Circulation Representation	Building	Activity-space network
7,6	Marriage, 2012	2012	Marriage, G. L. G. (2012). Significant social space: Connecting circulation in atrium design	PhD Dissertation	Architecture	Atrium Design	Building	Room network
8,4	Nourian, 2016	2012	Nourian, P. (2016). Configraphics: Graph theoretical methods for design and analysis of spatial configurations. A+ BEI Architecture and the Built Environment, (14), 1-348.	PhD Dissertation	Architecture	Spatial Configuration	Building	Room network
9,2	Çubukçuoğlu, 2023	2023	Çubukçuoğlu, C. (2023). HOPCA: Hospital Layout Design Optimization using Computational Architecture. A+ BEI Architecture and the Built Environment, (03), 1-250.	PhD Dissertation	Architecture	Hospital Layout	Site	Room network
11	Gorny, 2021	2021	Gorny, R. A. (2021). A Flat Theory: Toward a Genealogy of Apartments, 1540–1752.	PhD Dissertation	Architecture	Apartment Building	Building	Room network
12	Boeing, 2017	2017	Boeing, G. (2017). OSMnx: New methods for acquiring, constructing, analyzing, and visualizing complex street networks. Computers, environment and urban systems, 65, 126-139.	Academic Article	Urbanism	Street network	City	Street network
13	Jia et al. 2023	2023	Jia, Z., Nourian, P., Luscuere, P., & Wagenaar, C. (2023). Spatial decision support systems for hospital layout design: A review. Journal of Building Engineering, 106042.	Academic Article	Architecture	Hospital Layout	Building	Room network
14	Franz et al. 2005	2005	Franz, G., Mallot, H. A., & Wiener, J. M. (2005, August). Graph-based models of space in architecture and cognitive science: A comparative analysis. In 17th International Conference on Systems Research, Informatics and Cybernetics (INTERSYMP 2005) (pp. 30-38). International Institute for Advanced Studies in Systems Research and Cybernetics.	Academic Article	Architecture	Graph-based models	N/A	Occupancy, place, view, axial, isovist, and visibility graph

Appendix B: Methodology

B.1. Context Literature

The best way to describe this appendix in relation to the main text in Section 3.2 is that although the book “Fietsparkeren bij Stations” by Piersma & Ritzema (2021) was the most recurrent reference in the section, the book itself consolidated a lot of references, that while not directly stated on that text, influenced what was considered fact and assumption. This appendix tries to both reconstruct the variety of sources used before retrieving to using the book for most references.

A lot of sources from the Dutch context are already covered in the literature review, due to the sheer number of studies of the BT combination in that country. However, the documents compiled here represent more amateur (websites) or official (government) documentation of the BPFs, the stations, and their past, current and potential future connection. Therefore, the following table highlight sources and a description of how they helped to find or discard information for this study.

Table B.1.1. *Context literature*

#	Source Name	Source Link/ Reference	Category	Doc Type	General Description	Application
1	Het Nieuwe Instituut Archive	https://zoeken.nieuweinstituut.nl/nl/	Archive	Website	Used to analyse old station floor plans	Floor plans limited to collections from select station architects (e.g. Ravensteyn)
2	Amsterdam Municipal Archive	https://archief.amsterdam	Archive	Website		Floor plans limited to stations in Amsterdam
3	Utrecht Archives	https://hetutrechtsarchief.nl	Archive	Website		Floor plans limited to stations in Utrecht
4	Nationaal Archive	https://www.nationaalarchief.nl/onderzoeken	Archive	Website		Floor plans limited to stations in Den Haag
5	Stationsinfo	http://www.stationsinfo.nl	History	Website	Used to learn more about the history of stations	Used to identify the year stations were built as well as the implementation of BPFs and the development of the station site over time
6	Spoorbeeld Databank	https://www.spoorbeeld.nl/databank?types=stations	History	Website	Documentation of Station architecture	Used the waardestelling report collection to better understand the development of station sites, as well as the capacity and evolution of BPFs in each station within the collection
7	ProRail - Fietsen	https://www.prorail.nl/reizen/stations/fietsen	Data	Website	Update on BPFs at Dutch train stations	Used to keep updated on BPF capacity and implementation of new facilities at train station in the Netherlands
8	NS Ridership Dashboard	https://dashboards.nsjaarverslag.nl/reizigersgedrag	Data	Website	Overview of passenger flows across network	Used to extract numbers for bicycle modal share as access/egress mode to/from station

#	Source Name	Source Link/ Reference	Category	Doc Type	General Description	Application
9	Lansink, V. 1998	Lansink, V. M. (1998). Spoorwegstations in Nederland, 1955-1980, Variatie in standaardisatie.	History	PhD Dissertation	Overview of Postwar station design and development	Used to better understand difference among stations with regards to design. Due to the stations in this study being smaller stations, there is not a lot of information on BPFs as defined in this study
10	Cavallo, R. 2008	Cavallo, R. (2008). Railways in the Urban Context: An architectural discourse.	History	PhD Dissertation	Overview of the development of Amsterdam train stations	Used to better understand the development and evolution of Amsterdam train stations. Due to the focus being more on the urbanistic role of train stations, there is not a lot of information on BPF development
11	Piersma & Ritzema. 2021	Piersma, F., & Ritzema, W. (2021). Fietsparkeren bij stations - 20 jaar ontwikkeling, ontwerp en realisatie.	History	Book	Main source on all things BPFs at Dutch train stations	Used to better understand history of BT combination in the Dutch context, as well as extract table on BPF capacity to delimit case study case selection. Also, the books has many good sources on documents related to topic
12	Masterplan Fiets	Ministerie van Verkeer en Waterstaat.(1990). Eindrapport Masterplan Fiets. _Samenvatting, evaluatie en overzicht van de projecten in het kader van het Masterplan Fiets_, _1990-1997_.	Policy	Report	First report on the active implementation of BPFs at a national level	Used to better understand the development of BPF design and implementation. Although used mostly as a timestamp, it contains documents all sources related to the topic
13	Stationskwartier	Bureau Spoormeester. (2019). Het Nieuwe Stationskwartier: Ruimtelijke kwaliteit op het grensvlak van knooppunt en stad.	Policy	White Paper	Development of a new standard for train station area	Used to better understand the most recent design strategies to improve the BT intermodality. It was found that although the recommendations are based on a case study, there is no trace of such procedure, and there is no indications as to how the improvement to the desired state can be made
14	Stationsconcept	Bureau Spoorbouwmeester (2012). Het Stationsconcept:Visie en toepassing. Bureau Spoorbouwmeester. Utrecht.	Policy	White Paper	Development of a new standard for train stations	Used to understand station segmentation and categorisation. Also includes good sources on documents related to topic in the bibliography
15	Het Openlucht Station	Bureau Spoortmeester. (2018). Het Openluchtstation de nieuwe opgave: het vitale en comfortabele ontvangstdomein.	Design	White Paper	Development of design guidelines for approach domain in open air stations	Used to better understand design interventions at train stations with regards to existing structures. This is the most granular document in terms of case study and the procedure to classify stations according to their configuration. While it takes into account both public space and circulation towards train platforms, it fails to consider the role other modes (e.g. Bicycle) and so changes are more focused on approach domain (public space)

#	Source Name	Source Link/ Reference	Category	Doc Type	General Description	Application
16	OV2040	Toekomst openbaar vervoer 2040	Policy	White Paper	Government public transport agenda towards 2040	Used to better understand trajectory of BT combination policies and intentions for the future, where BT traveler is considered the most important PT traveler. It also contains many studies that analyse stations according to BPF capacity and other intermodalities, such as train-bus intermodality
17	ProRail -OVS00219	ProRail (2020). Bouw en ombouw van fietsenstallingen bij stations (OVS00219).	BT Combination	Design Guidelines	Inaccessible	Assumed to be an integrated version of Prorail 2005 and the Design Matrix in [13] with more detail on possible design strategies for BPFs at train stations
18	Ploeger. J. 2024	Ploeger, J. (2024). Het verstandshuwelijk van fiets en trein: Kansrijke ketenmobiliteit sinds 1900. .	BT Combination	PhD Dissertation	BT Combination history	Gives a very detailed description of the evolution of BT combination in the Netherlands from both a socio-cultural and political perspective. Also includes good sources on documents related to topic in the bibliography
19	Prorail - Basisstation	ProRail (2005). Basisstation 2005, deel A en B: Functionele normen en richtlijnen voor treinstations.	Design	Design Guidelines	Used to learn about station design	Used to learn how stations are designed in the Netherlands and what are their design guidelines. It was found that there are some provisions for BPFs, although they ultimately depend on the project's context
20	CROW	CROW (1996). Plaats maken voor de fiets: leidraad voor parkeren en stallen. Publicatie no. 98. Stichting Centrum voor Regelgeving en Onderzoek in de Grond-, Water- en Wegenbouw en de Verkeerstechniek C.R.O.W, Ede.	Data	Website	Inventory of white papers on BPFs at train stations	This document is the first report on the plan to actively implement BPFs at train stations. The CROW website also includes more reports/research on the topic, and also has a book on BPF design guidelines (Leidraad Fietsparkeren, 2023)
21	Fietsersbond	https://www.fietsersbond.nl/nieuws/tag/onderzoek/	Data	Website	Local cyclist association website	Research invetory on BPFs at train station from a user perspective
22	Martens, 2007	Martens, K. (2007). Promoting bike-and-ride: The Dutch experience. _Transportation Research Part A: Policy and Practice_, _41_(4), 326-338. (328)	Policy	Academic Article	Overview of BT combination policy success	Used to understand how BT combination numbers have increased over time. This article also gives indication of importance of proximity from BPFs to the station, although the sources can't be accessed.

#	Source Name	Source Link/ Reference	Category	Doc Type	General Description	Application
23	jonkeren et al. 2018	Jonkeren, O., Harms, L., Jorritsma, P., Huibregtse, O., Bakker, P., & Kager, R. (2018). Waar zouden we zijn zonder de fiets en de trein. _Een onderzoek naar het gecombineerde fiets-treingebruik in Nederland. Kennisinstituut voor Mobiliteitsbeleidl KiM_.	Policy	White Paper	Overview of BT combination development according to traveller data	Used to better understand BT combination increase over the year according to traveller data.
24	Hamersma & Haas, 2020	Hamersma, M., & de Haas, M. (2020). Kenmerken van 'veelbelovende' ketens: inzichten voor het stimuleren van ketenmobiliteit in Nederland. Kennisinstituut voor Mobiliteitsbeleid (KiM)	Policy	White Paper	Overview of the potential of intermodality and multimodality of public transport	Used to compile sources relating to the relationship between bicycle and train mode at the station. This includes the station environment, parking provision, bicycle-sharing systems, proximity and diversification.
25	Berenschot, 2010	Berenschot. (2010). Fietsparkeren bij stations: Oplossingsrichtingen voor een systeemsprong	Policy	Report	Diagnosis of BPF at train station implementation	Used to better understand how BPFs at train stations are analysed. Although has a lot of information of what is missing, it lacks analysis on an individual basis or the relation to the train platforms.

B.2. Case Selection (Stations)

For the case selection, the stations were filtered by picking those that had enclosed facility types according to the Table (Overview of bicycle parking facilities at railway stations, number of bicycle parking spaces per station to storage type (as of summer 2020)) from Piersma, F., & Ritzema, W. (2021). As of 2020, there were 95 stations that met the criterion of enclosed facilities. s04, Almere Centrum, was added to the list as it had two enclosed facilities built after 2020. All other BPFs at Dutch stations were built within the other 95 stations.

The table consists of describing the coding and description of the stations [Columns 1-6], their categorisation [7] which is verified by average daily passenger flows [8]. The rest of the table is focused on the station's relation regarding the bicycle mode and BPFs, where each station shows the number of BPF types present [11], as well as the total number of open [12] and enclosed [13] parking capacity, summing up to total parking capacity per station [14].

Table B.2.1. *Case selection: stations*

# [1]	Station ID [2]	Station Name [3]	Train Platforms [4]	Service Platforms [5]	Station Operator [6]	Station Class [7]	Total In/Out AVG '23 [8]	Bike Access '23 (%) [9]	Bike Egress '23 (%) [10]	BPF Types [11]	Open Capacity [12]	Enclosed Capacity [13]	Total Parking Capacity [14]
s01	AMR	Alkmaar	3	5	NS	Plus	15.833	42	17	2	3.229	1.787	5.016
s02	AMRN	Alkmaar Noord	2	2	NS	Basic	3.526	44	29	3	1.164	654	1.818
s03	AML	Almelo	1	3	Multiple	Plus	6.605	42	18	2	1.276	520	1.796
s04	ALM	Almere Centrum	2	4	NS	Mega	26.901	29	11	2	1.425	3.400	4.825
s05	ALMB	Almere Buiten	2	2	NS	Basic	5.106	39	10	2	513	1.060	1.573
s06	APN	Alphen aan den Rijn	3	4	NS	Plus	10.743	50	22	3	2.642	1.284	3.926
s07	AMF	Amersfoort Centraal	3	6	Multiple	Mega	45.442	50	18	2	4.642	2.864	7.506
s08	AMFS	Amersfoort Schothorst	2	3	NS	Basic	5.527	52	17	4	1.272	380	1.652
s09	ASA	Amsterdam Amstel	2	2	NS	Mega	26.925	46	16	2	2.431	3.390	5.821
s10	ASB	Amsterdam Bijlmer ArenA	4	6	NS	Mega	24.761	23	6	2	578	244	822
s11	ASD	Amsterdam Centraal	6	11	NS	Cathedral	178.501	31	10	3	8.849	3.117	11.966
s12	ASDM	Amsterdam Muiderpoort	2	4	NS	Plus	13.131	30	16	3	1.169	455	1.624
s13	RAI	Amsterdam RAI	2	4	NS	Basic	4.307	45	9	2	300	1.797	2.097
s14	ASS	Amsterdam Sloterdijk	5	10	NS	Mega	55.902	38	11	2	3.172	442	3.614
s15	ASDZ	Amsterdam Zuid	2	4	NS	Mega	61.390	39	13	2	2.311	9.448	11.759
s16	APD	Apeldoorn	3	4	Multiple	Plus	12.827	52	26	3	2.562	1.633	4.195
s17	AH	Arnhem Centraal	4	8	Multiple	Mega	44.040	34	10	2	230	4.586	4.816

# [1]	Station ID [2]	Station Name [3]	Train Platforms [4]	Service Platforms [5]	Station Operator [6]	Station Class [7]	Total In/Out AVG '23 [8]	Bike Access '23 (%) [9]	Bike Egress '23 (%) [10]	BPF Types [11]	Open Capacity [12]	Enclosed Capacity [13]	Total Parking Capacity [14]
s18	ASN	Assen	2	3	NS	Basic	7.402	43	18	2	816	3.500	4.316
s19	BRN	Baarn	3	4	NS	Basic	4.085	46	14	2	1.096	780	1.876
s20	BRD	Barendrecht	3	4	NS	Basic	5.238	42	27	2	1.312	314	1.626
s21	BGN	Bergen op Zoom	1	2	NS	Basic	5.311	40	17	2	1.902	681	2.583
s22	BET	Best	3	4	NS	Basic	5.090	34	37	2	862	1.300	2.162
s23	BV	Beverwijk	2	4	NS	Basic	4.228	60	21	2	10	2.500	2.510
s24	BHV	Bilthoven	1	2	NS	Basic	4.329	43	25	2	1.015	470	1.485
s25	BTL	Boxtel	2	4	NS	Basic	5.186	41	17	2	1.744	250	1.994
s26	BD	Breda	3	6	NS	Mega	35.484	45	18	2	1.661	4.412	6.073
s27	CAS	Castricum	1	2	NS	Basic	6.204	50	29	2	2.484	650	3.134
s28	CL	Culemborg	2	2	NS	Basic	7.872	60	31	2	1.434	1.267	2.701
s29	DT	Delft	2	2	NS	Mega	37.907	50	24	1	0	9.960	9.960
s30	GVC	Den Haag Centraal	7	12	NS	Cathedral	81.512	32	8	2	1.838	10.325	12.163
s31	GVC	Den Haag HS	3	5	NS	Mega	32.159	38	9	2	3.657	830	4.487
s32	HDR	Den Helder	2	3	NS	Basic	3.187	26	20	2	224	411	635
s33	DV	Deventer	2	3	NS	Mega	20.547	50	12	2	608	3.600	4.208
s34	DDR	Dordrecht	3	7	Multiple	Mega	20.970	38	14	3	1.760	702	2.462
s35	DB	Driebergen-Zeist	2	3	NS	Plus	8.612	53	27	1	0	3.100	3.100
s36	ED	Ede-Wageningen	2	3	Multiple	Plus	15.109	50	29	2	3.190	1.747	4.937
s37	EHV	Eindhoven Centraal	3	6	NS	Cathedral	64.619	41	15	2	3.262	2.321	5.583
s38	EMN	Emmen	2	2	Arriva	Basic				2	236	294	530
s39	ES	Enschede	2	5	Multiple	Plus	8.339	48	15	3	2.764	600	3.364
s40	GS	Goes	1	2	NS	Basic	5.769	35	14	2	1.372	554	1.926
s41	GD	Gouda	3	7	NS	Mega	27.538	52	17	3	4.950	2.790	7.740
s42	GN	Groningen	3	10	Multiple	Mega	16.185	45	18	3	7.950	2.323	10.273
s43	GERP	Groningen Europapark	2	3	NS	Basic	1.287	30	15	1	0	573	573
s44	HLM	Haarlem	3	6	NS	Mega	39.030	52	20	4	2.349	5.491	7.840
s45	HD	Harderwijk	1	2	NS	Basic	4.993	53	15	2	632	1.539	2.171
s46	HAD	Heemstede-Aerdenhout	2	2	NS	Basic	5.826	66	21	2	1.162	583	1.745
s47	HR	Heerenveen	1	2	NS	Basic	5.234	32	12	2	1.400	346	1.746
s48	HWD	Heerhugowaard	2	3	NS	Basic	6.105	45	17	2	1.798	326	2.124
s49	HRL	Heerlen	2	4	Multiple	Plus	3.871	14	8	2	434	180	614
s50	HM	Helmond	2	2	NS	Basic	6.758	36	18	1	0	2.028	2.028

# [1]	Station ID [2]	Station Name [3]	Train Platforms [4]	Service Platforms [5]	Station Operator [6]	Station Class [7]	Total In/Out AVG '23 [8]	Bike Access '23 (%) [9]	Bike Egress '23 (%) [10]	BPF Types [11]	Open Capacity [12]	Enclosed Capacity [13]	Total Parking Capacity [14]
s51	HGL	Hengelo	1	3	Multiple	Plus	6.088	47	14	3	2.500	327	2.827
s52	HT	s-Hertogenbosch	3	5	NS	Mega	56.146	41	12	2	1.070	4.500	5.570
s53	HVS	Hilversum	3	5	NS	Mega	26.006	50	24	2	3.280	1.441	4.721
s54	HVSP	Hilversum Sportpark	2	2	NS	Basic	5.982	42	3	2	576	168	744
s55	HFD	Hoofddorp	2	4	NS	Plus	14.665	31	13	2	1.188	489	1.677
s56	HGV	Hoogeveen	2	3	NS	Basic	3.694	37	28	2	1.320	386	1.706
s57	HN	Hoorn	2	3	NS	Plus	12.749	44	10	2	1.640	887	2.527
s58	HTN	Houten	1	2	NS	Basic	6.505	55	21	1	0	3.400	3.400
s59	HTNC	Houten Castellum	1	2	NS	Basic	5.008	52	28	1	0	1.706	1.706
s60	KPN	Kampen	1	1	Keolis	Basic				2	1.223	441	1.664
s61	LW	Leeuwarden	4	6	Multiple	Plus	8.285	43	18	2	1.456	1.895	3.351
s62	LEDN	Leiden Centraal	3	6	NS	Cathedral	80.342	56	18	3	7.936	8.185	16.121
s63	LDL	Leiden Lammenschans	1	1	NS	Basic	4.636	33	13	2	585	230	815
s64	LLS	Lelystad Centrum	2	4	NS	Plus	11.247	44	12	2	1.775	398	2.173
s65	MAS	Maarssen	1	2	NS	Basic	3.907	50	14	3	240	1.460	1.700
s66	MT	Maastricht	3	6	Multiple	Plus	10.719	29	11	2	616	2.850	3.466
s67	MP	Meppel	2	3	NS	Basic	6.211	41	20	2	1.440	515	1.955
s68	MBD	Middelburg	2	2	NS	Basic	3.940	42	6	2	1.750	426	2.176
s69	NDB	Naarden-Bussum	2	3	NS	Basic	8.388	52	26	2	1.562	1.507	3.069
s70	NM	Nijmegen	2	4	Multiple	Mega	40.316	48	18	2	4.427	5.653	10.080
s71	O	Oss	2	2	NS	Basic	7.090	42	15	2	1.700	672	2.372
s72	RSW	Rijswijk	2	4	NS	Basic	5.292	24	4	2	634	222	856
s73	RM	Roermond	2	3	Multiple	Plus	8.713	37	9	2	840	1.525	2.365
s74	RSD	Roosendaal	2	3	Multiple	Plus	12.275	36	21	2	1.056	1.503	2.559
s75	RTD	Rotterdam Centraal	7	13	NS	Cathedral	104.840	30	12	2	1.692	5.163	6.855
s76	SDM	Schiedam Centrum	3	4	NS	Plus	20.633	18	9	2	1.104	804	1.908
s77	STD	Sittard	2	4	Multiple	Plus	8.285	26	12	3	1.421	555	1.976
s78	SWK	Steenwijk	1	2	NS	Basic	3.140	37	13	2	969	137	1.106
s79	TL	Tiel	2	3	Multiple	Basic	2.863	32	16	2	1.104	499	1.603
s80	TB	Tilburg	2	3	NS	Mega	32.679	51	18	2	2.200	7.300	9.500
s81	UT	Utrecht Centraal	8	16	NS	Cathedral	226.708	48	11	1	0	22.300	22.300
s82	UTO	Utrecht Overvecht	2	3	NS	Basic	7.496	47	15	2	1.410	270	1.680
s83	UTVR	Utrecht Vaartsche Rijn	2	4	NS	Basic	8.746	40	19	2	567	670	1.237

# [1]	Station ID [2]	Station Name [3]	Train Platforms [4]	Service Platforms [5]	Station Operator [6]	Station Class [7]	Total In/Out AVG '23 [8]	Bike Access '23 (%) [9]	Bike Egress '23 (%) [10]	BPF Types [11]	Open Capacity [12]	Enclosed Capacity [13]	Total Parking Capacity [14]
s84	VL	Venlo	2	5	Multiple	Basic	3.227	34	14	2	1.333	680	2.013
s85	VS	Vlissingen	2	3	NS	Basic	2.005	29	14	2	304	395	699
s86	VB	Voorburg	1	2	NS	Basic	1.354	39	24	2	784	357	1.141
s87	WT	Weert	1	2	NS	Basic	6.698	39	15	2	1.285	571	1.856
s88	WP	Weesp	2	4	NS	Plus	14.089	41	12	2	1.132	1.100	2.232
s89	WD	Woerden	2	4	NS	Plus	13.309	57	19	2	3.075	1.176	4.251
s90	WM	Wormerveer	3	4	NS	Basic	3.490	49	6	2	780	586	1.366
s91	ZD	Zaandam	2	4	NS	Mega	22.344	36	11	3	2.500	638	3.138
s92	ZBM	Zaltbommel	2	2	NS	Basic	3.272	49	16	2	1.079	200	1.279
s93	ZP	Zutphen	2	3	NS	Plus	10.295	48	13	2	600	3.290	3.890
s94	ZWD	Zwijndrecht	3	4	NS	Basic	4.328	45	16	2	1.265	542	1.807
s95	ZL	Zwolle	5	11	Multiple	Mega	44.182	53	18	2	5.296	8.347	13.643

Sources:
Column [1] was created by the author to code the section of stations for this research.
Columns [2 - 7] were retrieved on 20241026 from Wikipedia: https://nl.wikipedia.org/wiki/Lijst_van_spoorwegstations_in_Nederland
Columns [8 - 10] were retrieved on 20241020 from NS: https://dashboards.nsjaarverslag.nl/reizigersgedrag
Columns [11 - 14] were retrieved from: Piersma, F., & Ritzema, W. (2021), 246-253.

B.3. BPF Facility Information

Because the Source table (B.2) did not mention the number of BPFs per BPF type, different methods were applied to identify all enclosed BPFs within the 95 stations. Although the best was made to ensure all the information in this table to be accurate, it can best be described as an approximation, as there is no official database for all BPFs at Dutch train stations, nor an overview of bicycle parking characteristics within websites regarding a municipality, ProRail or NS. Therefore, the information in this table was compiled using various sources and cross-referencing each other to verify the information across them. This is especially the case with regards to year built [6] and capacity [7], as different sources would contain different values for these. An overview of sources per column is provided below this table.

A total of 136 BPFs were identified for analysis and coded as such [1]. The BPFs are identified with their station ID [2], station name following a number for stations where the is more than one BPF [3]. Where possible to identify, the number is according to year built, so newer facilities go last. In cases where the facilities have an alias, this has been added to distinguish them according to something other than number (e.g. location, operator, or cardinal direction) [4]. The BPF type was identified either because it was written in some article on the internet or verified by inspecting images of the BPF [5]. Year built was found by searching on the internet "[Station] bicycle parking facility opening" in both English and Dutch [6]. Cells within this column that have the year in red indicate a renovation on an existing BPF (same location/structure). The capacity of BPFs was either found in the internet article saying its opening, in articles searching for "[Facility_Alias] capacity" in English and Dutch. In cases where the station did not have new facilities post-summer 2020 and only one facility was missing capacity, the total enclosed capacity was used to derive the capacity against the other facilities. In cases where none the of above was possible, not available is displayed (N/A).

Table B.3.1. *Case selection: BPFs*

# [1]	Station ID [2]	Station Facility (Number) [3]	Alias [4]	BPF Type [5]	Year Built [6]	Capacity [7]
001	AMR	Alkmaar		Indoor	2015	1.787
002	AMRN	Alkmaar Noord		Indoor	2011	654
003	AML	Almelo		Underground	1968	520
004	ALM	Almere Centrum (1)	Landdrostdreef	Indoor	2022	2.750
005	ALM	Almere Centrum (2)	Busplein	Indoor	2022	650
006	ALMB	Almere Buiten	Baltimoreplein	Indoor	2013	1.060
007	APN	Alphen aan den Rijn (1)		Underground	2009	1.284
008	APN	Alphen aan den Rijn (2)	De Fietsappel	Fietsflat	2012	970
009	AMF	Amersfoort Centraal (1)	Stationplein	Underground	2000	N/A
010	AMF	Amersfoort Centraal (2)	Mondriaanplein	Underground	2004	N/A
011	AMFS	Amersfoort Schothorst		Indoor	2015	380
012	ASA	Amsterdam Amstel		Underground	2018	3.390
013	ASB	Amsterdam Bijlmer ArenA		Indoor	2008	244
014	ASD	Amsterdam Centraal (1)	Stationsplein Oost	Indoor	2017	1.700
015	ASD	Amsterdam Centraal (2)	IJzijde West	Indoor	2017	1.300
016	ASD	Amsterdam Centraal (3)	Stationplein	Underground	2022	7.000
017	ASD	Amsterdam Centraal (4)	IJboulevard	Underground	2023	4.000
018	ASDM	Amsterdam Muiderpoort		Indoor	2017	2.700
019	RAI	Amsterdam RAI		Indoor	2020	1.800

# [1]	Station ID [2]	Station Facility (Number) [3]	Alias [4]	BPF Type [5]	Year Built [6]	Capacity [7]
020	ASS	Amsterdam Sloterdijk		Indoor	1986	442
021	ASDZ	Amsterdam Zuid (1)	Zuidplein	Underground	2020	1.291
022	ASDZ	Amsterdam Zuid (2)	Mahlerplein	Underground	2016	3.000
023	ASDZ	Amsterdam Zuid (3)	Strawinskylaan	Underground	2018	3.750
024	APD	Apeldoorn (1)		Underground	2007	1.633
025	APD	Apeldoorn (2)	Noordzijde	Fietsflat	2012	1.200
026	AH	Arnhem Centraal (1)		Underground	2015	4.000
027	AH	Arnhem Centraal (2)	Sonsbeekzijde	Underground	2012	820
028	ASN	Assen		Underground	2019	3.500
029	BRN	Baarn		Indoor	2018	780
030	BRD	Barendrecht		Underground	2001	314
031	BGN	Bergen op Zoom		Indoor	2013	681
032	BET	Best		Indoor	2002	1.300
033	BV	Beverwijk		Underground	2015	2.500
034	BHV	Bilthoven		Underground	2015	470
035	BTL	Boxtel		Indoor	2000	250
036	BD	Breda (1)	Stationplein (Zuidzijde)	Underground	2016	1.500
037	BD	Breda (2)	Belcrum (Noordzijde)	Underground	2016	1.500
038	CAS	Castricum		Indoor	2013	650
039	CL	Culemborg		Indoor	1975	1.267
040	DT	Delft (1)	Delft P1	Underground	2015	5.000
041	DT	Delft (2)	Delft P2	Underground	2017	2.700
042	DT	Delft (3)	Delft P3 I Antoni	Underground	2020	2.400
043	GVC	Den Haag Centraal (1)	Stichthage	Underground	1984	1.200
044	GVC	Den Haag Centraal (2)	Koningin Julianaplein	Underground	2020	8.000
045	GVC	Den Haag Centraal (3)	Fietsflat Rijnstraat	Fietsflat	2014	1.383
046	GVC	Den Haag Centraal (4)	Anna v. Buerenstraat	Indoor	2015	1.100
047	GV	Den Haag HS	Zuidzijde	Indoor	2020	2.500
048	HDR	Den Helder		Underground	1958	411
049	DV	Deventer		Underground	2016	3.600
050	DDR	Dordrecht		Indoor	2009	702
051	DB	Driebergen-Zeist		Underground	2020	3.100
052	ED	Ede-Wageningen	Zuidzijde	Indoor	2024	5.500
053	EHV	Eindhoven Centraal (1)	Zuidzijde	Underground	1953	2.100
054	EHV	Eindhoven Centraal (2)	Noordzijde	Underground	1991	200
055	EMN	Emmen		Underground	1965	294
056	ES	Enschede (1)	NS-Stalling	Indoor	2000	600
057	ES	Enschede (2)	Stationsplein West	Fietsflat	2019	1.000
058	ES	Enschede (3)	Stationstalling Noord	Fietsflat	2017	1.000
059	GS	Goes		Underground	1982	554
060	GD	Gouda (1)	West	Indoor	2021	600
061	GD	Gouda (2)	Oest	Indoor	2021	1.750
062	GD	Gouda (3)	Midden	Underground	2022	800
063	GD	Gouda (4)	Bloemendaalzijde	Indoor	2013	2.250
064	GN	Groningen (1)	NS Stalling	Indoor	1981	N/A
065	GN	Groningen (2)	De Stadsbalkon	Underground	2007	5.439

# [1]	Station ID [2]	Station Facility (Number) [3]	Alias [4]	BPF Type [5]	Year Built [6]	Capacity [7]
066	GN	Groningen (3)		Fietsflat	2015	1.300
067	GERP	Groningen Europapark		Underground	2022	1.300
068	HLM	Haarlem (1)	Fietsouterrain	Underground	2013	4.810
069	HLM	Haarlem (2)	Fietscarre	Indoor	2012	1.100
070	HLM	Haarlem (3)	Fietsgevel	Fietsflat	2015	1.700
071	HD	Harderwijk		Indoor	2016	1.539
072	HAD	Heemstede-Aerdenhout		Indoor	1965	583
073	HR	Heerenveen		Indoor	2009	346
074	HWD	Heerhugowaard		Indoor	1989	326
075	HRL	Heerlen		Indoor	2012	180
076	HM	Helmond		Indoor	2014	2.028
077	HGL	Hengelo (1)		Underground	1951	327
078	HGL	Hengelo (2)		Fietsflat	2016	2.200
079	HT	s-Hertogenbosch		Underground	1998	4.500
080	HVS	Hilversum		Underground	1992	1.441
081	HVSP	Hilversum Sportpark		Indoor	1952	168
082	HFD	Hoofddorp		Indoor	2008	489
083	HGV	Hoogeveen	Benny Wolbers	Indoor	1984	386
084	HN	Hoorn	Fietspoint Ruiter	Indoor	1959	887
085	HTN	Houten		Indoor	2010	3.400
086	HTNC	Houten Castellum	Fietstransferium	Indoor	2011	1.706
087	KPN	Kampen		Underground	1983	441
088	LW	Leeuwarden		Underground	1991	1.895
089	LEDN	Leiden Centraal (1)	Zeezijde	Underground	2003	2.200
090	LEDN	Leiden Centraal (2)	LUMC-zijde	Indoor	1996	2.235
091	LEDN	Leiden Centraal (3)	Centruumzijde	Indoor	1996	1.340
092	LEDN	Leiden Centraal (4)	De Lorentz	Underground	2020	4.800
093	LEDN	Leiden Centraal (5)	Taxistandplaats	Underground	2021	2.120
094	LDL	Leiden Lammenschans		Indoor	1997	230
095	LLS	Lelystad Centrum		Indoor	1988	398
096	MAS	Maarssen		Indoor	2004	1.460
097	MT	Maastricht		Underground	2018	2.850
098	MP	Meppel	Fietspoint Wolbers	Underground	2011	515
099	MDB	Middelburg		Indoor	1923	426
100	NDB	Naarden-Bussum		Indoor	2003	1.507
101	NM	Nijmegen (1)		Underground	2001	1.653
102	NM	Nijmegen (2)	Doornzijde	Underground	2014	4.000
103	O	Oss		Underground	2013	672
104	RSW	Rijswijk (1)	Fietsenwacht	Indoor	1998	250
105	RSW	Rijswijk (2)	NS stalling	Indoor	1998	250
106	RM	Roermond		Indoor	2008	1.525
107	RSD	Roosendaal		Indoor	2006	1.503
108	RTD	Rotterdam Centraal		Underground	2012	5.163
109	SDM	Schiedam Centrum		Indoor	2000	804
110	STD	Sittard		Underground	1993	555
111	SWK	Steenwijk		Indoor	1972	137

# [1]	Station ID [2]	Station Facility (Number) [3]	Alias [4]	BPF Type [5]	Year Built [6]	Capacity [7]
112	TL	Tiel	Van Bekkum	Indoor	2008	499
113	TB	Tilburg (1)	Noordzijde	Indoor	2020	3.900
114	TB	Tilburg (2)	Zuidstalling	Indoor	2021	3.400
115	UT	Utrecht Centraal (1)	Stationplein	Megaparking	2019	12.300
116	UT	Utrecht Centraal (2)	Jaarbeursplein	Underground	2014	4.867
117	UT	Utrecht Centraal (3)	Knoop	Underground	2018	4.571
118	UT	Utrecht Centraal (4)	Sijpesteijnkade	Indoor	1986	700
119	UTO	Utrecht Overvecht		Indoor	1995	270
120	UTVR	Utrecht Vaartsche Rijn (1)	Oosterkade	Indoor	2016	670
121	UTVR	Utrecht Vaartsche Rijn (2)	Westerkade	Indoor	2020	142
122	VL	Venlo		Underground	1958	680
123	VS	Vlissingen		Indoor	1950	395
124	VB	Voorburg		Indoor	1988	357
125	WT	Weert		Indoor	2008	571
126	WP	Weesp		Indoor	2013	1.100
127	WD	Woerden		Underground	2014	1.176
128	WM	Wormerveer		Indoor	2014	586
129	ZD	Zaandam (1)	De Droogschuur	Fietsflat	2020	1.350
130	ZD	Zaandam (2)	Fietspoint Rataplan	Indoor	2018	2.800
131	ZBM	Zaltbommel		Indoor	2011	200
132	ZP	Zutphen (1)		Underground	2006	3.290
133	ZP	Zutphen (2)		Indoor	2017	600
134	ZWD	Zwijndrecht		Underground	1998	542
135	ZL	Zwolle (1)	Lübeckplein	Underground	2012	700
136	ZL	Zwolle (2)	Fietspoint Spruijt	Indoor	1984	1.847

Sources:
Columns [1, 3] were created by the author to code the section of BPFs for this research.
Column [2] was retrieved from Table B.2.
Columns [4, 5] were retrieved from various sources, but most were retrieved using Google Maps and Google Streetview (google.maps.com).
Columns [6, 7] were retrieved from various sources, but most retrieved using the following websites: Prorail.nl, ns.nl, stationsinfo.nl, indebuurt.nl, municipality website on bicycle parking in the city or plans for the station quarter, veiligstallen.nl, wikipedia.com, and the spoorbeeld waardstelling collection on various train stations.

B.4. Spatial Composition Research Overview

In the recent academic study of architecture, "spatial composition theory" has achieved a certain result for comprehension of various architectural forms. The theory allows a cross-sectoral analysis beyond building types by extracting an arrangement of abstract volumes without finishes and scale. However, most of the previous research related to spatial composition theory is in Japanese. This appendix provides an overview of spatial composition studies that support the ideas presented in Ch.2 and Ch.3 about the malleability of spatial composition to frame space at different scales and focus on different aspects of the same scale and object to derive distinct types.

The table is organised according to scale and year. Because a compilation of spatial composition studies already exists for the work from Sakamoto et al. 2012, this overview presents those relevant to this research and more contemporary studies.

Table B.4.1. *Spatial composition literature*

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
1	Tsukamoto & Sakamoto. 1994	1994	Tsukamoto, Y., & Sakamoto, K. (1994). Spatial articulation and connection in contemporary Japanese houses: A study on the compositional forms of residential architecture. Journal of the Architectural Institute of Japan, 59(465), 85-93.	Building	Room connection	Main/non-main rooms	8	Acquisition of spatial continuity by the main room, and chain-like connection of articulated rooms.
2	Ogawa et al. 1998	1998	Ogawa, J., Sako, K., & Sakamoto, K. (1998). Composition of contemporary Japanese architectural works with atrium spaces: Research on architectural composition form seen from the composite of volumes (4). Proceedings of the Architectural Institute of Japan, Planning Department. , 63(508), 91-98.	Building	High-rise Atrium Space	Atrium and rest of building	11	Arrangement of space in circulation path responds to the building function, which is thought to be one of the structures differentiating the building types as spatial composition.

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
3	Ogawa et al. 2000	2000	Ogawa, J., Onoda, T., & Sakamoto, K. (2000). Composition of outside volumes and rooms in contemporary japanese houses Architectural composition of contemporary japanese houses in terms of relation between interior and exterior. JOURNAL OF ARCHITECTURE PLANNING AND ENVIRONMENTAL ENGINEERING, (537), 117-124.	Building	House Exterior-Interior Space Relation	Rooms	13	Entirety by the size and circulation path of main room, ambiguity in size between interior and exterior and fragmentation of main room.
4	Okamura et al. 2002	2002	Okamura, K., Ogawa, J., & Sakamoto, K. (2002). The composition of urban housing from the perspective of the arrangement and connection of exterior spaces: Compositional forms based on the relationship between interior and exterior in contemporary Japanese housing (2). Journal of the Architectural Institute of Japan, Planning and Planning Series, 67(552), 141-146.	Building	Exterior Space connection to Interior space	Interior and exterior space	13	The composition provides a representation of the three-dimentional network that emerges from the interaction between interior and exterior spaces in a house
5	Murata et al. 2012	2012	Murata, R., Suzuki, E., & Yasuda, K. (2012). Openness and closedness of living space in contemporary Japanese courthouses viewed from the front road. Journal of Architecture and Planning, 77(672), 351-358.	Building	House's Courtyard	Façade, interior-outside, interior-inside	10	The composition affects visibility and movement according to enclosedness
6	Machin & Almazan. 2017	2017	Machin E., & Almazan J. (2017). A study on historical transitions of contemporary Japanese museum architecture through analysis of floor plan composition. Journal of Architecture and Planning, 82(735), 1309-1318.	Building	Museum plan configuration	Exterior boundaries and interior layout	10	From regular orthogonal boudaries to free dynamic movement due to inclusion of external boundary in design

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
7	Matsushima et al. 2020	2020	Matsushima, J., Inuiya, S., Murata, R., Yasuda, K. (2020). Space integration methods through room and finishing layouts in contemporary museum architecture. Architectural Institute of Japan Planning Journal, 85(767), 49-57.	Building	Room relation in Museum	Rooms and surface finishes	12	It becomes possible to understand spatial integration of architecture through the relationship between spatial composition and superficial finish
8	Yokoyama et al. 2022	2022	Yokoyama, K., Katagiri, Y., Horikoshi, K., & Iwaoka, T. (2022). Spatial composition based on three-dimensional circulation lines in postwar Japanese residential buildings. Journal of the Architectural Institute of Japan, Planning and Planning Series, 87(796), 1074-1083.	Building	Vertical circulation in houses	Number of levels and stairs, interior/exterior rooms	14	inside and outside stairs have different roles for the vertical circulation of the house according to the user.
9	Minobe et al. 2001	2001	Minobe, Y., Mashiyama, E., & Sakamoto, K. (2001). Architectural composition of extended buildings by arrangement and connection of volumes. _Journal of Architecture,_ _Planning & Environmental Engineering_ _(AIJ)_, No.547, 119-126.	Buildings	Building extensions arrangment and connection to original building	Interior and exterior volumes	10	Shows how the relation between existing and extension volumes provide the extension with a role (separate/integrated)
10	Kaijima et al. 1997	1997	Kaijima, M. Sakamoto, K. and Tsukamoto, Y. (1997). The Connection of Rooms in Circulation Path, A Study on Spatial composition in Circulation Path in Japanese Contemporary Architecture. Journal of Architecture, Planning and Environmental Engineering (Transactions of AIJ), No. 498, pp. 131-138, 1997.8.	Buliding	Circulation path in houses	1/2 story rooms and interior/exterior rooms	10	circulation path in compositions is clarified as accentuation, superimposition, elimination or combination of spatial feature latent in the room-connecting composition, such as "interiority","traversability","circularity".
11	Tsukamoto et al. 1995	1995	Tsukamoto, Y., Shigemasa, & Sakamoto, K. (1995). Segmentation and integration of exterior spaces in contemporary Japanese houses: A study on the compositional forms of residential architecture. Journal of the Architectural Institute of Japan, 60(470), 95-104.	Site	Articulated Exterior space	Houses split terms of their materially framed open air space and built space	7	"Contrast" or "homogeneity" of inside / outside , expressed by visible relationship and functional connections controlled by the articulation of building elements

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
12	Terauchi et al. 1997	1997	Terauchi, M. Sakamoto, K. & Okuyama, S. (1997). Segmentation and arrangement form of the external space of architecture: A study on the composition form of the external space of architecture from the perspective of territorial characteristics. Proceedings of the Architectural Institute of Japan, Planning Department, 62 (491), 91-98.	Site	Exterior Space	Articulated and Arranged exterior space	17	Hierarchical connection of spaces, combination of public and private characters, open spaces.
13	Terauchi et al. 1999	1999	Terauchi, M., Murata, A., & Sakamoto, K. (1999). External Form and Approach Space in Contemporary Japanese Architectural Works: A Study on the External Space Composition Form from the Viewpoint of Territorial Character (2). Journal of Architecture and Planning, 64(525), 129-135.	Site	Approach space	Relation between exterior composition of building and approach Space	12	Acquisition of spatial continuity by the main room, and chain-like connection of articulated rooms.
14	Konno et al. 2009	2009	Konno, C., & Tsukamoto, Y. (2009). The nature of loggia-like spaces in residential buildings from the perspective of sunlight. Journal of the Architectural Institute of Japan, Planning and Planning Series, 74(644), 2289-2296.	Site	Loggia space's sunlight behavior	Loggia space and adjacent built space	13	Various typological characters of loggia spaces are generated by the combination of sunlight patterns, adjoining rooms, and compositional layout
15	Sasaki & Tsukamoto. 2022	2022	Sasaki, H., & Tsukamoto, Y. (2022). Characteristics of eaves in contemporary Japanese public architecture from the perspective of appropriation of approaches. Journal of Architecture and Planning, 87(800), 2080-2089.	Site	Eaves' relation to approach space	Eave domains	3	relation between eaves and approach ranges among division, cover, and integration
16	Li et al. 2023	2023	Li, H., Tsukihashi O., & Yang, Y.. (2023). Study on spatial layout and composition of exterior space in building sales centers: Focusing on the spatial representation methods of Chinese modern commercial housing. Journal of Architecture and Planning, 88(803), 316-327.	Site	Sales centre exterior composition	Layout, boundaries, and approach space	11	It becomes possible to respresent sale centres' composition via spatial representation

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
17	Yu & Shiozaki. 2023	2023	Yu, Z., & Shiozaki, T. (2023). Expression of interior/exterior overlap through the arrangement of linear elements in contemporary Japanese urban residential works published in Shinkenchiku magazine since 1970. Journal of the Architectural Institute of Japan, Planning and Architecture Series, 88(808), 2018-2028.	Site	Linear elements arrangement	Internal and external elements	13	The arrangement of elements provide a better understanding of the independence between internal and external linear elements
18	Nakai & Sakamoto. 1999	1999	Nakai, K., & Sakamoto, K. (1999). Segmentation of space composition and usage in modern Japanese city hall architecture: Study on architectural composition form by segmentation of external volume. Proceedings of the Architectural Institute of Japan, Planning Department, 64(519) , 147-153.	Complex	City hall composition	exterior composition via articulation spaces and function	8	The characteristics of the spatial composition of Japanese contemporary city halls mainly depends on how the exterior volumes articulates their functions, and that the exterior open space surrounded by building tends to appear with big interior spaces
19	Inamochi et al. 2021	2021	Inamochi, R., Inomata, K., & Okuyama, S. (2021). Continuity of urban space from the perspective of the articulation format of transit spaces in station buildings. Journal of Planning and Architecture, 86(779), 325-334.	Complex	Station Passageway Network	passage spaces according to continuity and function	14	Station passageways can ensure continuity via continuity of spatial patterns, sich as a wall or scale.
20	Okumura & Terauchi. 2022	2022	Okumura, T. & Terauchi, M. (2022). Selection and territoriality of approaches in the exterior space of a detached housing complex. Journal of Architecture and Planning, 87(799), 1634-1642.	Complex	Housing Complex exterior space	4 Kinds of exterior space: garden, surrounding, periphery and residual	9	Composition show the relation between the accessibility of the approach space and the contact rate.

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
21	Kuroyanagi & Tamura. 2005	2005	Kuroyanagi, A. & Tamura, S. (2005). Compositional methods of water and architecture from the perspective of the relationship with the interior space: Study on the relationship between water and architecture in architectural space, Part 1. Journal of the Architectural Institute of Japan, Planning and Planning Series, 70(593), 101-108.	Area	Water as architectural space	Water, exterior, and building outline	9	Range of comosition from segregation to integration
22	Yasumori et al. 2008	2008	asumori A., Sakamoto K., & Terauchi M. (2008). Collective forms of station squares in JR stations in Tokyo's 23 wards. Study on the composition of open space in contemporary Japanese urban space (3). Journal of the Architectural Institute of Japan, Planning and Planning Series, 73(632), 2099-2105.	Area	Station square composition with regards to surroundings	Segmentation according to physical barriers (tracks, roads, and buildings)	4	The station square assembly has multiple ways to portray integration or segmenation of its surroundings
23	Katafuchi et al. 2024	2024	Kazuhiro K., Minami U., Hiraki, & Koichi Y.. (2024). Accessibility to canals and application procedures on private coastal land in the Shibaura Konan and Tennozu areas. Architectural Institute of Japan Planning Journal, 89(815), 140-149.	Area	Waterfront accessibility	Space division between street and water	10	Type relates to accessibility, view, and circulation
24	Yasumori et al. 2009a	2009	Yasumori A., Saito K., Sakamoto K., & Terauchi M. (2009). Spatial composition of intersections based on the arrangement of architectural volumes: A study on the composition of open spaces in contemporary Japanese urban spaces (4). Journal of Planning and Planning, 74(638), 815-822.	Area	Arrangement of building volumes according to intersection	Intersection and adjacent buildings	9	The intersection affects what kind of buildings appear around it, as well as having a role to play against other barriers and the area's topography

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
25	Minobe et al. 2002	2002	Minobe, Y., Sakamoto, K., & Terauchi, M. (2002). Integrated form of urban architecture from the viewpoint of its adjacency with the surrounding environment: A study on integrated form of modern architecture by arrangement of volumes. Journal of the Architectural Institute of Japan, Planning and Planning Series, 67(558), 137-144.	Block	Building's relationship to other buildings via external surroundings	Main volume, external volume, and exterior space	10	Describes levels of separation
26	Kitahara et al. 2009	2009	Kitahara, K., Kobayashi, H., Kaneko, S., Korenaga, M., & Yagi, K. (2009). The composition of open courtyard spaces in the Faubourg Saint-Antoine district. A study on the composition of exterior spaces within city blocks in Paris. Journal of the Architectural Institute of Japan, 74(635), 113-120.	Block	Inner Courtyard	Thresholds	10	Type relates to courtyard structural characteristics
27	Yasumori et al. 2009b	2009	Yasumori A., Okimura T., & Sakamoto K. (2009). Spatial composition of housing complexes based on the scale and arrangement of buildings. Study on the composition of open space based on the distributed arrangement of buildings in contemporary Japanese urban spaces. Journal of Planning and Planning, 74(643), 2013-2019.	Block	Complex arrangement and size	The combination of buildings is segmented according to each building's scale within the complex	8	The complex's arrangement can give the block a general urban character and frame the city's open spaces
28	Saito & almazan. 2020	2020	Saito, N., & Almazan, J. (2020). Configuration form of space under elevated railway tracks in the wards of Tokyo. Re-evaluation of the remaining space in the wards of Tokyo from the perspective of spatial configuration and usage pattern (2). Architectural Institute of Japan Planning Series Proceedings, 85(769), 771-780.	Block	Space under elevated railway track	Space division according to crossing and internal alleys	15	Study shows examples of how pedestrian permeability can be implemented in under-railway-track spaces in order to make them an active part of the city

#	Author and Year	Year	Title	Scale	Subject Matter	Segmentation	Types	Rhetoric
29	Konno et al. 2010	2010	Konno, C., Miyagishima, T., & Tsukamoto, Y. (2010). The nature of loggia-like spaces as public spaces in contemporary architectural works. Journal of the Architectural Institute of Japan, 75(657), 2719-2727.	Neighbor-hood	Loggia Space	Loggia space and adjacent external space	12	The combination of two contrasting axis of spatial qualties, the architectural aspect of structure vs. covering and the external relation to openness vs. gap space, is clarified as a basic characteristic of loggia space
30	Saito et al. 1995	1995	Saito, C., Hachiya, K., & Sakamoto, K. (1995). Typology of spatial composition of "town" in Tokyo's wards: A study of architectural aggregation forms in city blocks. Journal of the Architectural Institute of Japan, 60(474), 123-131.	District	Spatial composition of a district according to blocks group arrangement	Street grid and building shape	2	The type relates to the grade of homogeneity on the arrangement and shape of buildings to frame the order of the contemporary urban space

B.5. Analysis Framework

Although it is assumed that the analysis framework is straightforward as presented in the main text, this appendix is provided to clarify, verify and justify both procedural choices and design main choices. As such this appendix is organised in two sections, which touch on what is considered the most important moments of judgement within the development of the analysis framework that might need more detail than what is provided in the main text. The first deals with the iterative process of refining the framework towards its final version, and the second deals with representation of the abstraction of space and the logic regarding segmentation and exceptions.

Reiterating the Framework

As much as with the literature review as with the methodology, there was a long period of gestation regarding what to capture within the subject matter, in this case the built environment, to then abstract, analyse, and measure. This study started with four cases, four BPFs from four different stations (Assen, Delft, Amstel, and Driebergen-Zeist). With these cases, the focus was on the floor plan of the BPF and the relation to the station's floorplan in terms of circulation. Studies like this already existed (e.g., Dolders & Reiling, (2020)) and acquiring the actual proportions of the 4 cases and the stations (8 floor plans) was not only challenging but begged the question if it was the right scale or medium to study the bicycle-train relationship.

A second version of the definition of the framework was to relate bicycle to train facilities according to their disposition within the station site. This version of the relation abstraction consisted of tracing the direction of movement with regards to the position of spaces (BPF, Train plaftorms and in-between space). It was from this version that the idea of composition, later supported by spatial composition theory, was used to ground the medium on which to analyse, by relation between spaces and not necessarily quantitative data, such as distance or time, as previous studies.

From here, alternative representations were explored, such as the station ground plan, the station map (axonometric) and network graph map. Upon searching for various references that might be used for circulation purposes, it was found that the closest representation of a station to the study's scope was that of "barrier-free facilities" and "station accessibility maps" from Japanese railway and metro stations. While both are covered by station operators, some maps in display at the stations were developed by users. For the convenience of transfering from a train wagon to search for an elevator, the "Convinience Transfer Map" (のりかえ便利マップ) by Yasuyo Fukui in 1995.

Following her on-site observations and station analysis, a field survey for the analysis framework was proposed. The survey consisted of travelling to stations where the circulation space between facilities and train platforms could not be verified using online tools. Upon arriving to a station, the bicycle-train space would be recorded by sketching and taking pictures walking from a platform to the facilities. Upon identifying each facility, the spatial composition of the site, and the floors between them is identified. This is repeated for each facility and all platforms are accounted for. For the facilities, it was checked if the facility had more than one entrance and if it did, to which components did it have access to. Written descriptions were also recorded in components that could have various interpretations. Also, a note was made of where a user can check into and out the station.

A field survey would probably be the best way to get accurate results, but the resources needed to visit 95 stations when most of them could be assumed to be up to date made proved the idea to be abandoned. In turn, this same procedure was made virtually through maps and photographs of each station and adjacent spaces. At this point, given the analysis is being done on a computer, a typical analysis tool was considered, which was to shade parts of a map according to the definitions established for this study, as seen in the figure below. The feature of colour-coding spaces according to their definition was adapted, but it was considered that sketching diagrams from the screen was more productive to figure out the procedure through which to visualise all cases.

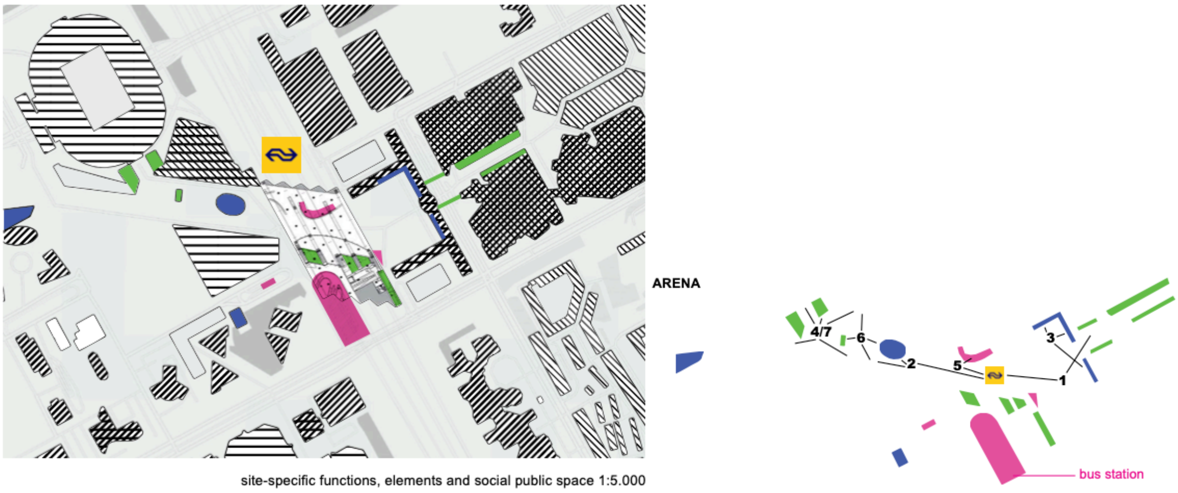


Figure B.5.1. *Map outline shading to capture space in Amsterdam Bijlmer Arena Station. (Source: Rouwenhorst, 2019)*

The three maps, or rather diagrams, were considered and used to communicate how circulation occurs between the BPFs and train platforms at a station. However, it was still not clear how the plan, axonometric, and graph would be used to communicate different aspects of the circulation. The next iteration of the analysis framework fluctuated between using the numbering system for stations (95) or BT floors (based on 136 BPFs). Because the study was identifying and abstracting both the multimodal station and the intermodal space, it was decided that the different diagrams would be used to abstract different scales. As such, what previously tried to cover all in either a composite station diagram (for all and each BT floor) or a repeating station diagram (same station composition but isolating BPFs and platforms relevant to each BT floor) then became two separate diagrams: the station composition and the intermodal configuration. The composition diagram would look like the figure above and the configuration like the figure below.

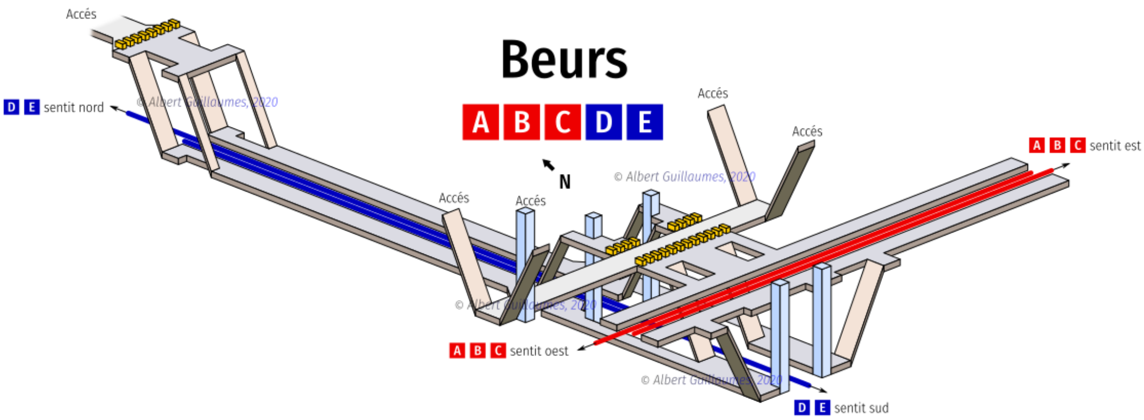


Figure B.5.2. *Example of axonometric station map (Rotterdam Beurs Metro Station). (Source: http://stations.albertguillaumes.cat)*

By showing a station from an axonometric perspective, it becomes possible to see the different levels present in the traversable space inside and outside the station. In this case, the Beurs metro station in Rotterdam is shown with all the connecting spaces between the outside and the platforms via stairs (beige), passageways (grey), and elevators (pale blue). This level of detail is better suited to show the positional relationship amongst spaces, which in the station setting, BPFs and train platforms can be at different levels and require spaces to connect them. Upon drawing 1,753 metro stations across the world to understand how engineers fit and connect multiple lines underground, the author of the figure above has drawn these diagrams by pen, to later digitalise, using spatial vision and the willingness to navigate all the staircases, corridors, platforms and mezzanines of a station. In cases where not possible to visit in person, historic, construction and survey maps, pictures and videos are used to understand how the space is formed. This study opted for the latter to draw the diagrams.

The third diagram, the network graph, is intended to provide a determinate movement within the visualised space. This movement can be a route, flow, or trajectory, between two endpoints. Taking the previous diagrams, the next step is then to use them subsequently to understand how the space informs the possible route(s). This can be observed in Figure B.5.3. where combination of plan and axonometric diagram inform a graph diagram (right). The plan (composition) provides the segmentation of parts according to mode and connecting spaces horizontally (transfer floor); the axonometric (configuration) provides a vertical segmentation of parts according to their position in relation to one another, which justifies the presence connection spaces (e.g. stairways); and the graph (trajectory) provides an abstraction of how movement occurs between the endpoints (BPFs and train platforms) via transfer floors.

However, the graph diagram in this study is divided in two levels of abstraction: the network of BPFs and groups of platforms via transfer floors (articulation) and the network from one BPF to the farthest platform (trajectory). A major difference between the two is that articulation takes into account changes in level, while trajectory considers splits according to different farthest platforms that are not connected to each other, or rather, are dead ends. This distinction was applied in order to have articulation be a transition between the configuration diagram to the trajectory diagram, where a lot of information is filtered out. As such, the trajectory diagrams can group together different articulation that have the same articulation, that is, the same number of spaces between a BPF and the farthest platform.

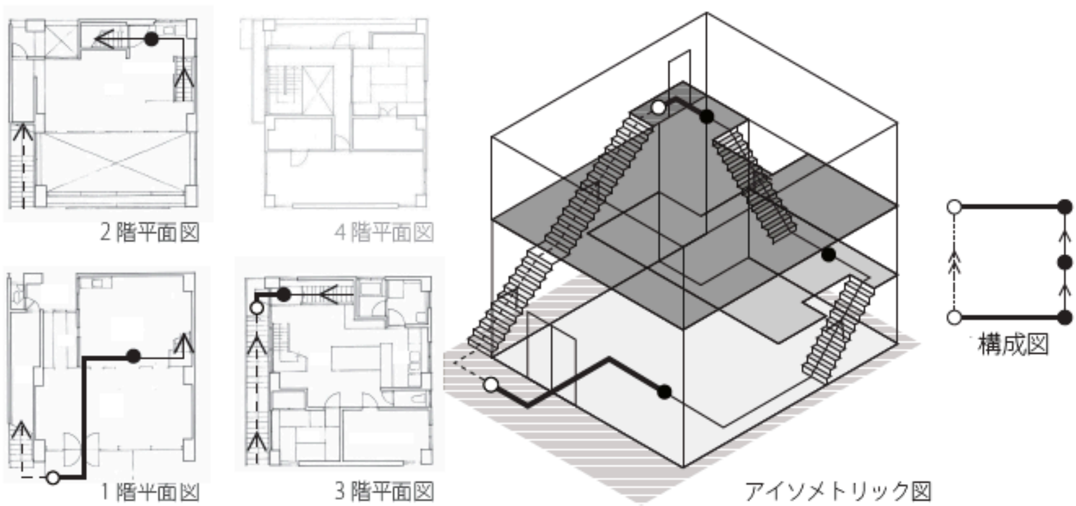


図 1-10　第 3 章における動線の記述方法および構成図

Figure B.5.3. *Abstraction towards graph diagram. (Source: Yokoyama, I. 2024)*

Together, they represent and adapt the spatial composition theory to this study while addressing how the spatial composition theory is the analysis of a space at multiple levels of abstraction that are all interrelated. With this framework, the circulation between bicycle and train would be considered at the level of the station, all BPFs-platforms, and each BPF-farthest platform. The last abstraction would be the enumeration of trajectories according to the number of spaces present in the trajectory. Borrowing from other quality systems denoting performance based on a single character like the energy label on electro domestics or school grades, the letter grading system was chosen (A-Z).

Incorporating Exceptions into Abstraction

As the framework has been established and justified, the next step was to address the relation between the composition and configuration in terms of the connecting link: the transfer floor. The transfer floor is pre-defined as the floor between the two ends (BPFs and train platforms), but the demarcation of such floors was missing to capture the space for these diagrams. In Figure B.5.1, the transfer floor is not shaded and is represented as everything in grey (walkable spaces between outside and the platforms) and is represented in the analysis diagram as a link. In Figure B.5.2., the transfer space comprises all spaces within the station, which is all spaces underground (physical demarcation), where the enclosure of being underground forms the traversable space. In figure B.5.3. the graph and axonometric diagram are derived from the house floor plans, which also provide the movement via the proportion of spaces within and the orientation of stairways. As such, the problem with the study's context is that the space, when not enclosed, need to be defined.

Hence, to demarcate the transfer floor in this study, it was opted to segment transfer floors according to levels in order to reduce the area of transfer floors and to split spaces that require a change in direction (vertical). This logic follows the Japanese Development Specification for Spatial Network Model for Pedestrians (MLIT. 2018). In this data specification, levels (delimited by nodes) are segment upon a change in level. Landings, as seen below, are assigned as a half level change (0.5). In this study, other floors may be assigned as half floor change if it functions as a landing in relation to other floors in the configuration. By borrowing the logic from this data specification, the logic behind the segmentation of BT floors is backed by other studies were this is applied (e.g., Arai et al. 2021).

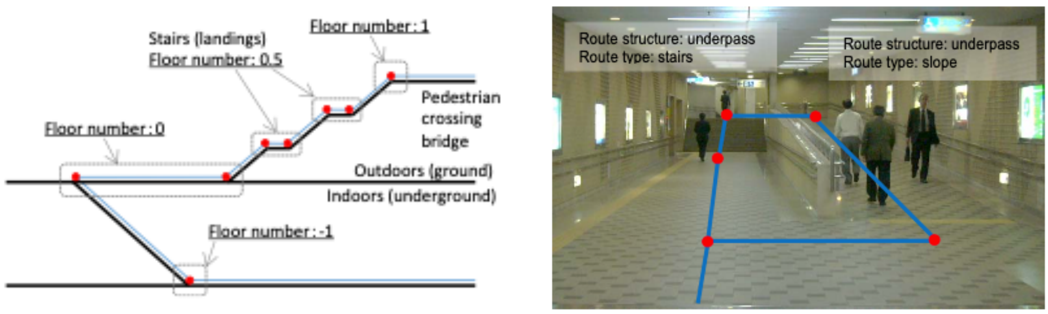


Figure B.5.4. *Floor Segmentation process according to levels. (Source: MLIT. 2018)*

The assignment of transfer floor, while straightforward at first, was then met with exceptions. Exceptions appeared during the analysis using the framework, and towards the final version, changes to conditions to be able to integrate exceptions within it were required to make the framework applicable to every case. This made the analysis process iterative and changed the way everything was abstracted every time a new exception was encountered. It can be said that all the material studied affected the final framework and so the following paragraphs explain why these choices were made and how the exceptions found were dealt with.

Horizontal segmentation

Through the splitting of floors according to mode and level, cases where transfer floors were met with roads, train tracks and change in direction towards the train platforms created a problem with the framework where floors would only segment due to change in level. This resulted in three categories of horizontal segmentation: Tracks, Road, and Orientation. The first two act as a physical barrier upon which the traveller must momentarily stop to check if they can cross that space, or in the case of train tracks, may be prevented from crossing if a train is incoming with a temporary gate. The orientation segmentation was added upon realising that some cases, while having the same articulation, would not be similar in their configuration. One example would be BPFs that would be next to a transfer space and a platform. By orientation, what is meant is that if the BPF exit is not facing the platform in question, an orientation segmentation would occur, and the articulation would include a transfer space.

These segmentations were displayed on the configuration diagrams by the letters (T, R, O). These are exceptions because in many cases, they are only possible because of these segmentations, such as the direct link between two adjacent platforms, where the train tracks are a transitory space denoted as a link, instead of a transfer floor due to not being available to stand on it and use it at any moment. This is exemplified in the main text by analysing Hoorn (s57), which has two horizontal segmentations (O, T).

BPFs Levels

This second one is a bit more difficult because it contradicts the main way of segmenting the BT floor. Initially and for a long time, BPF were considered to be one floor despite their number of levels. The presence of entrances at different levels considered a bicycle floor to branch out to different possible trajectories. This became an exception when, through analysis, it was found that there 31 cases of multi-level BPFs and that 11 of them had 2 entrances, which ultimately differentiated from other cases in the same pattern when not considering this aspect. Therefore, multiple levels were displayed in the configuration diagram and articulation graph.

However, the trajectory graph did not include the extra levels but kept the branching out from a bicycle floor into different routes in a trajectory. The logic here is that if the extra floors were added to the trajectory graph, it would penalise every case for having an extra level. While this would be more realistic, as a cyclist could park in any of the levels of a BPF, this was not deemed necessary for two reasons: the presence of an entrance would motivate a cyclist to park close to an exit so to shorten the walking distance to the train platforms, and the movement within the BPF is assumed as a single floor because the choice of where to park depends on availability and so parking in a second level without an entrance is just the result of not finding something in the level with an entrance. Another way of explaining this is that the platforms are distinct floors for the trip ends there if the traveller needs to board a train on that platform. To assess the circulation performance of each level within the BPF would be granular in the same way as separating the platform into sections, such as considering either side of the platform a service platform (platform 1 and 2 on a single island platform) or splitting a single service platform along its length (e.g. 2a and 2b).

Trajectory affecting Composition

Not necessarily a reflection, but important to note with regards to operationalising a framework in progress while adapting for exceptions is that the changes in the framework could happen at the level of abstraction of the trajectory and could affect all the way to the way compositions were segmented. The final version of the framework may seem comprehensive, but all the modification along the way while assessing the analysis results proves to be a challenging for the number of changes needed to be made within the tables and diagram numbering/categories. However, because the principle of type took everything in despite the variations (exceptions), it was deemed necessary to also apply this principle to the framework itself.

Sources:

Rouwenhorst, J. (2019). Between dwelling and rail: seeking mutual benefit in transit-oriented development and railway station expansion in the peri-urban area.

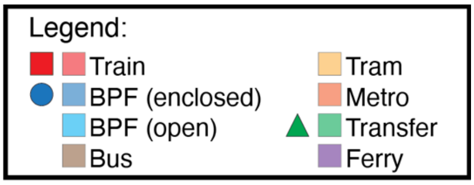
Ministry of Land Infrastructure Transport and Tourism (2018). Development Specification for Spatial Network Model for Pedestrians. Retrieved on 20241103 from: https://www.mlit.go.jp/common/001244373.pdf

Yokoyama, I. (2024). Constitutive features of post-war Japanese houses with three-dimensional wandering lines [立体回遊動線をもつ戦後日本の住宅作品における構成的特徴] (Doctoral dissertation, Tokyo University of Science). (In Japanese)

Appendix C: Analysis

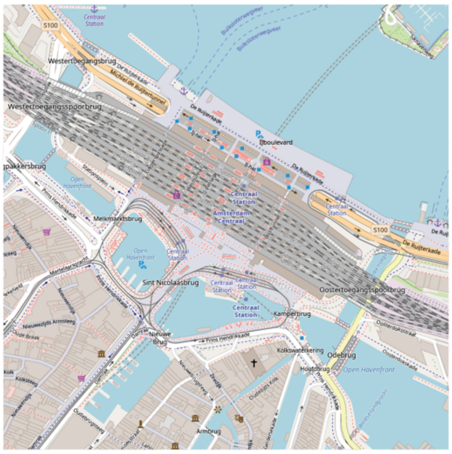
C.1. Station Composition Analysis

Figure C.1.1. *Analysis diagram legend*

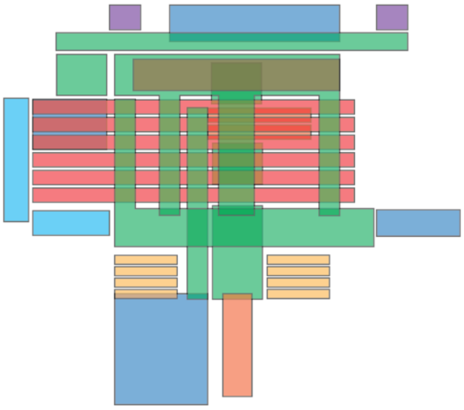


Case No.	Station Name
s11	Amsterdam Centraal

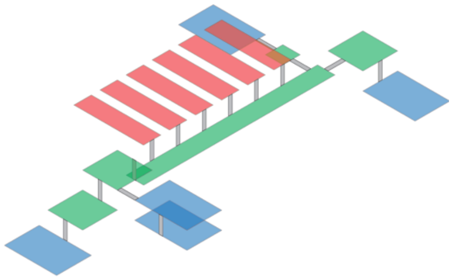
Site map



Composition

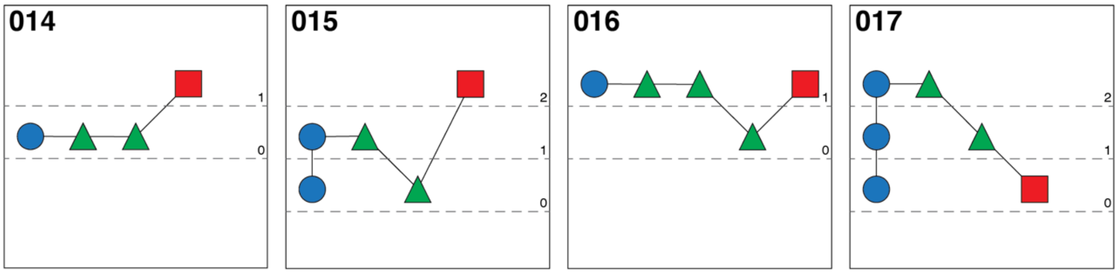


Arrangement



BT Space No.

Articulations



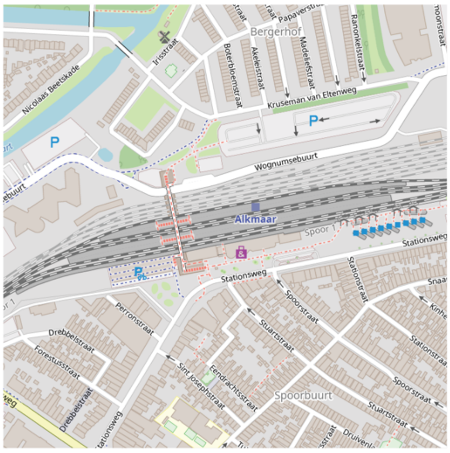
Trajectories

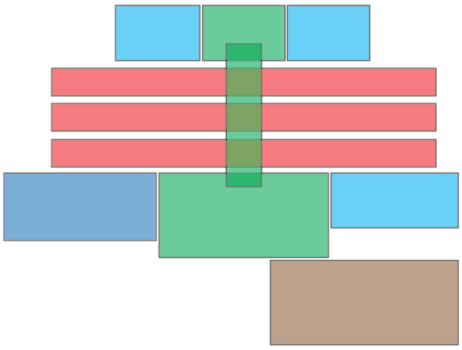
Grades

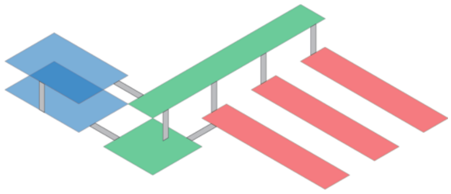
014	015	016	017
C	C	D	C

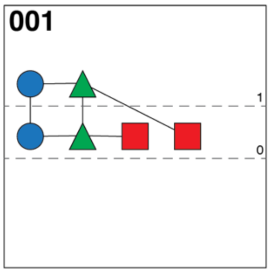
__Table C.1.2.__ Station composition analysis diagrams

s01 Alkmaar



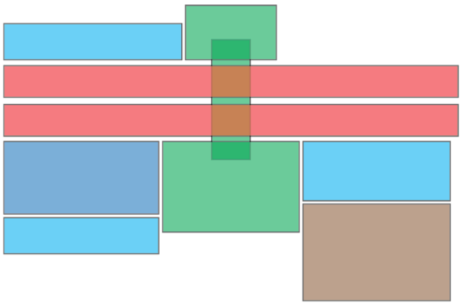


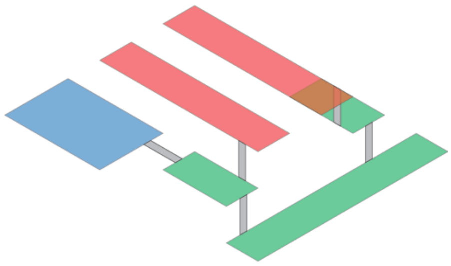


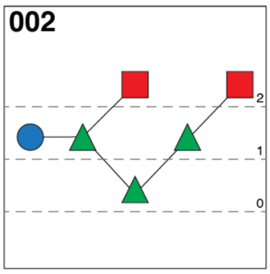


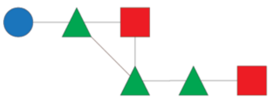
B

s02 Alkmaar Noord



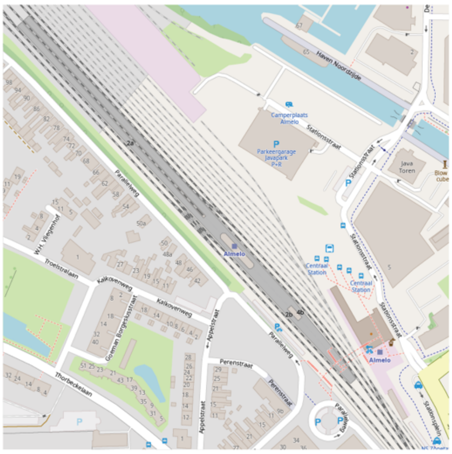


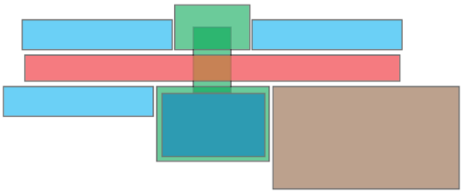


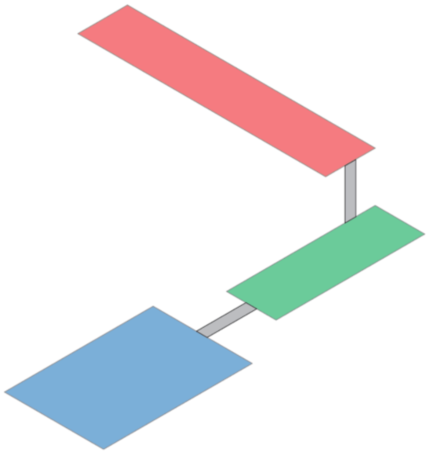


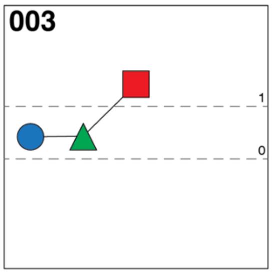
D

s03 Almelo



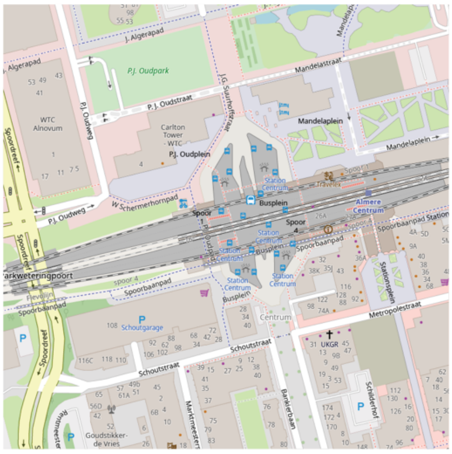


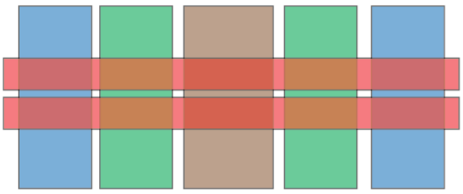


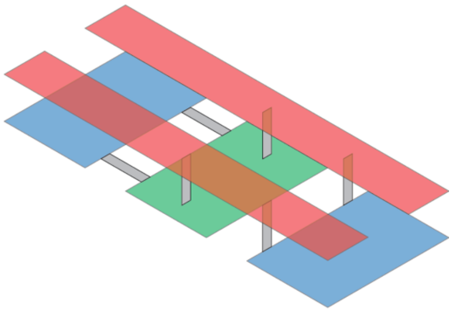


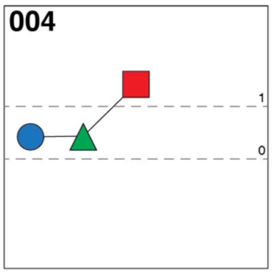
B

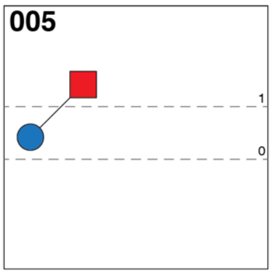
s04 Almere Centrum

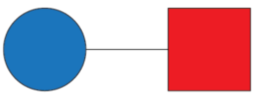






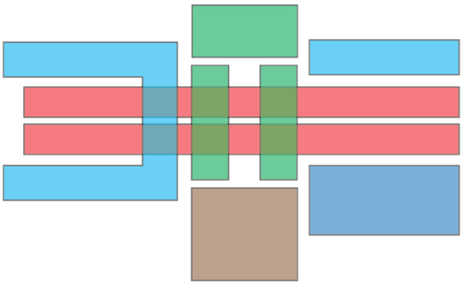


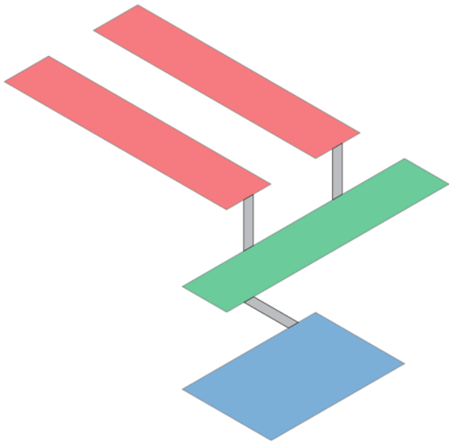


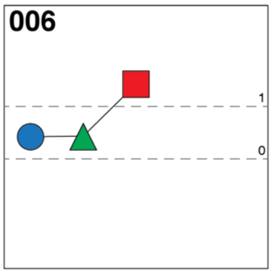


B **A**

s05 Almere Buiten

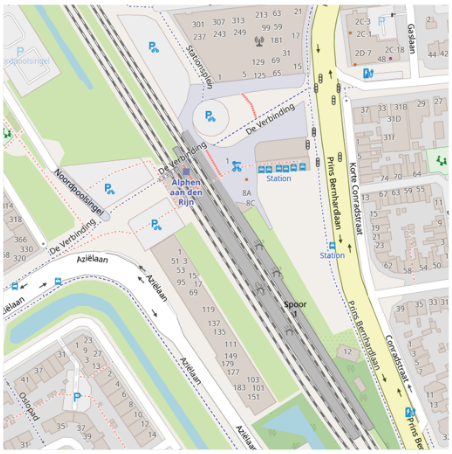


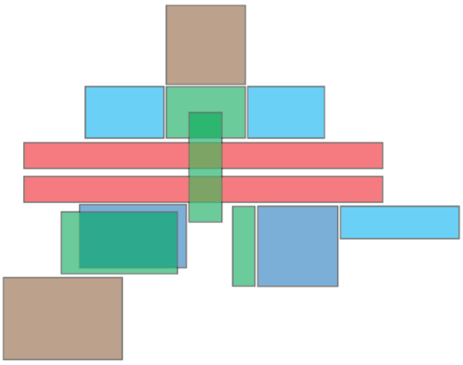


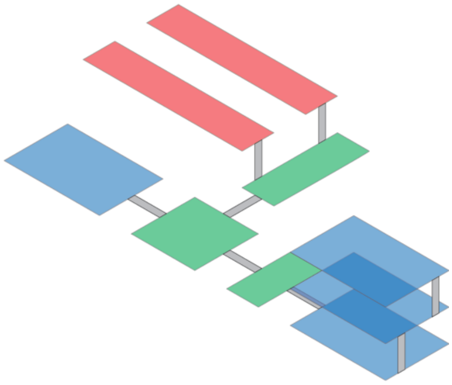


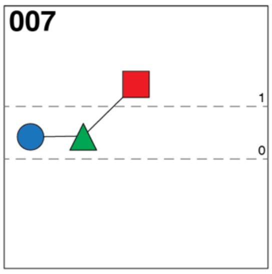
B

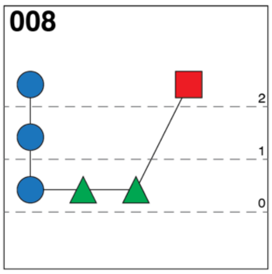
s06 Alphen aan den Rijn





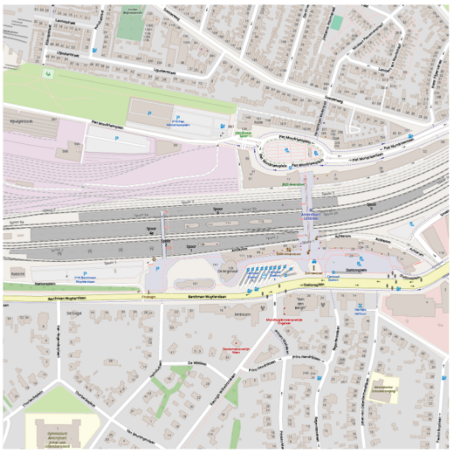


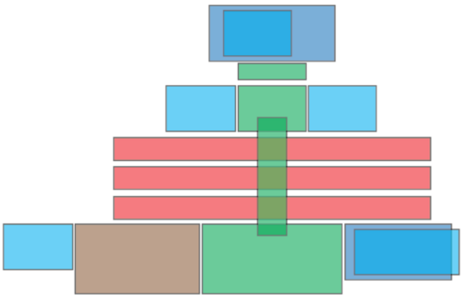


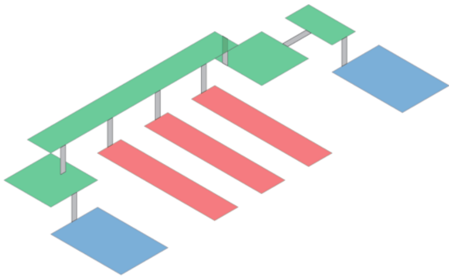


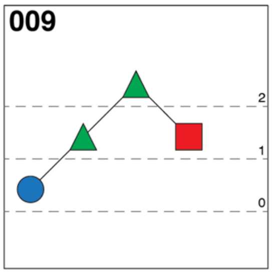
B **C**

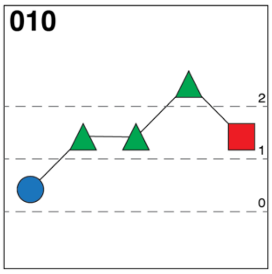
s07 Amersfoort Centraal





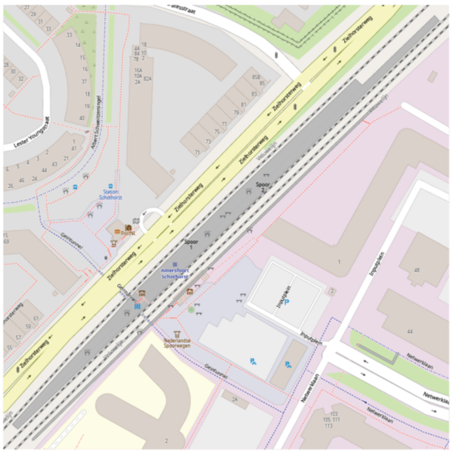


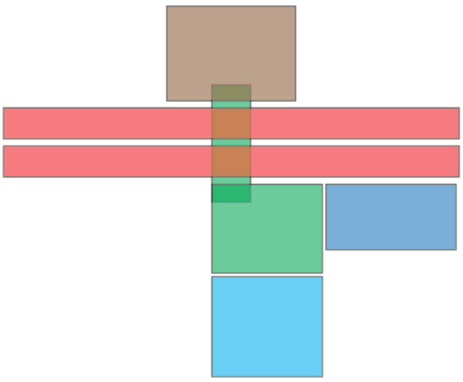


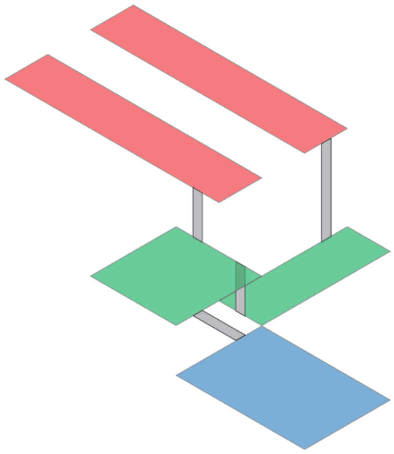


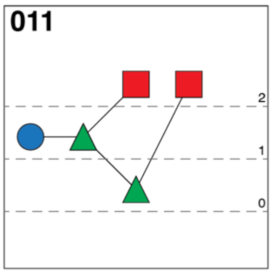
C **D**

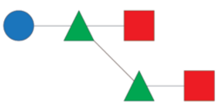
s08 Amersfoort Schothorst











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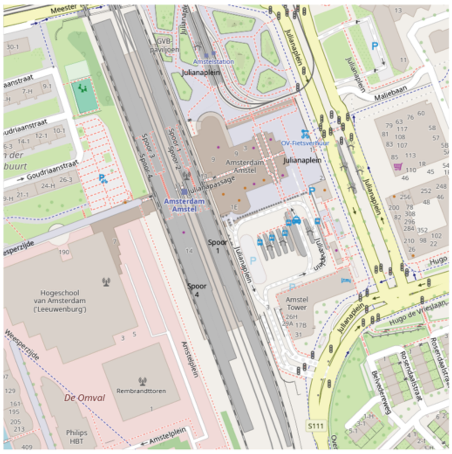
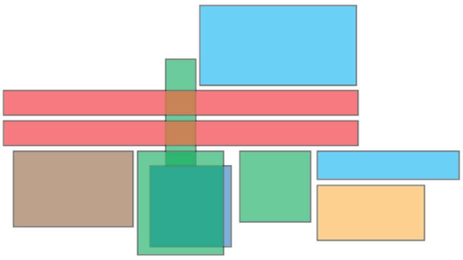
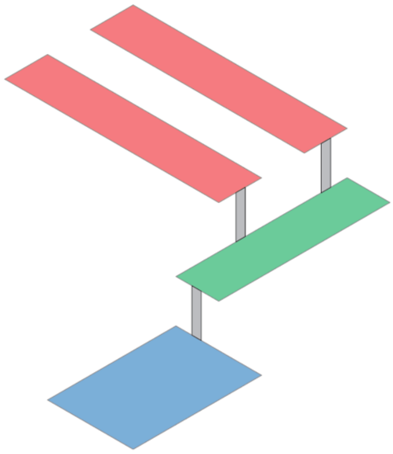
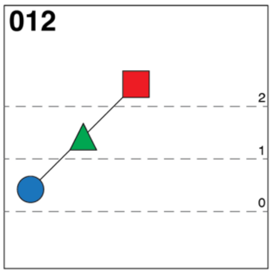
s09 Amsterdam Amstel









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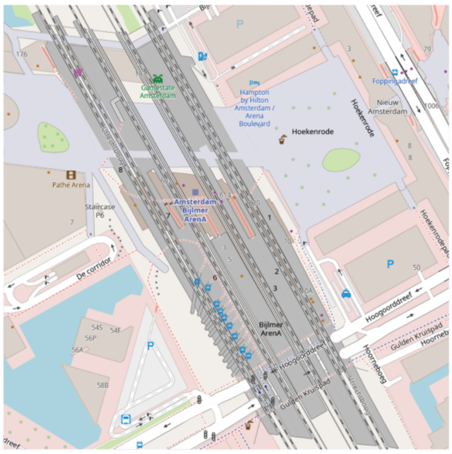
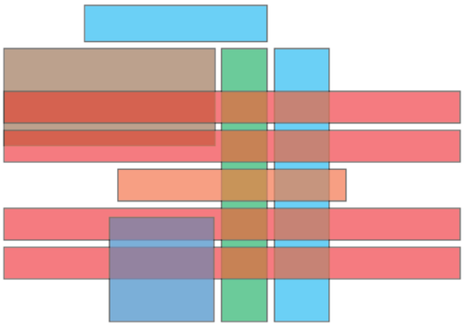
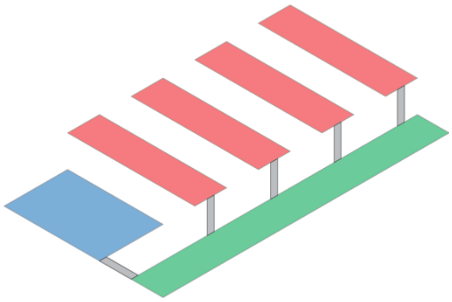
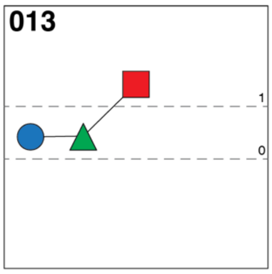
s10 Amsterdam Bijlmer ArenA









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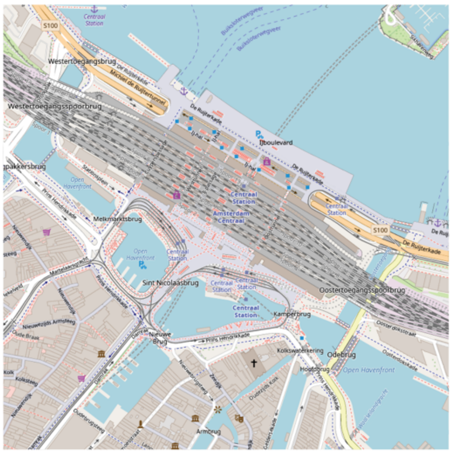
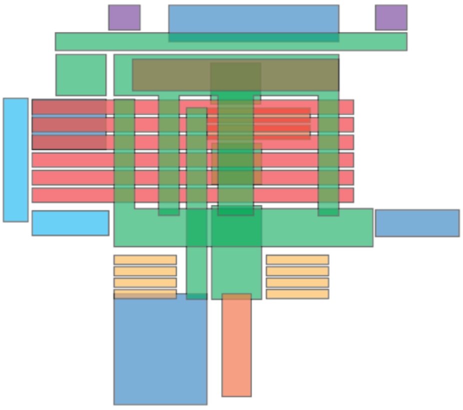
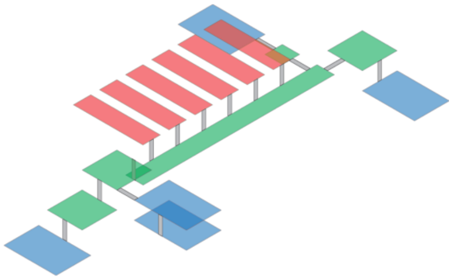
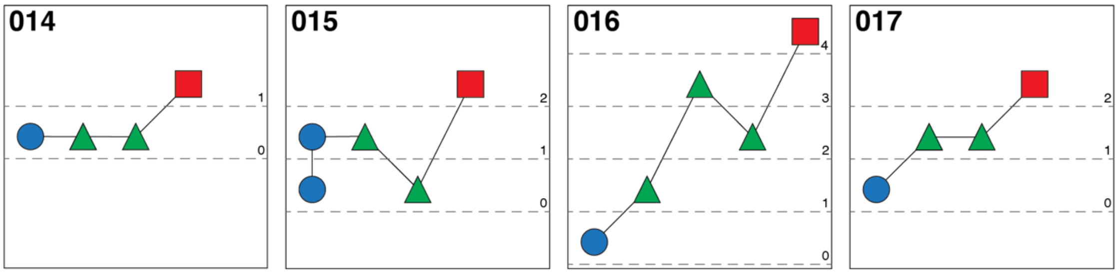
s11 Amsterdam Centraal



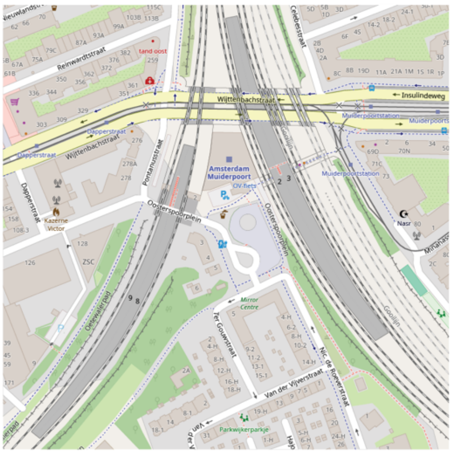


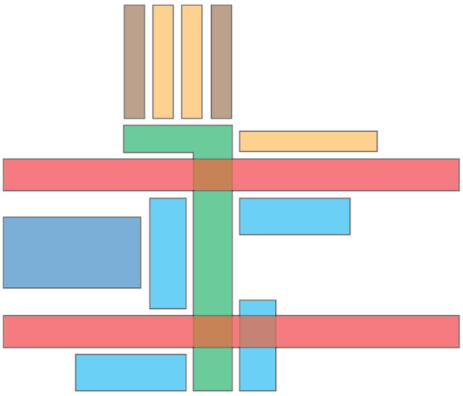


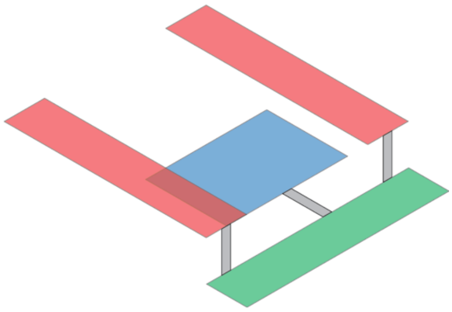


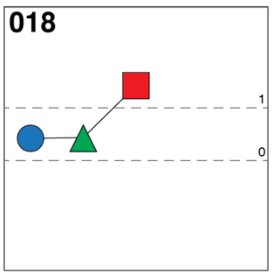
C C D C

s12 Amsterdam Muiderpoort









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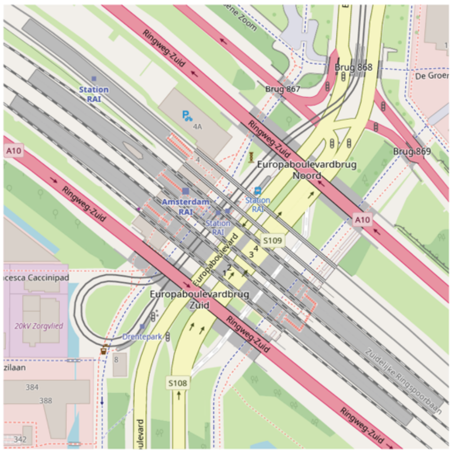
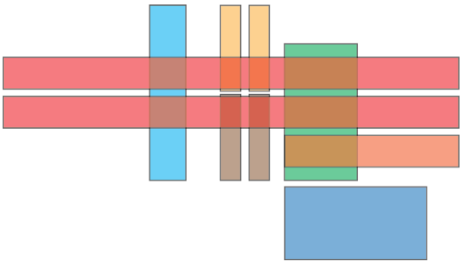
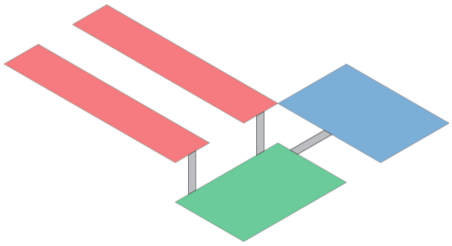
s13 Amsterdam RAI







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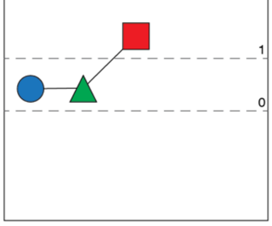

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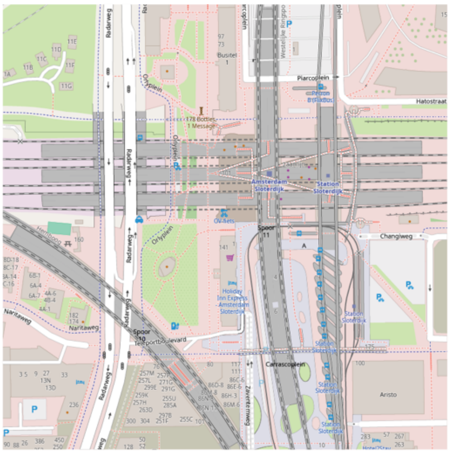
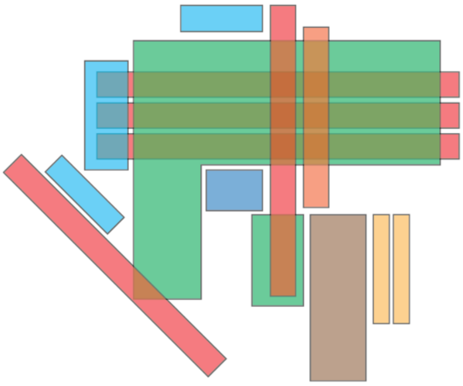
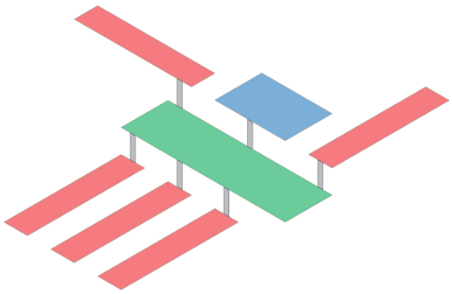
s14 Amsterdam Sloterdijk







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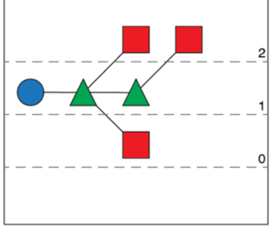
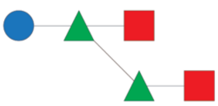
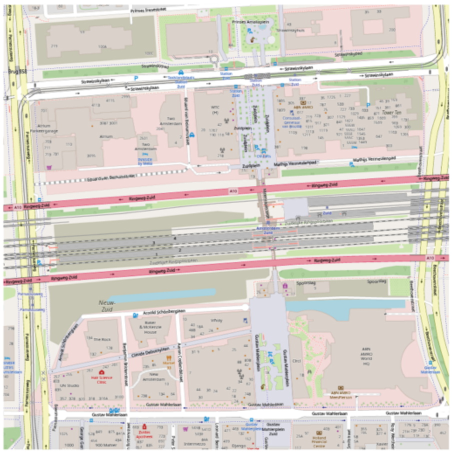
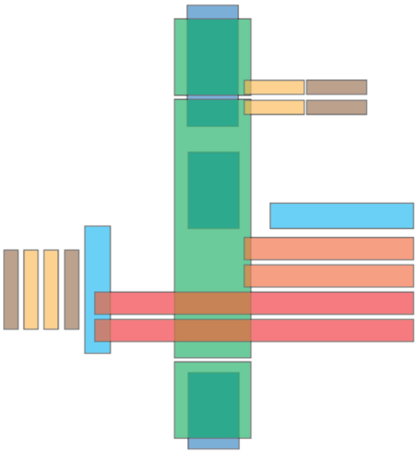


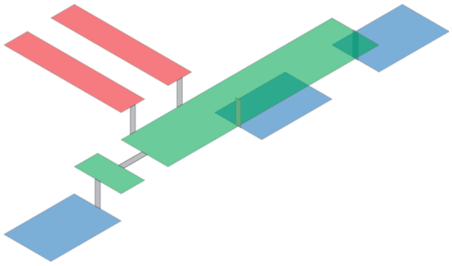


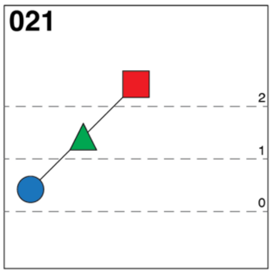
C

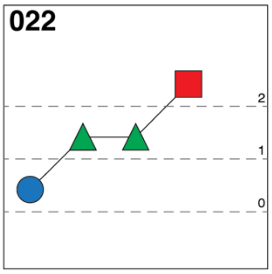
s15 Amsterdam Zuid

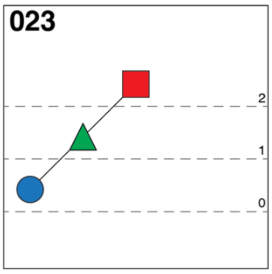






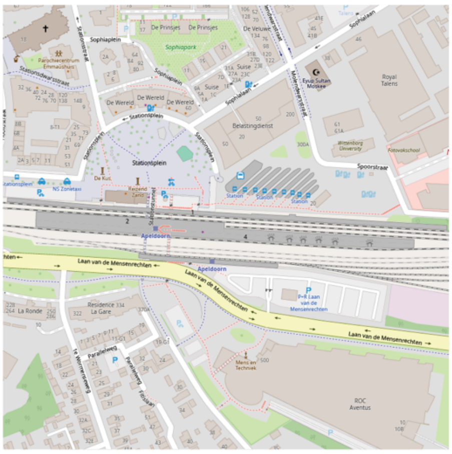


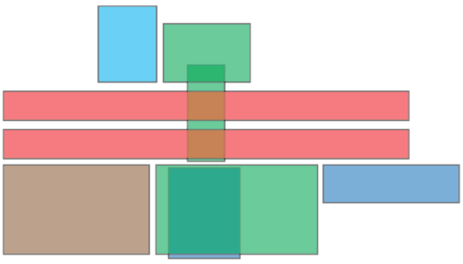


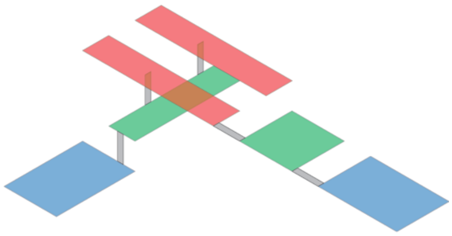


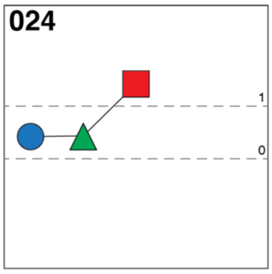
B **C** **B**

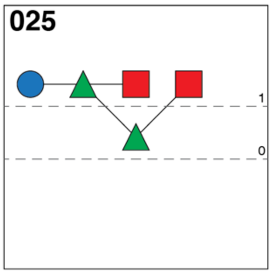
s16 Apeldoorn





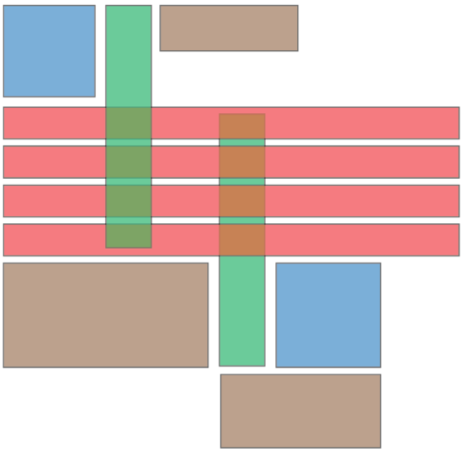


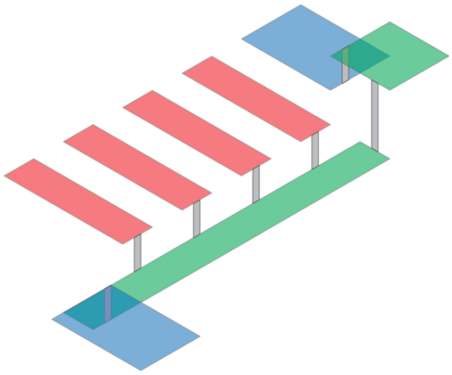


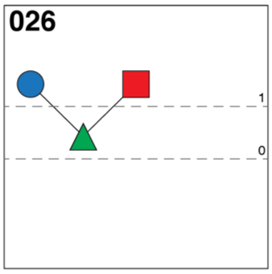


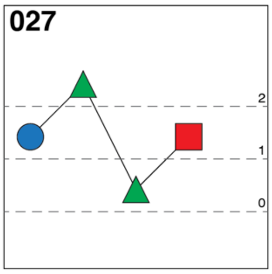
B **C**

s17 Arnhem Centraal



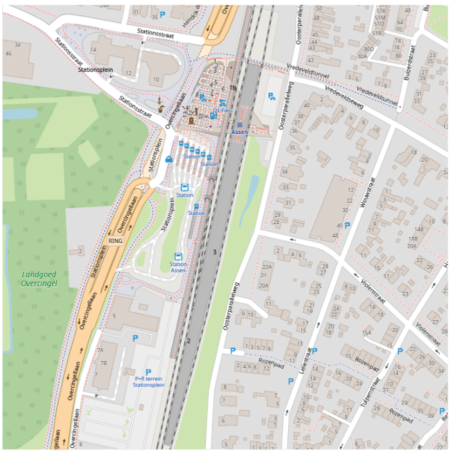


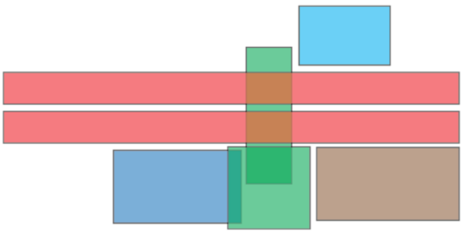


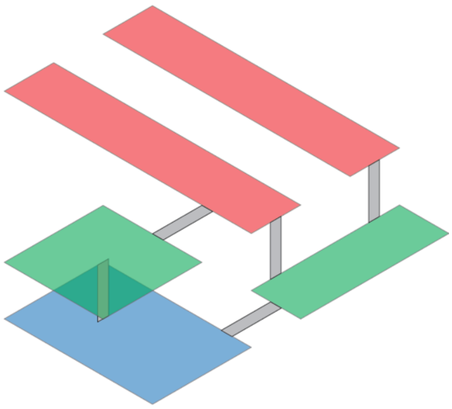


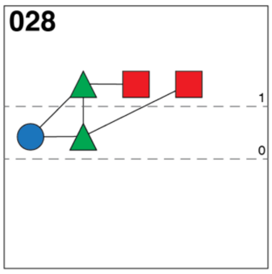
B **C**

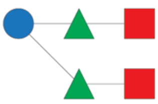
s18 Assen











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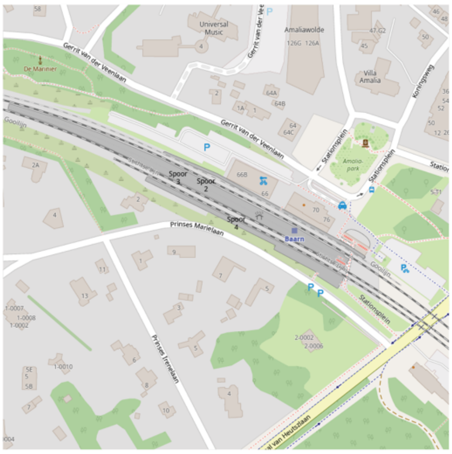
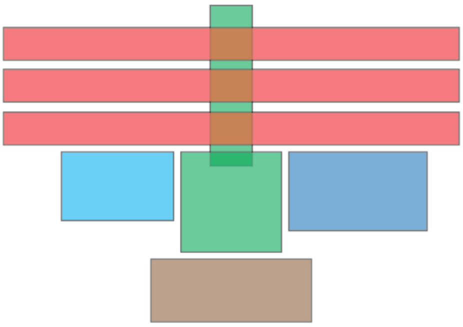
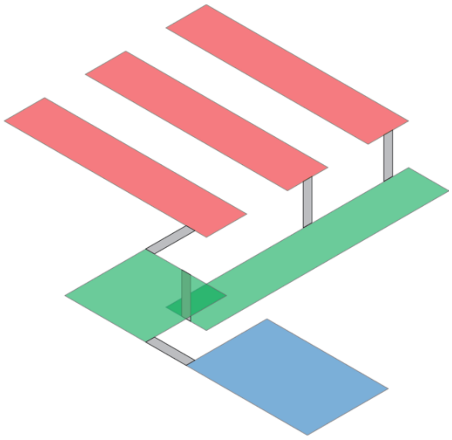
s19 Baarn







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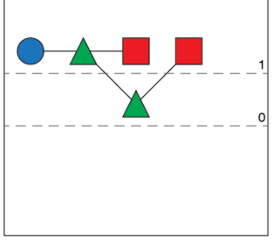

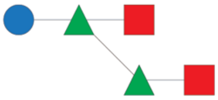

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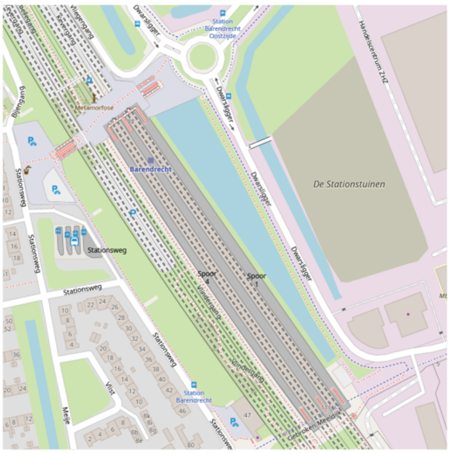
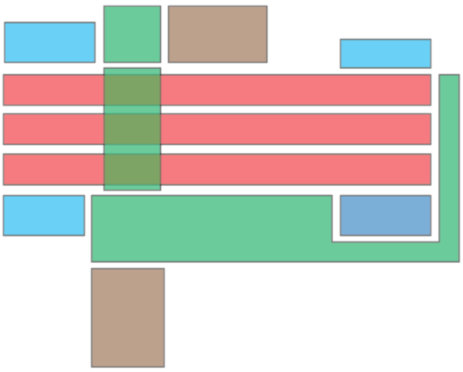
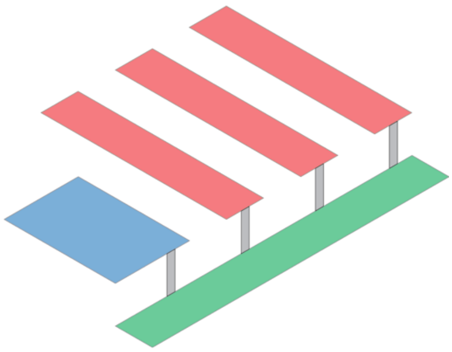
s20 Barendrecht







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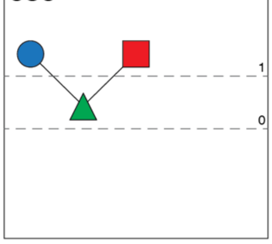
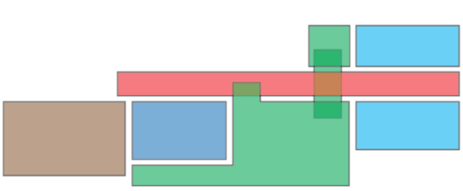
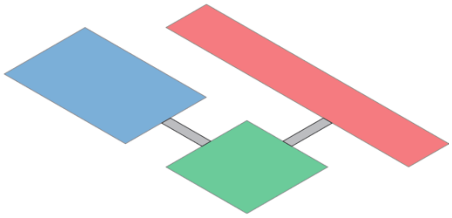
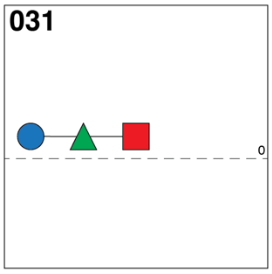


B

s21 Bergen op Zoom







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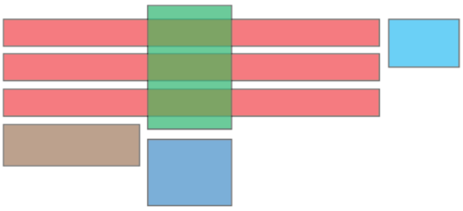
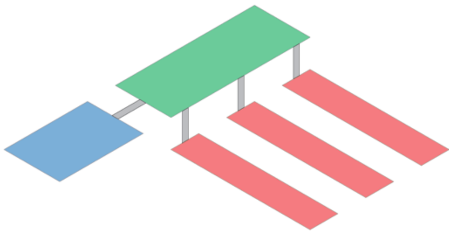
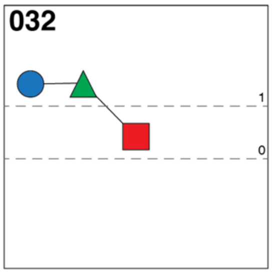
s22 Best







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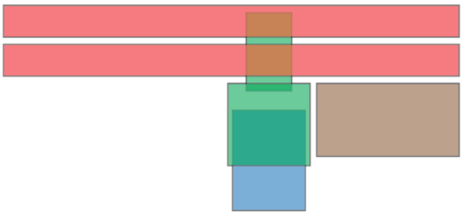
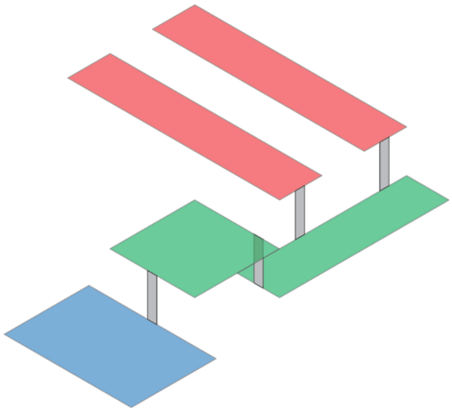
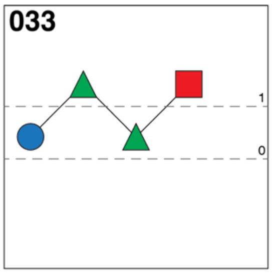
s23 Beverwijk

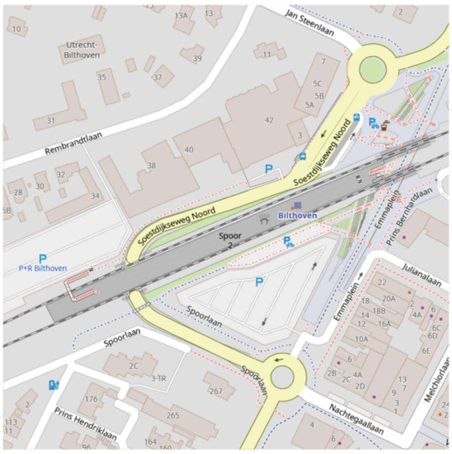


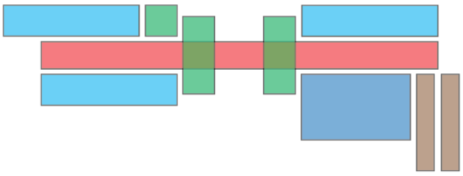


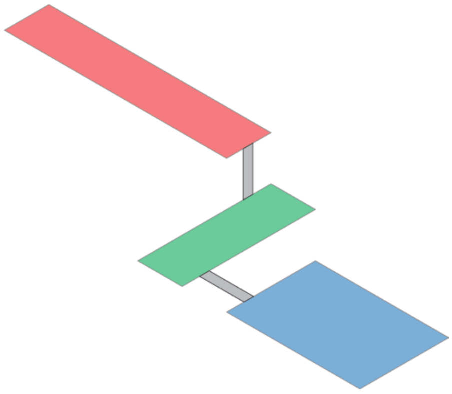


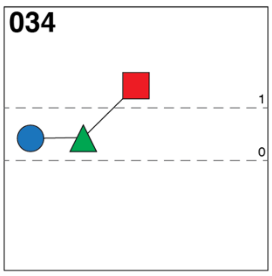
C

s24 Bilthoven









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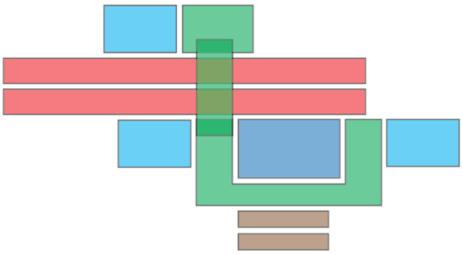
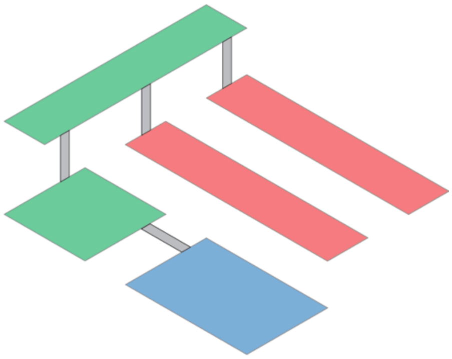
s25 Boxtel





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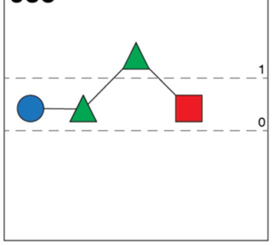

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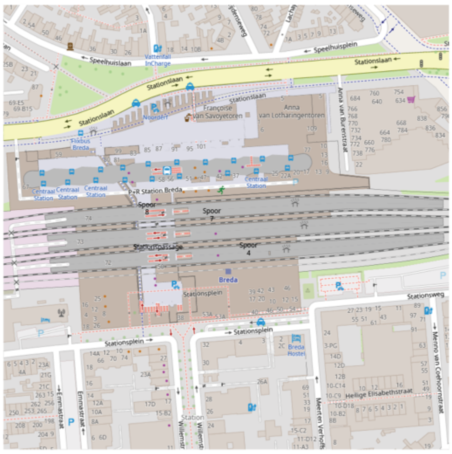
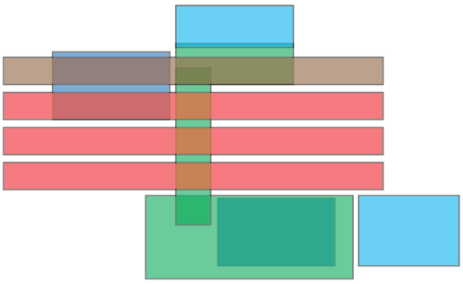
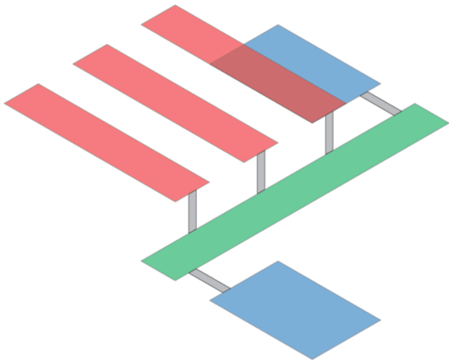
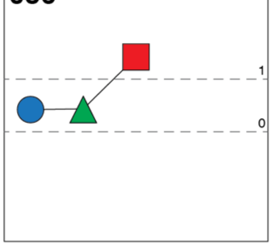
s26 Breda



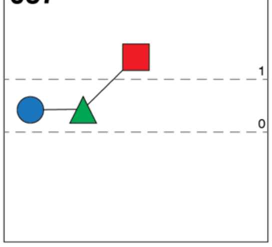




036

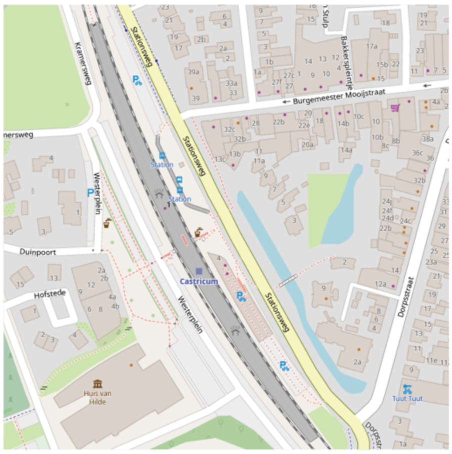


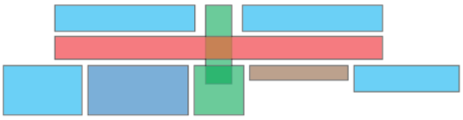
037

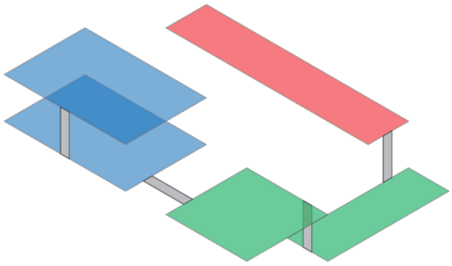


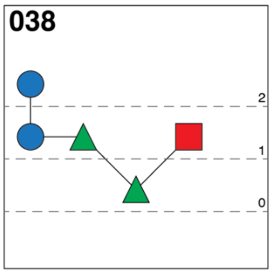
B **B**

s27 Castricum



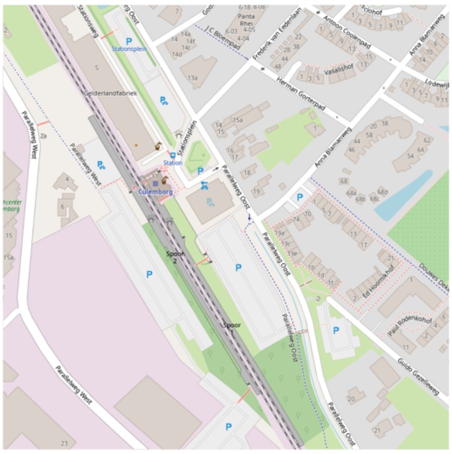


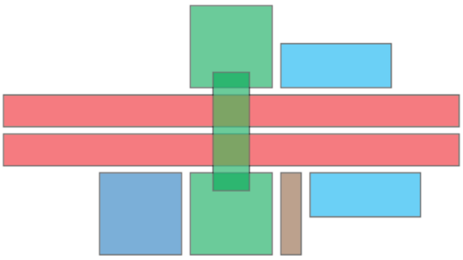


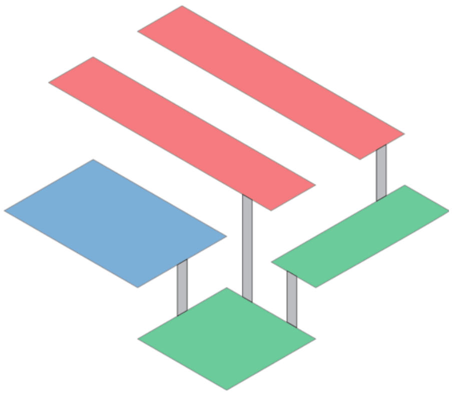


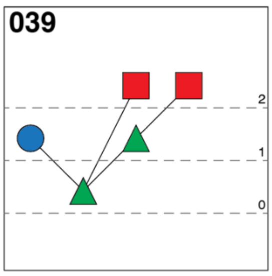
C

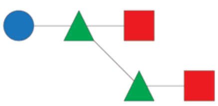
s28 Culemborg





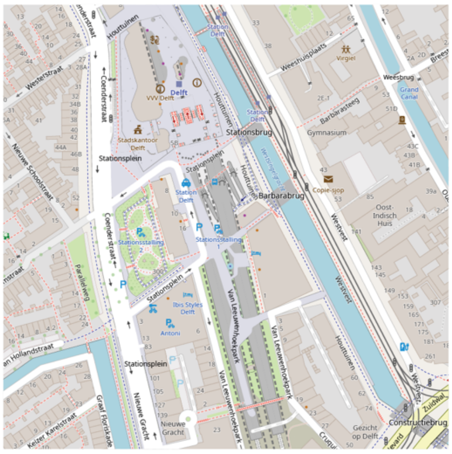


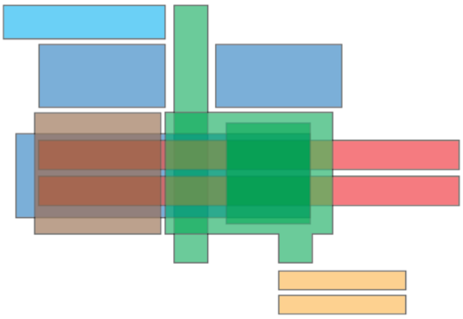


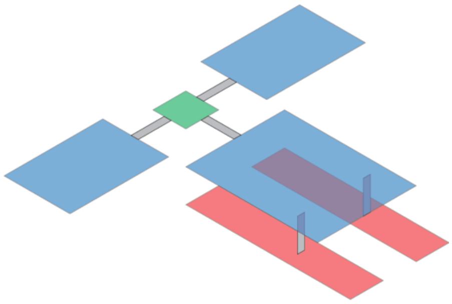


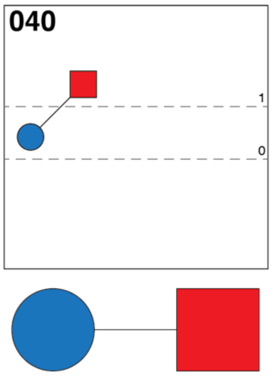
C

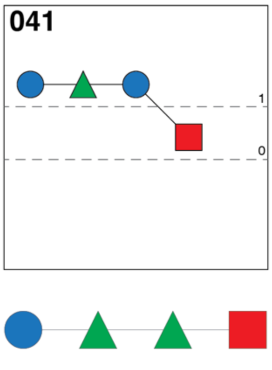
s29 Delft

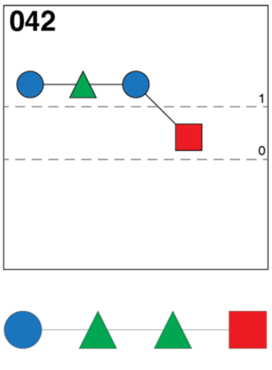






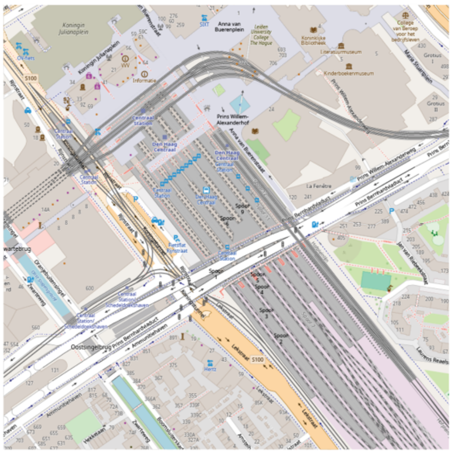


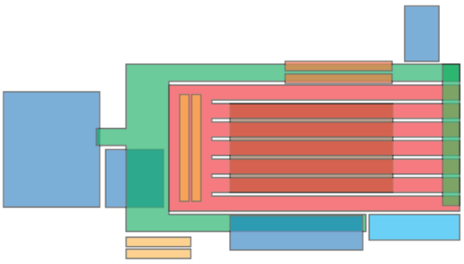


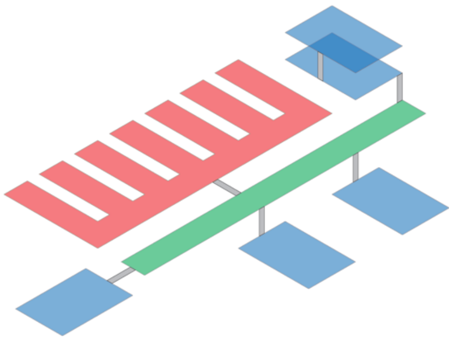


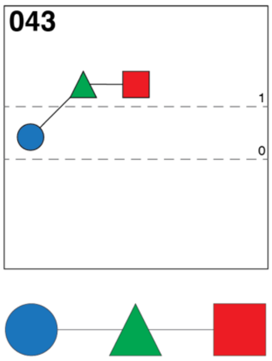
A **C** **C**

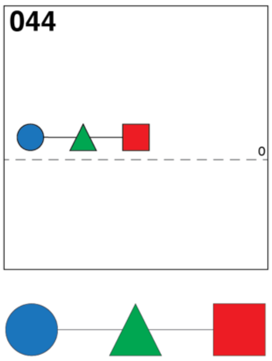
s30 Den Haag Centraal

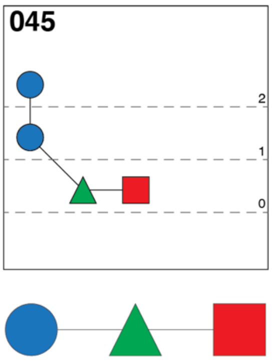


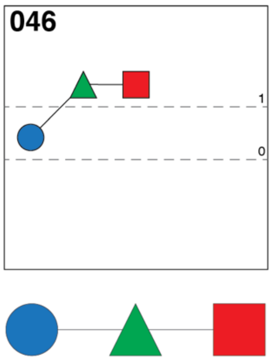






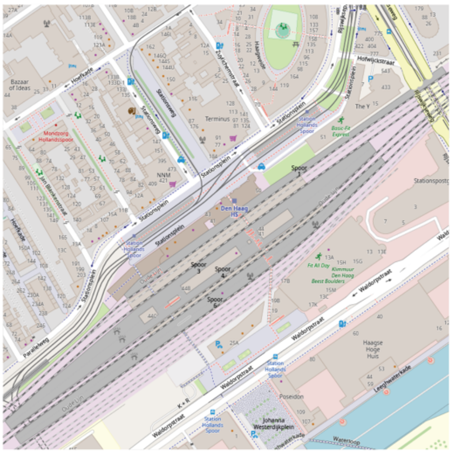


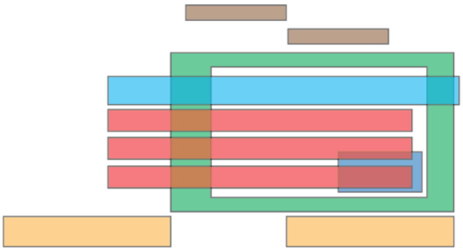


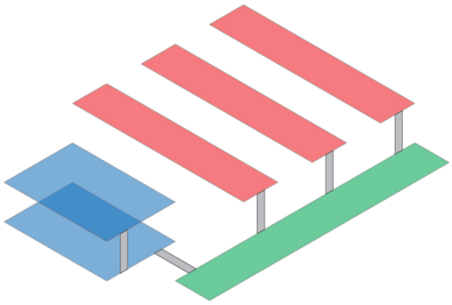


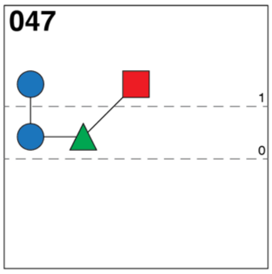
B **B** **B** **B**

s31 Den Haag HS



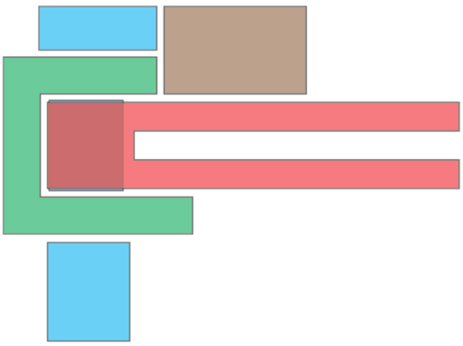


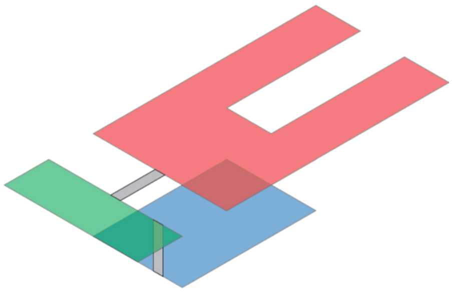


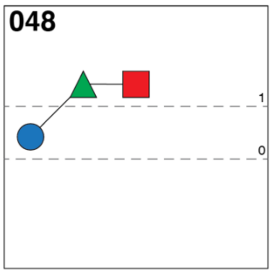


B

s32 Den Helder







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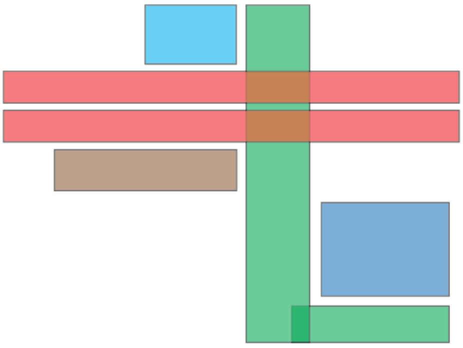
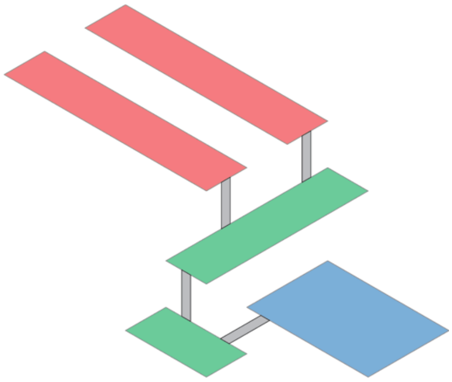
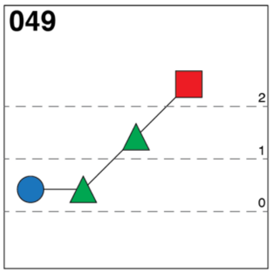
s33 Deventer







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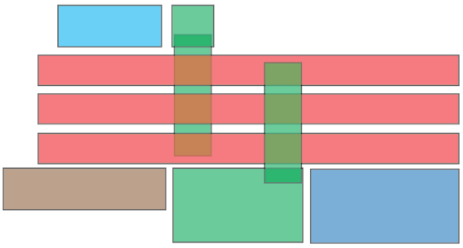
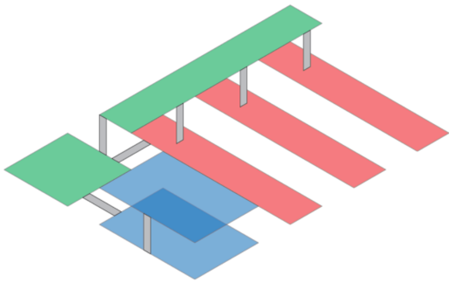
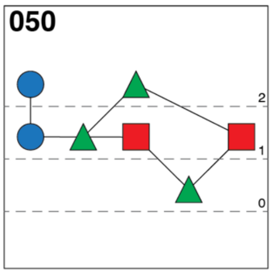
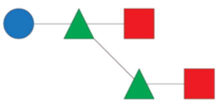
s34 Dordrecht



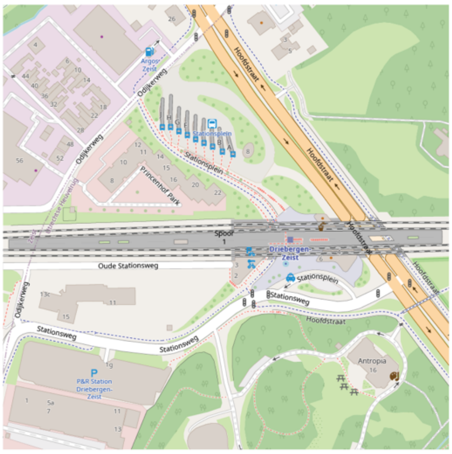


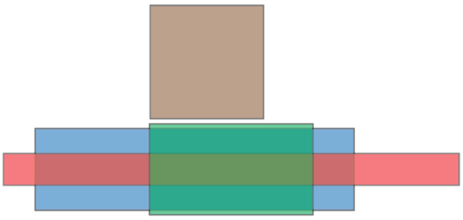


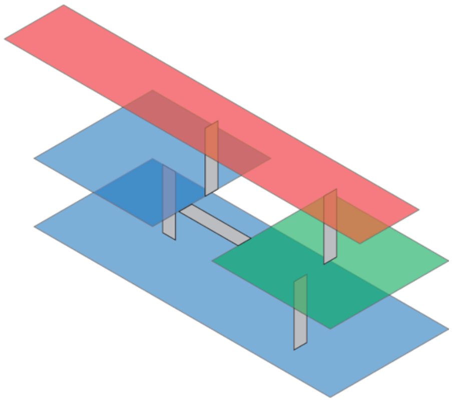


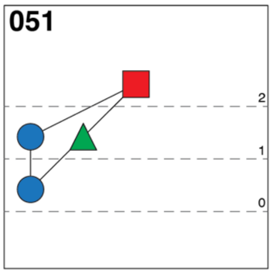
C

s35 Driebergen-Zeist









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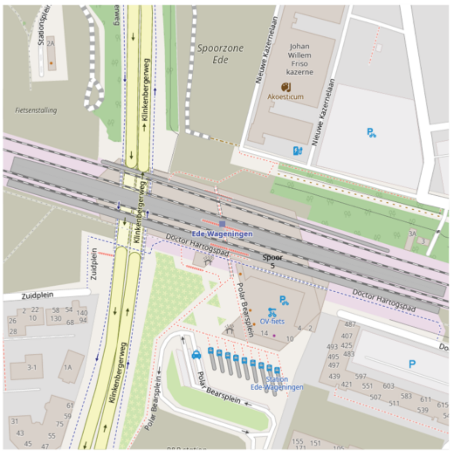
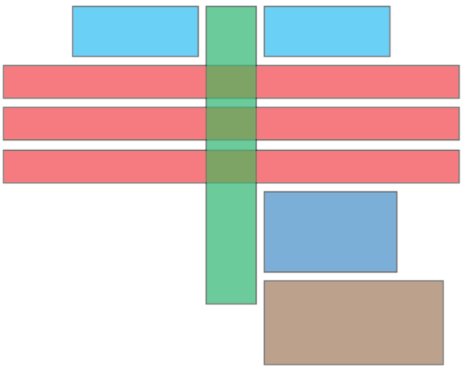
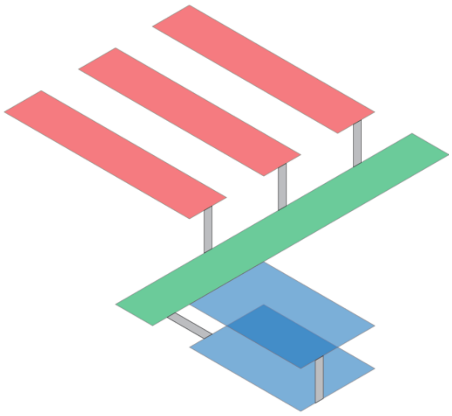
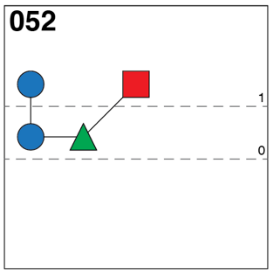
s36 Ede-Wageningen



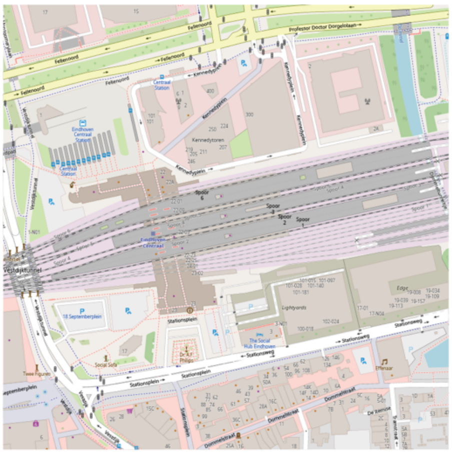


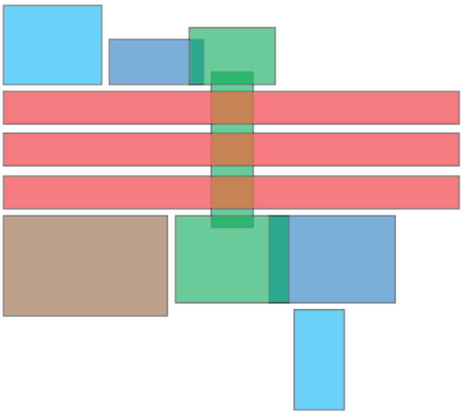


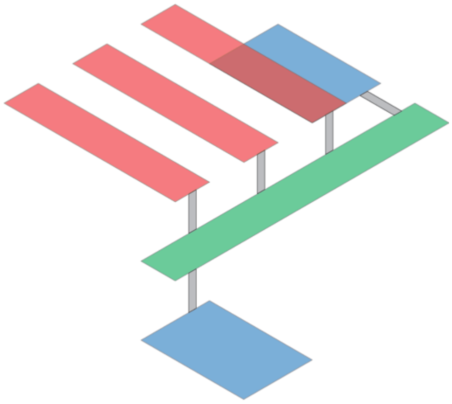


B

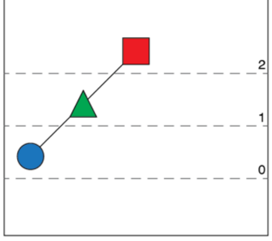
s37 Eindhoven Centraal







053



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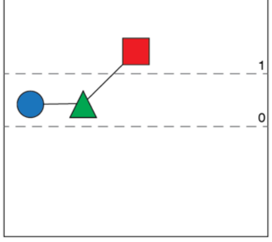
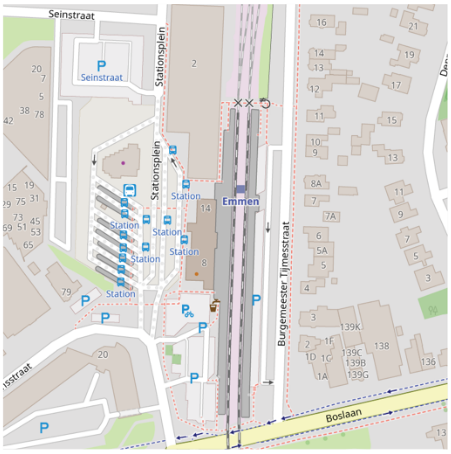
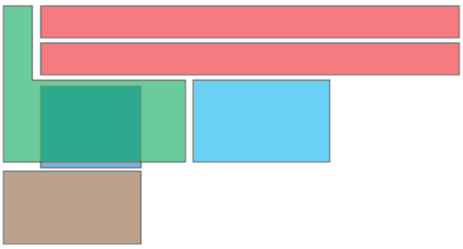
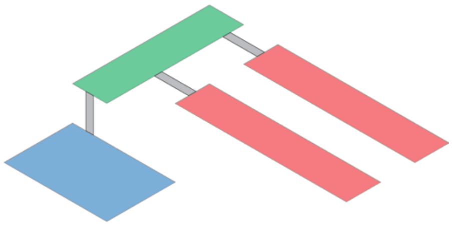


B **B**

s38 Emmen







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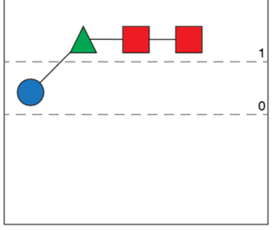
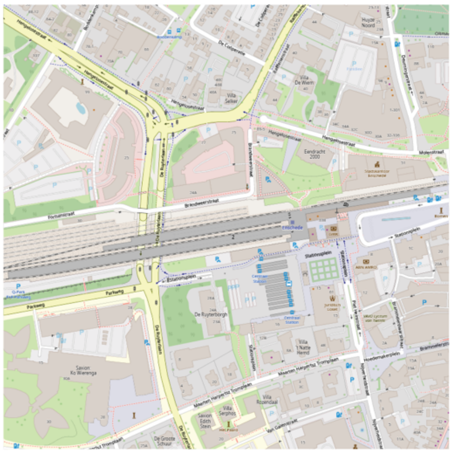
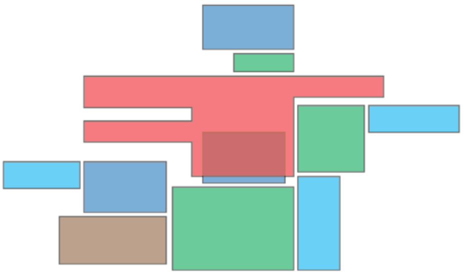
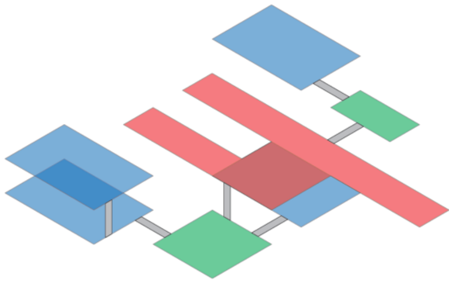


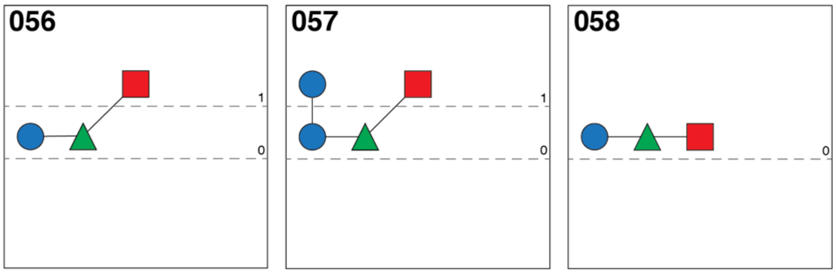
C

s39 Enschede



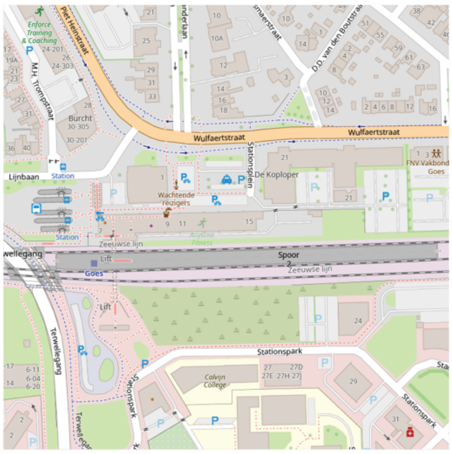


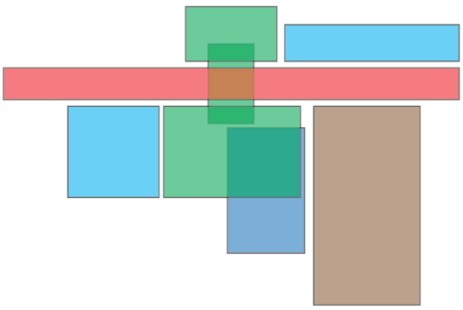


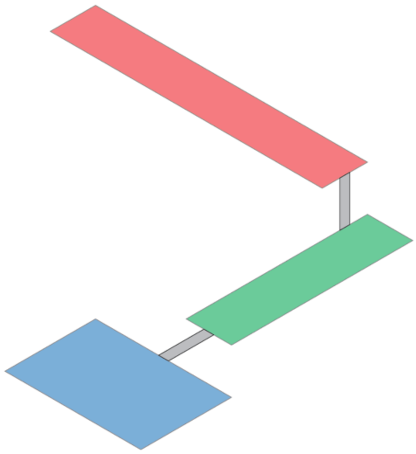


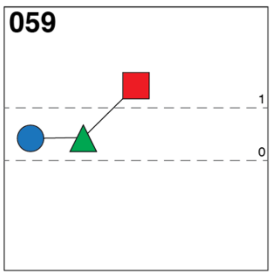
B **B** **B**

s40 Goes



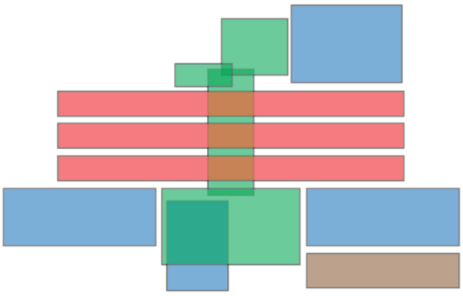


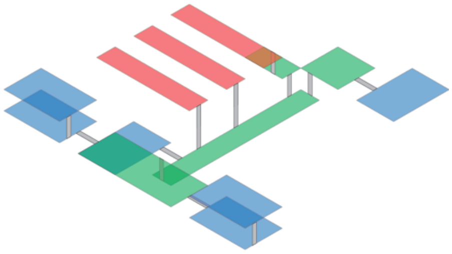


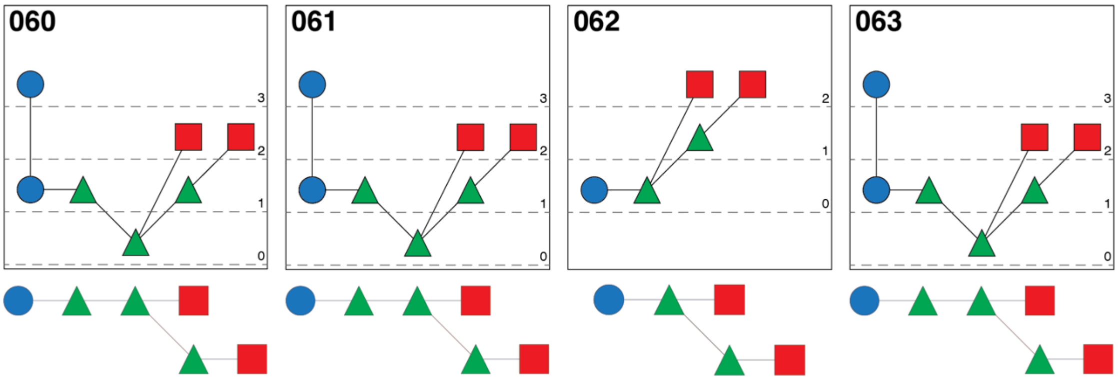


B

s41 Gouda

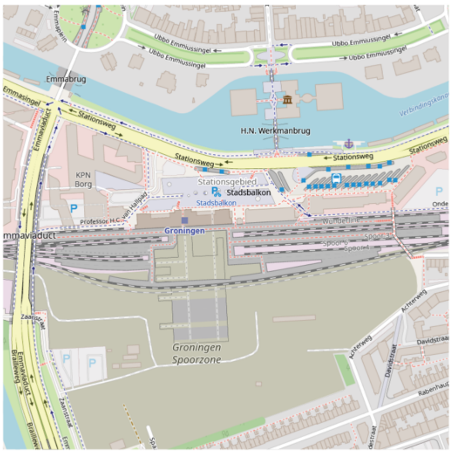


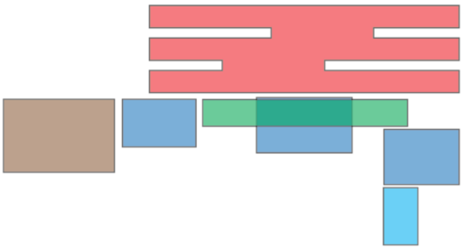


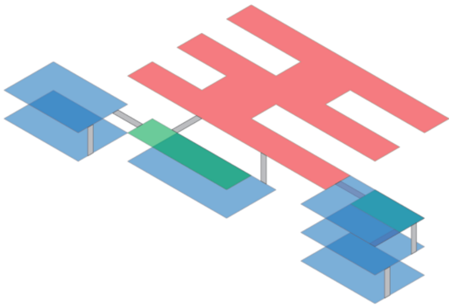


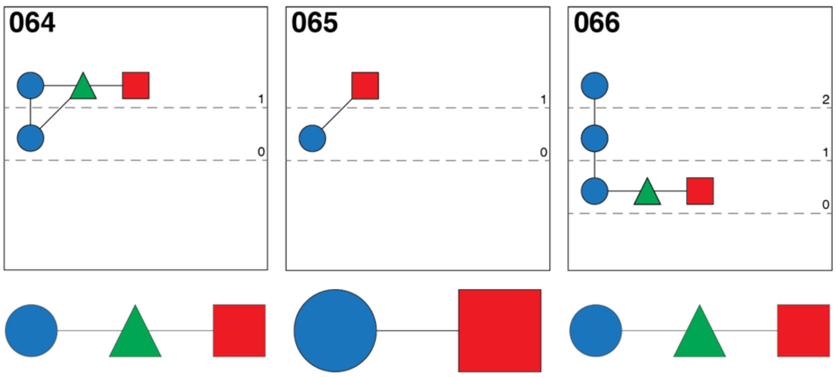
D **D** **C** **D**

s42 Groningen



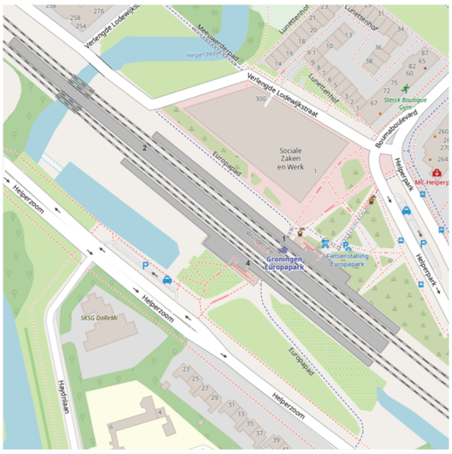


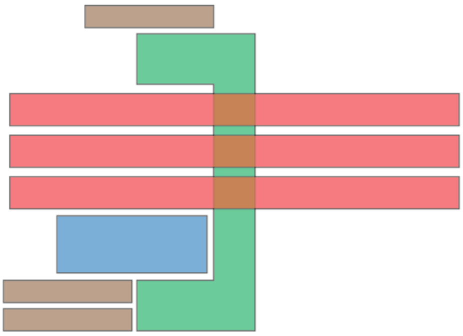


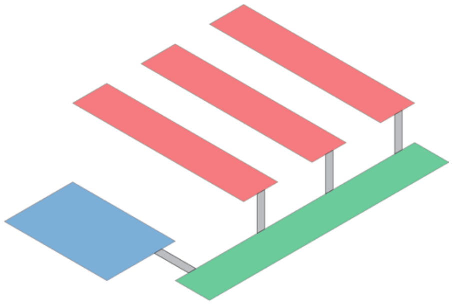


B **A** **B**

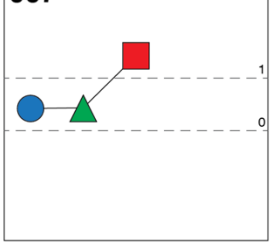
s43 Groningen Europapark





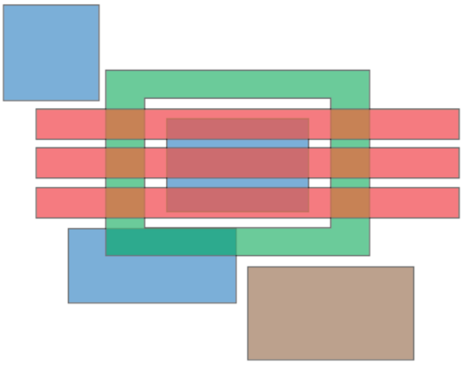


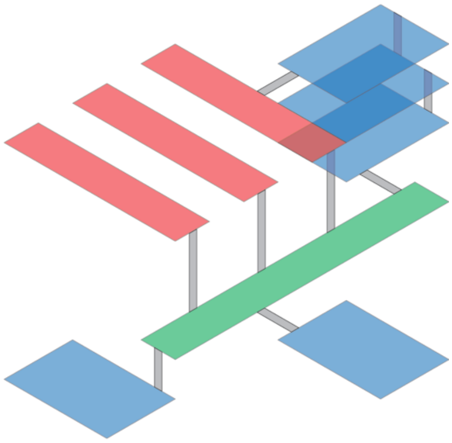
067



B

s44 Haarlem





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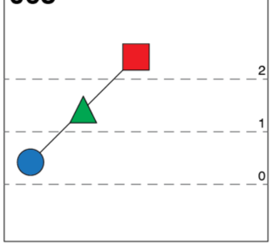

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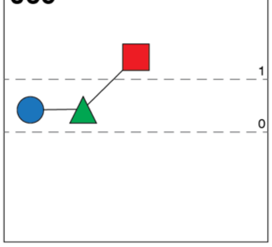

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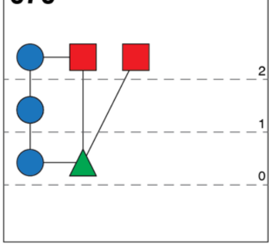
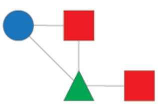
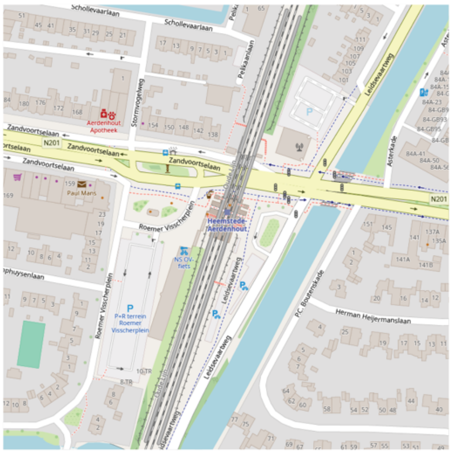
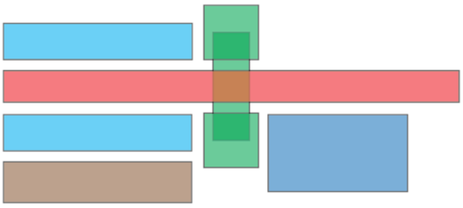


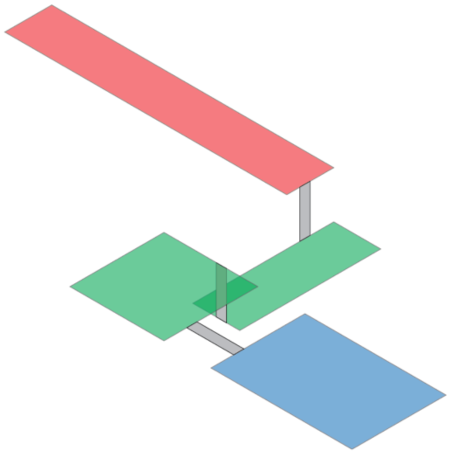


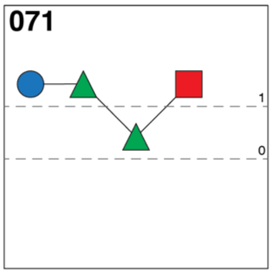
B **B** **B**

s45 Harderwijk



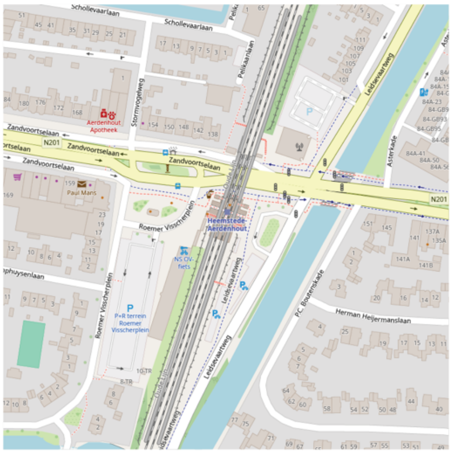


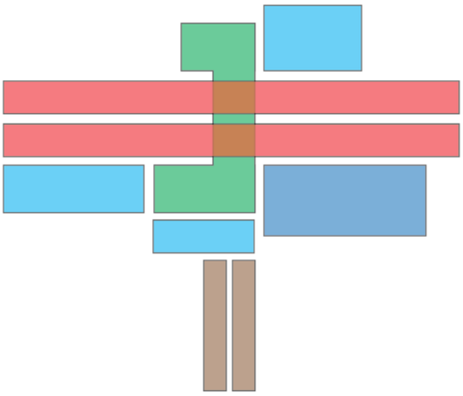


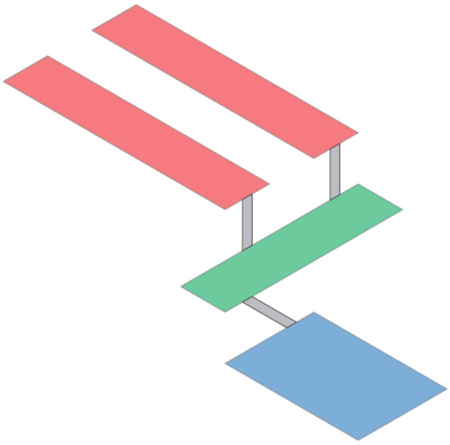


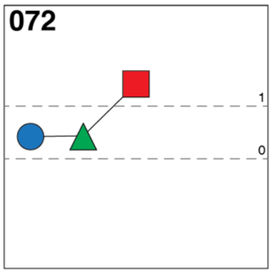
C

s46 Heemstede-Aerdenhout



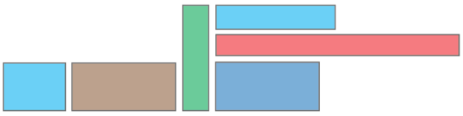


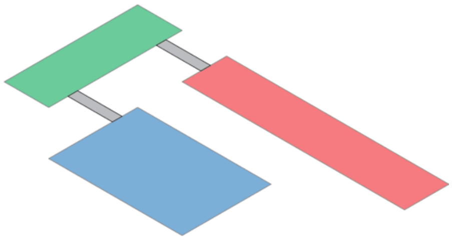


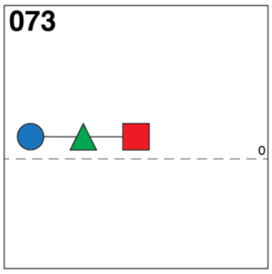


B

s47 Heerenveen

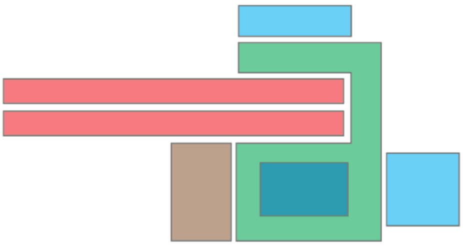


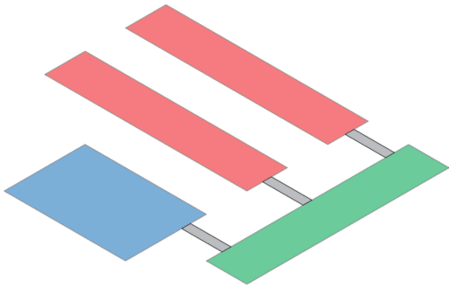


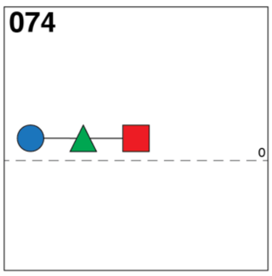


B

s48 Heerhugowaard

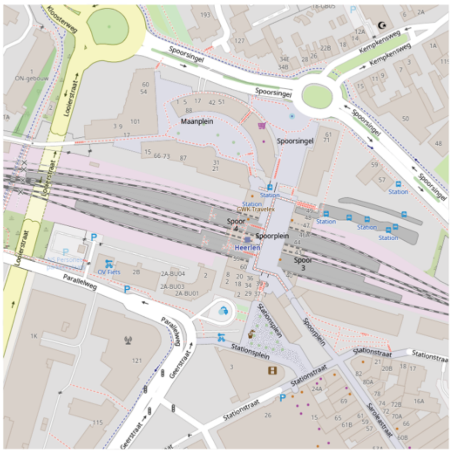


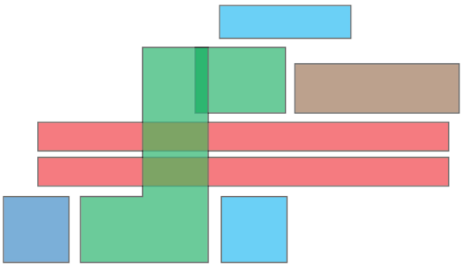


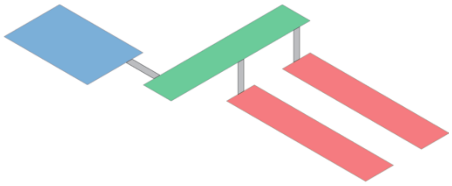


B

s49 Heerlen







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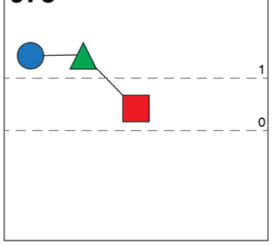
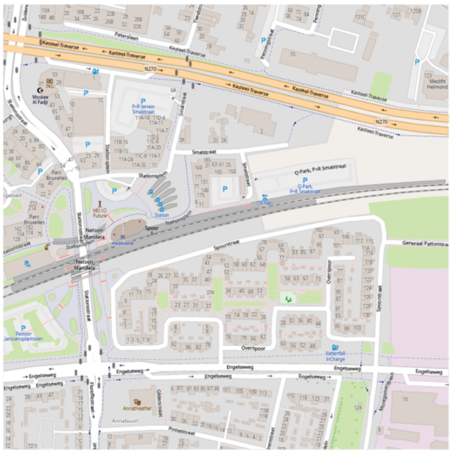
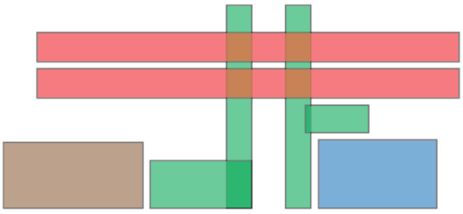
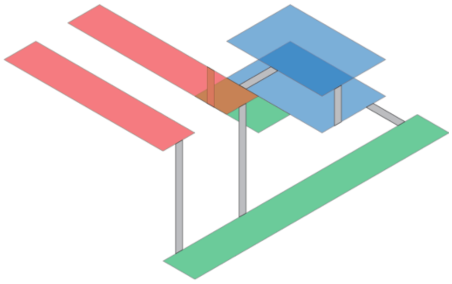


B

s50 Helmond







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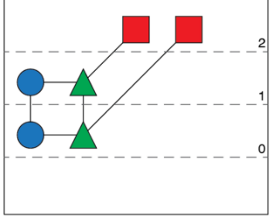
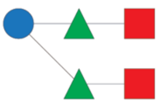
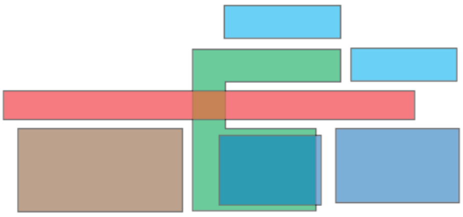
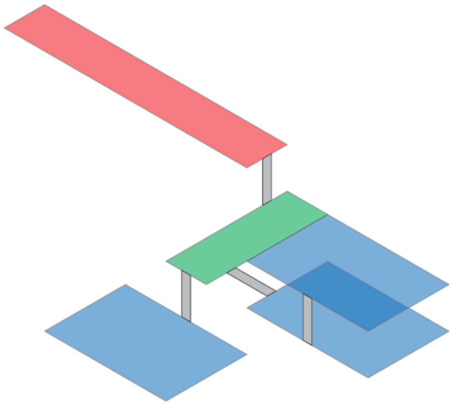


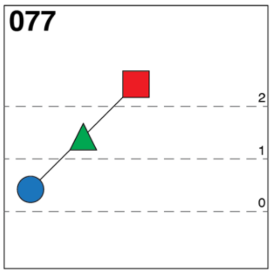


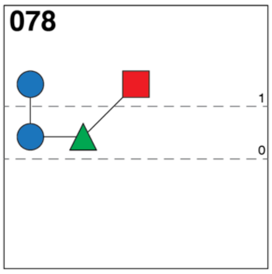
B

s51 Hengelo



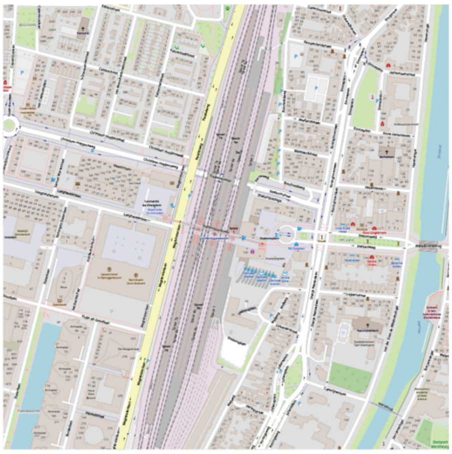


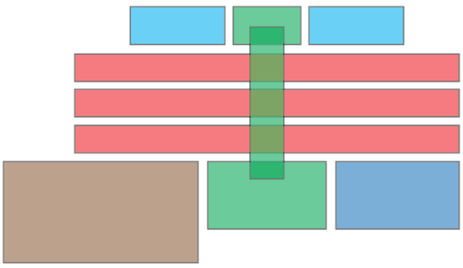


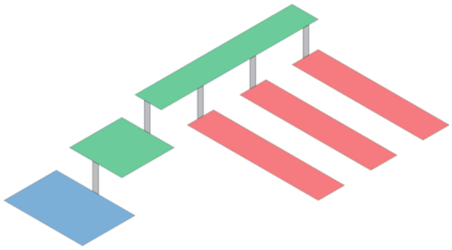


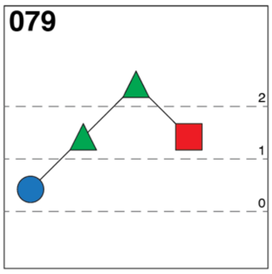
B **B**

s52 s-Hertogenbosch



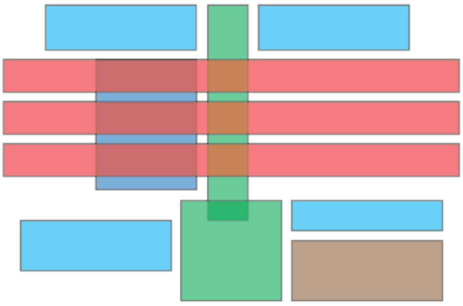


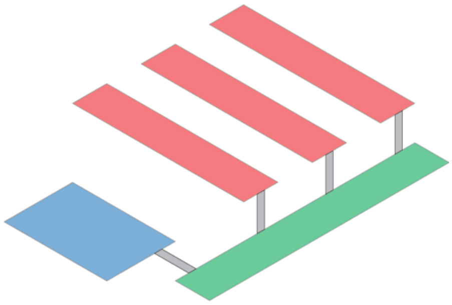


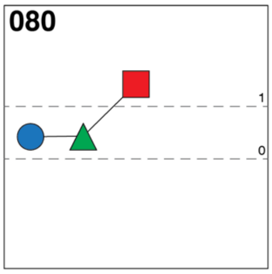


C

s53 Hilversum

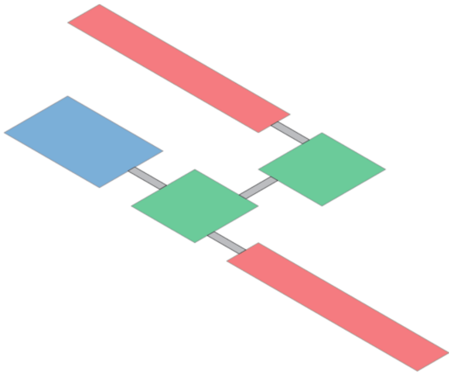


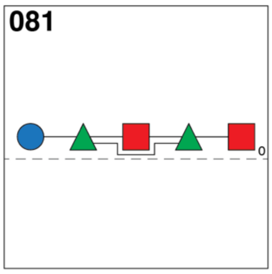


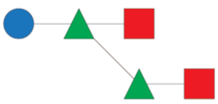


B

s54 Hilversum Sportpark

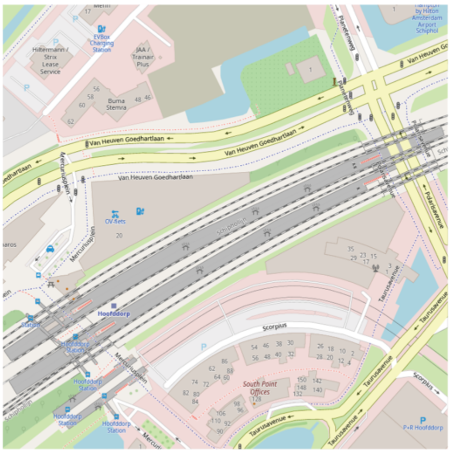


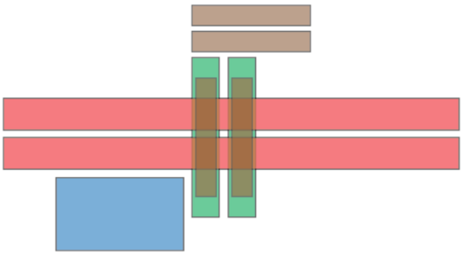


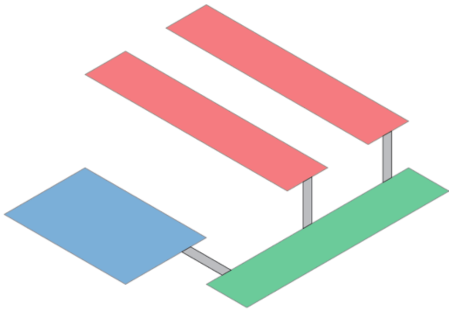


C

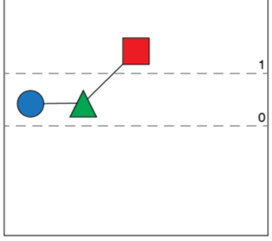
s55 Hoofddorp





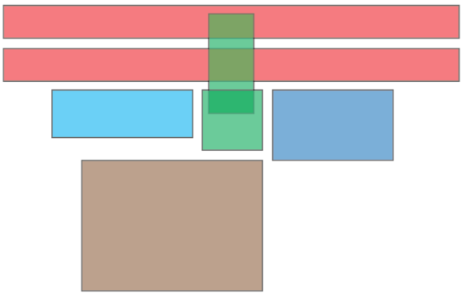


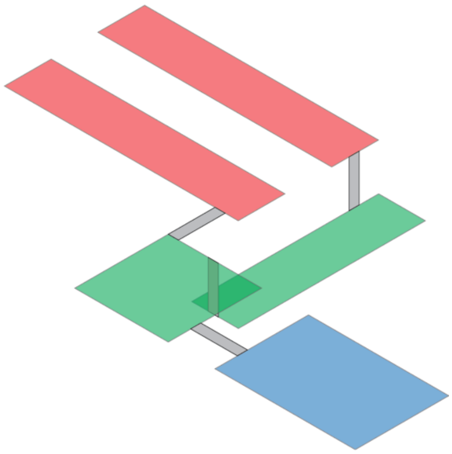
082



B

s56 Hoogeveen





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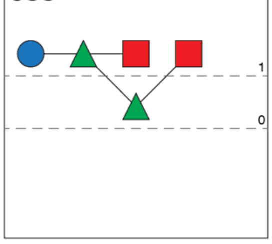

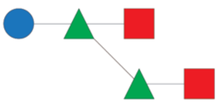

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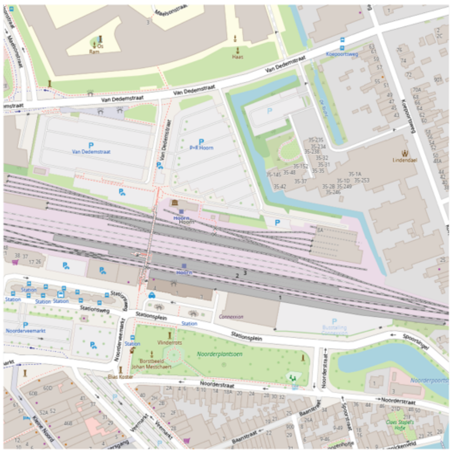
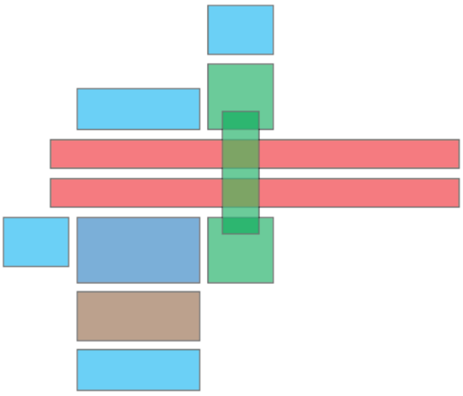
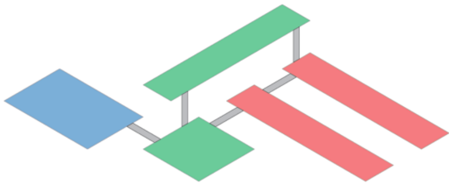
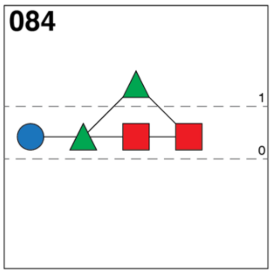
s57 Hoorn









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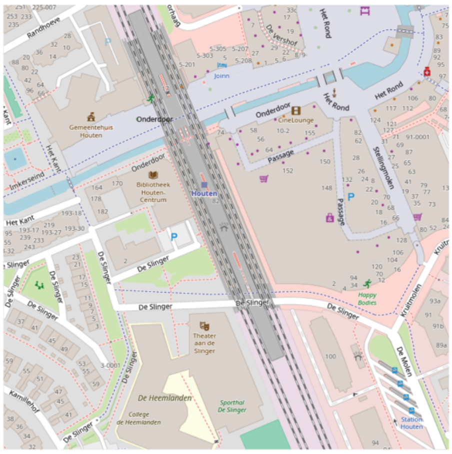
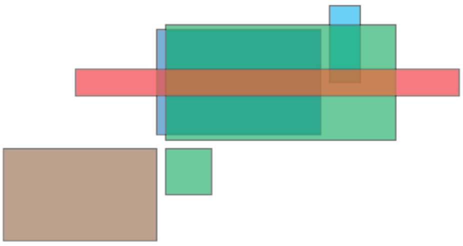
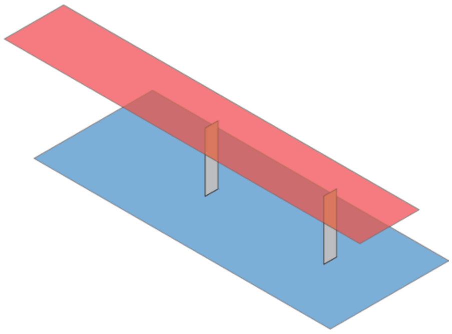
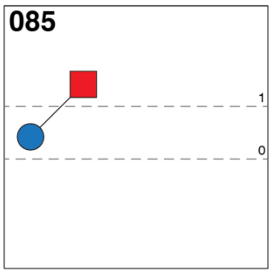
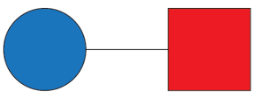
s58 Houten





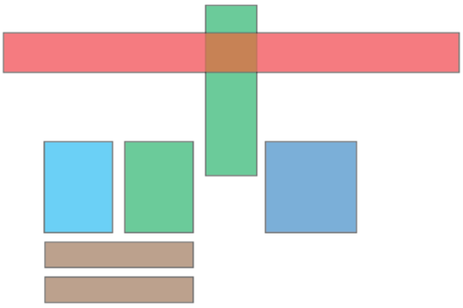


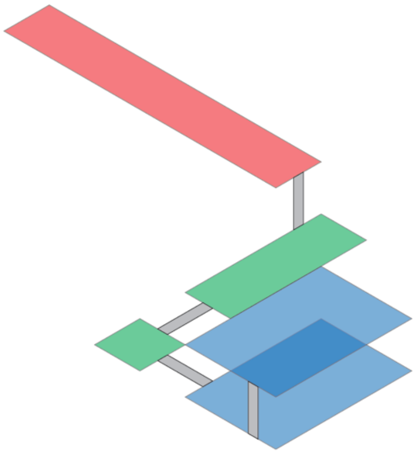


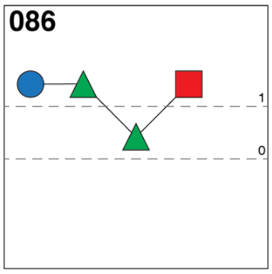


A

s59 Houten Castellum

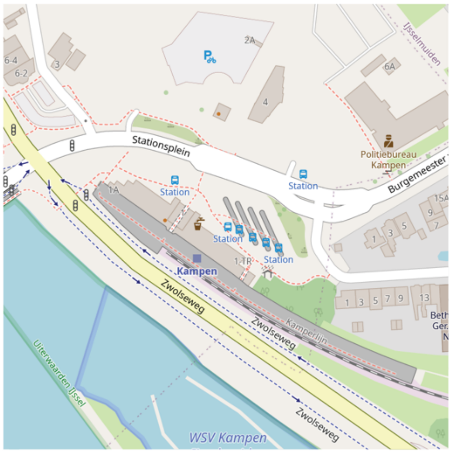


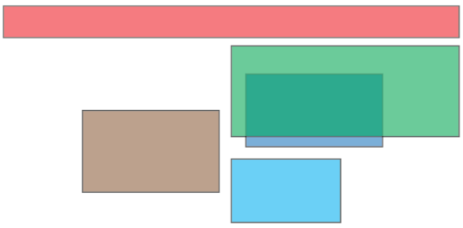


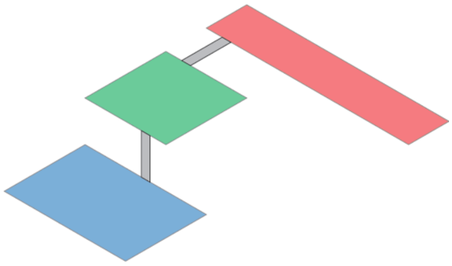


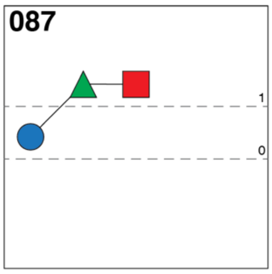
C

s60 Kampen



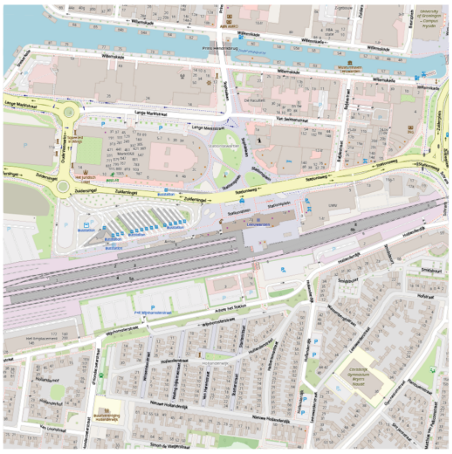


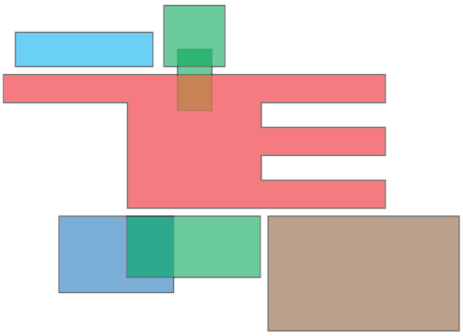




B

s61 Leeuwarden





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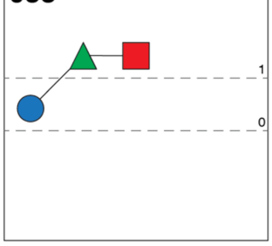
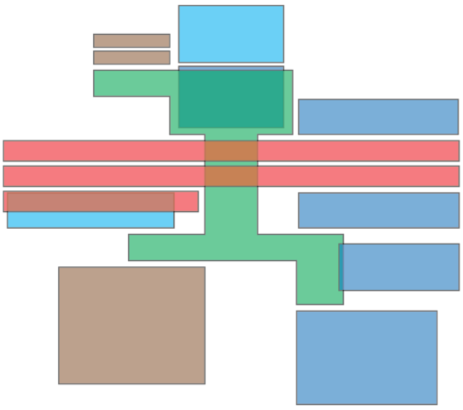
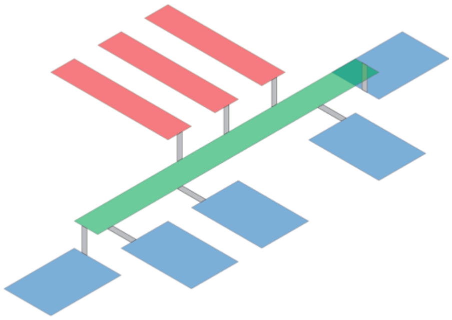


B

s62 Leiden Centraal





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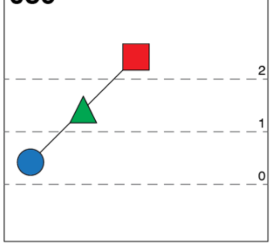

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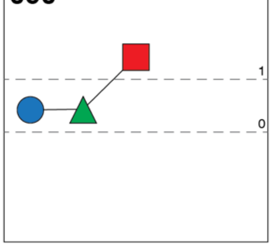

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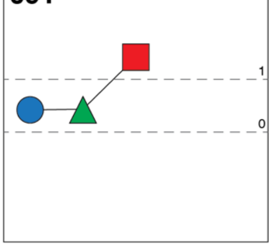

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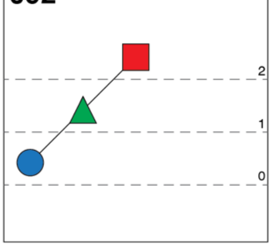

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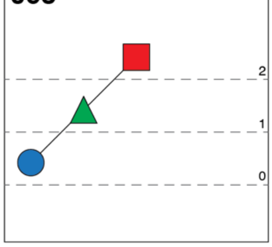
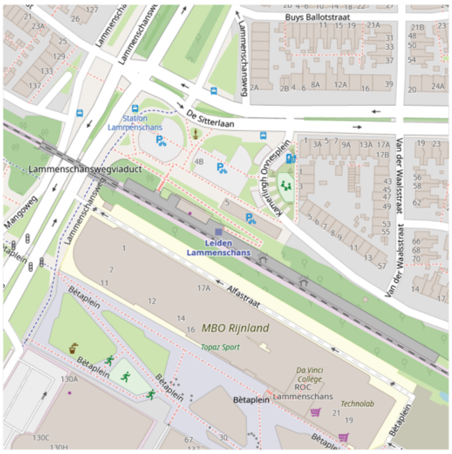
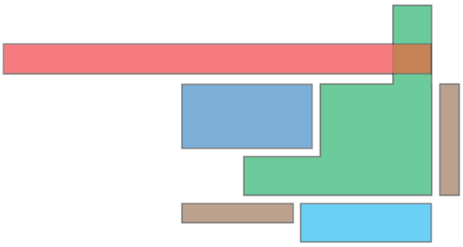
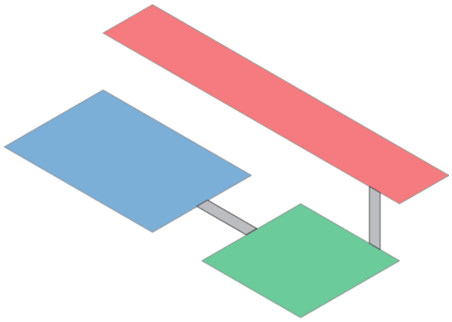


B **B** **B** **B** **B**

s63 Leiden Lammenschans







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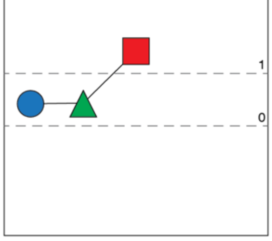

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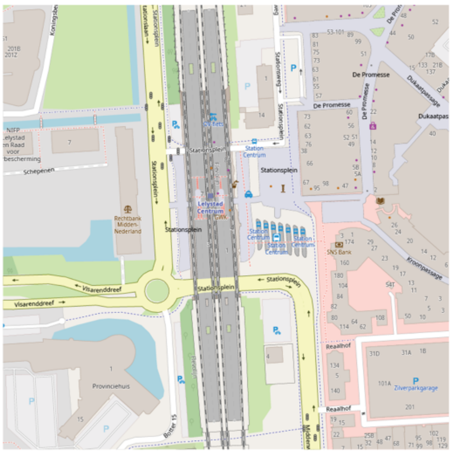
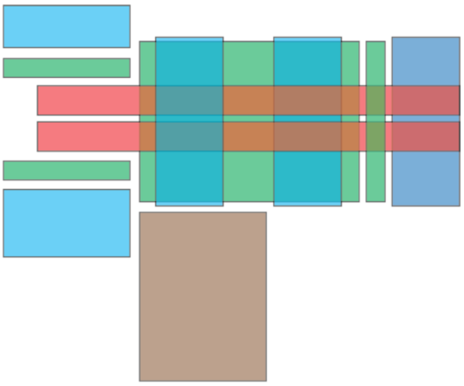
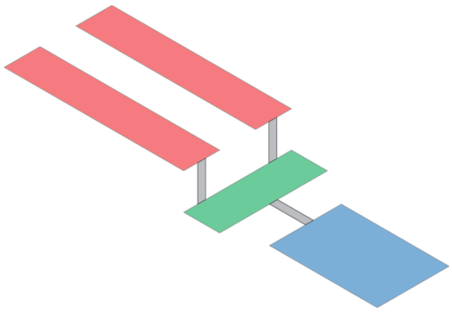
s64 Lelystad Centrum







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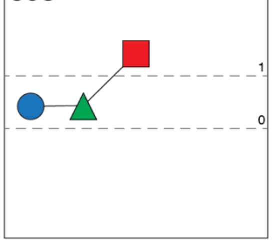

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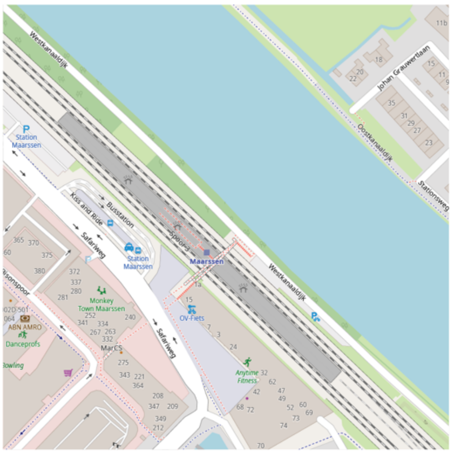
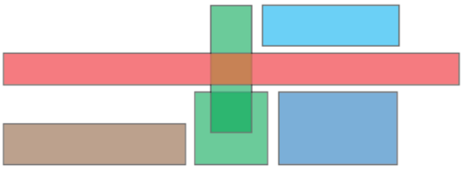
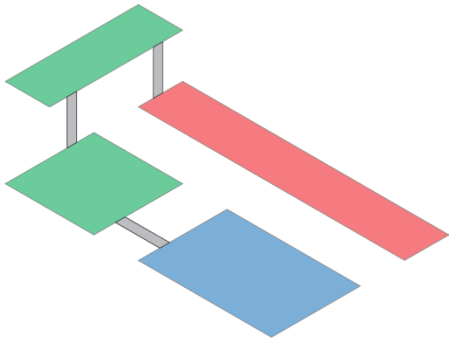
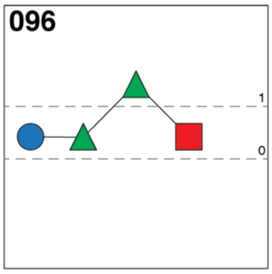
s65 Maarssen



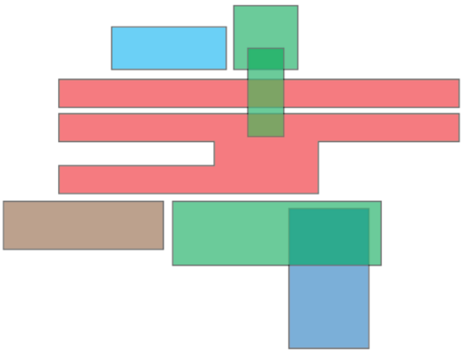


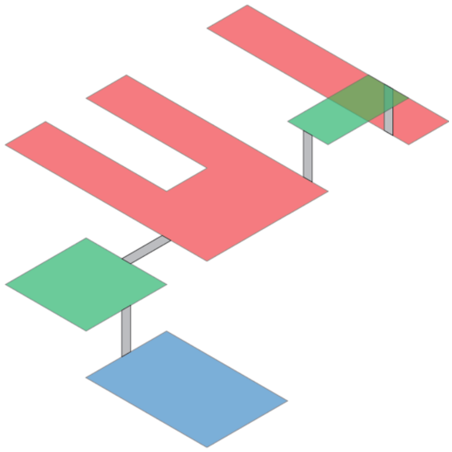


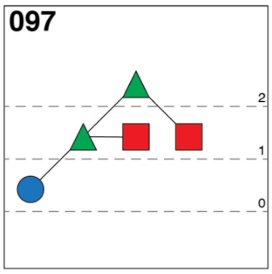


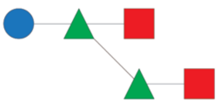
C

s66 Maastricht









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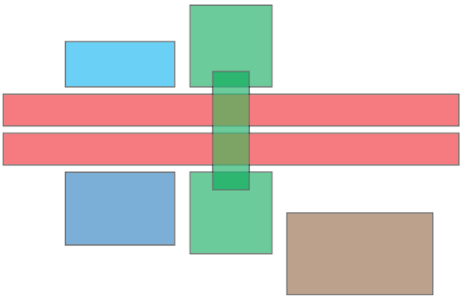
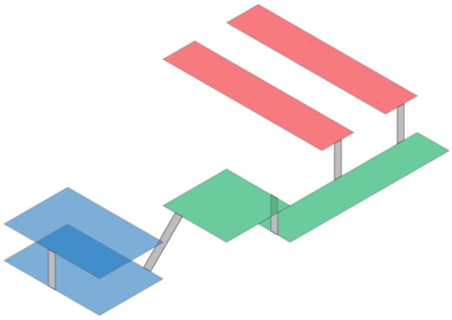
s67 Meppel





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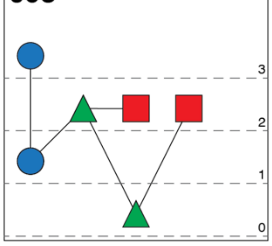

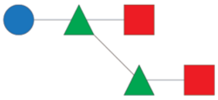

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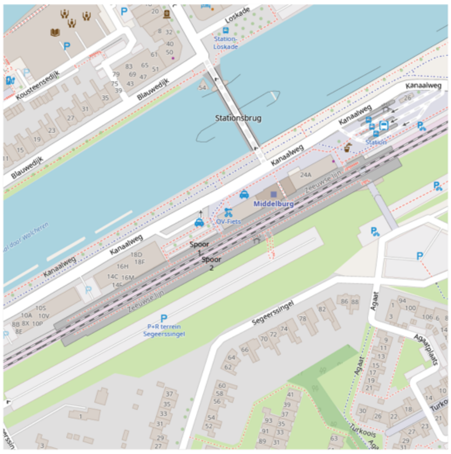
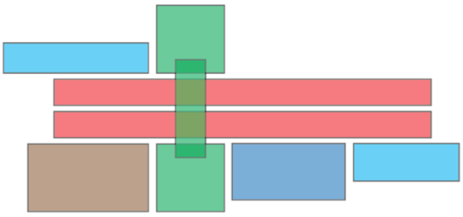
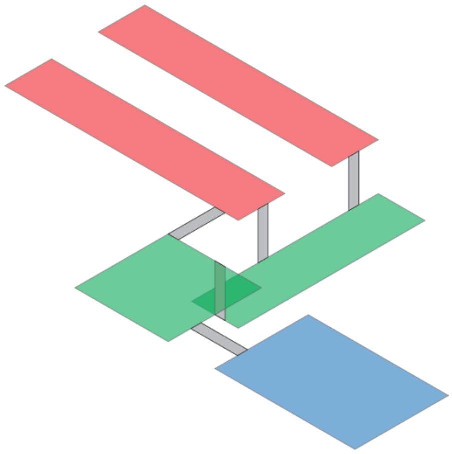
s68 Middelburg







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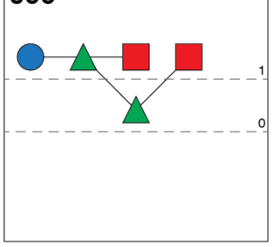

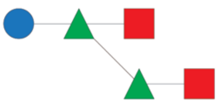

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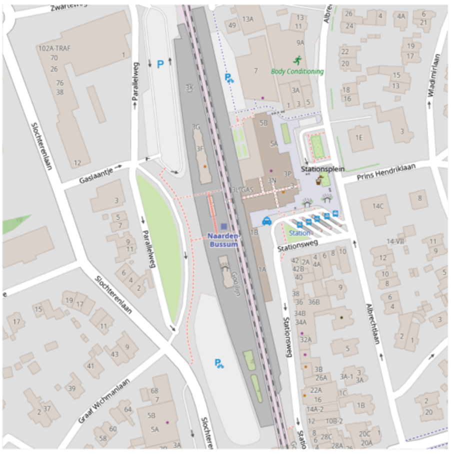
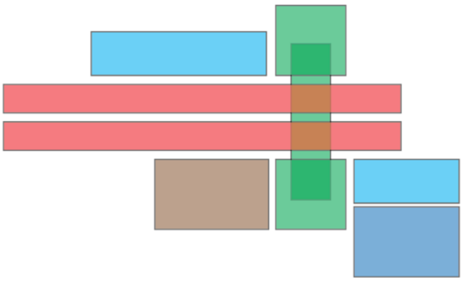
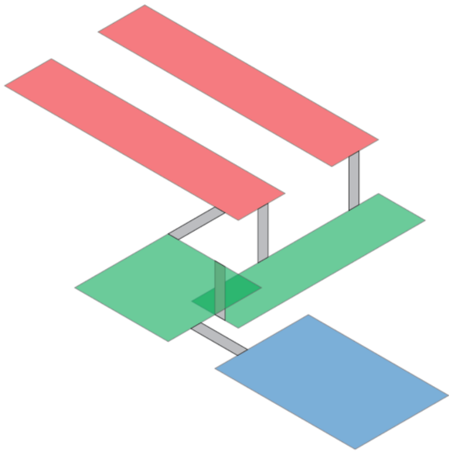
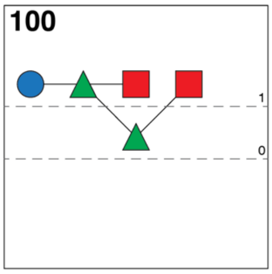
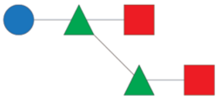
s69 Naarden-Bussum





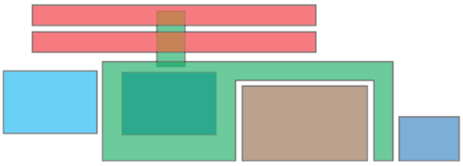


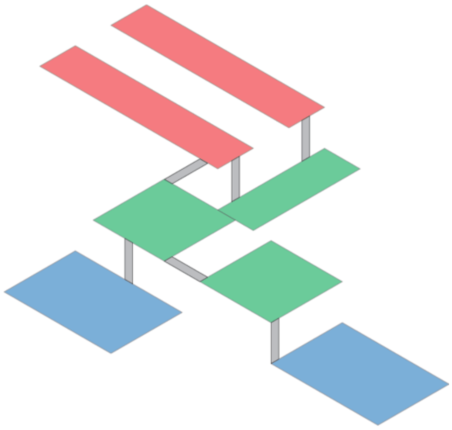


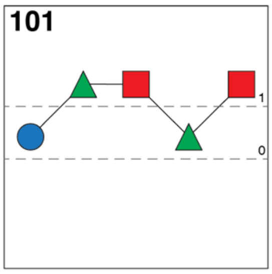


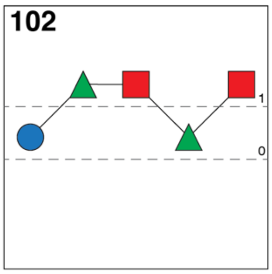
C

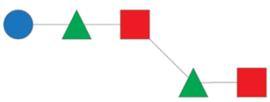
s70 Nijmegen

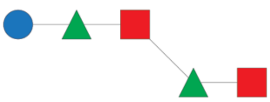






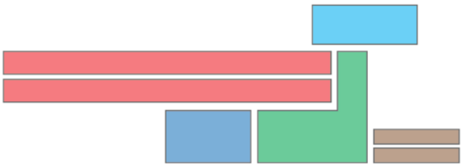


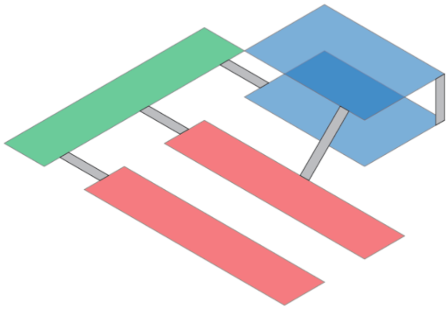


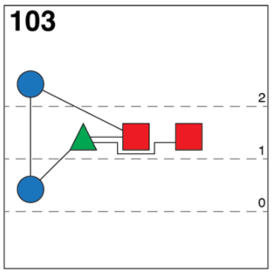


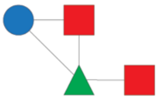
D **D**

s71 Oss



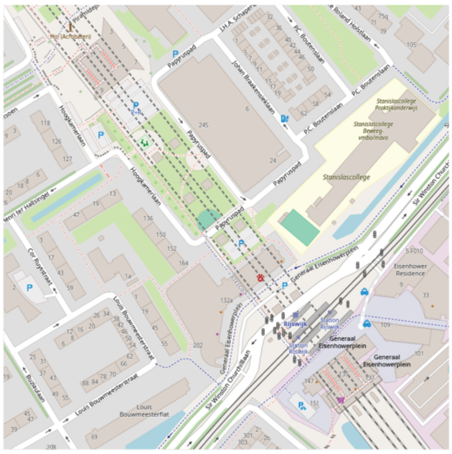


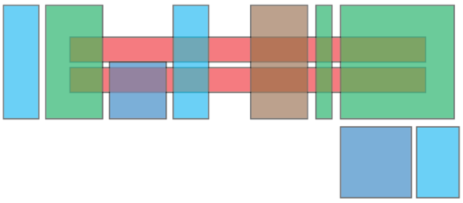


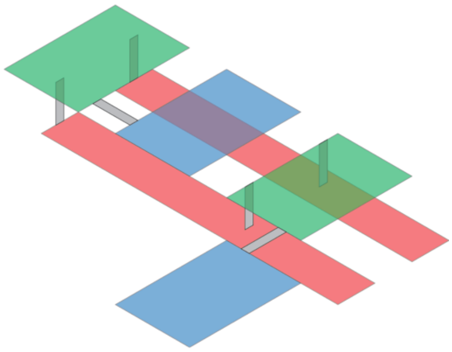


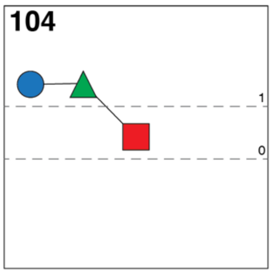
B

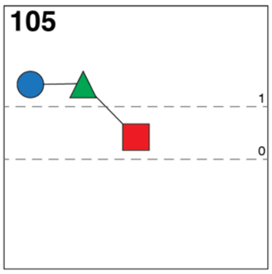
s72 Rijswijk





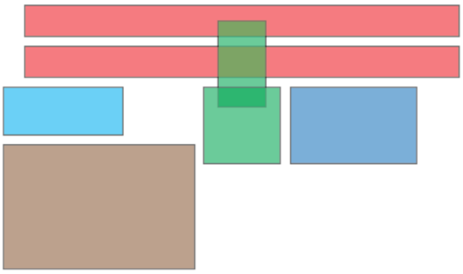


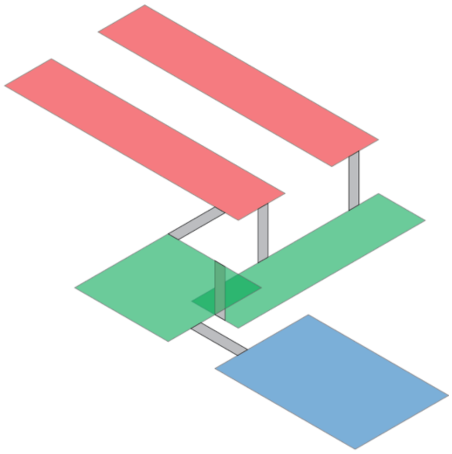


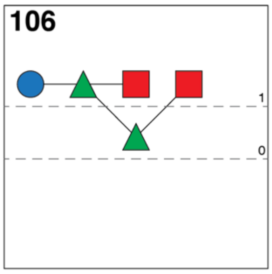


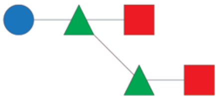
B **B**

s73 Roermond









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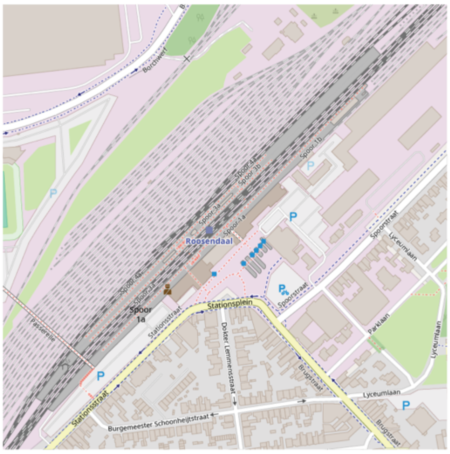
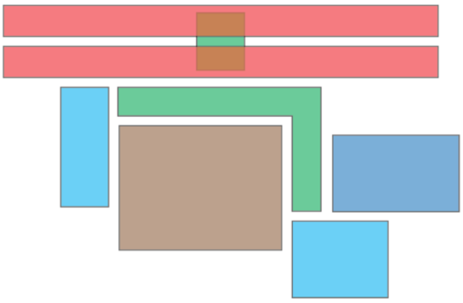
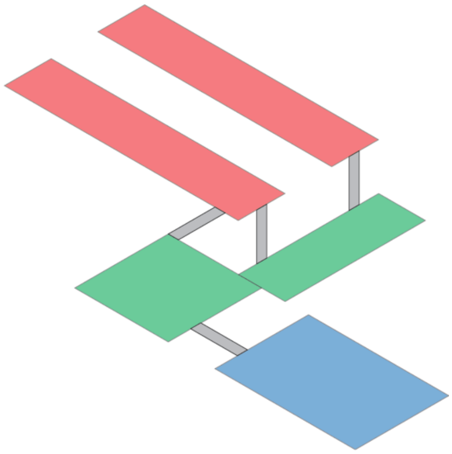
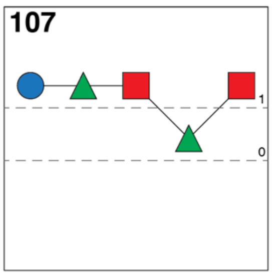
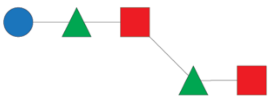
s74 Roosendaal





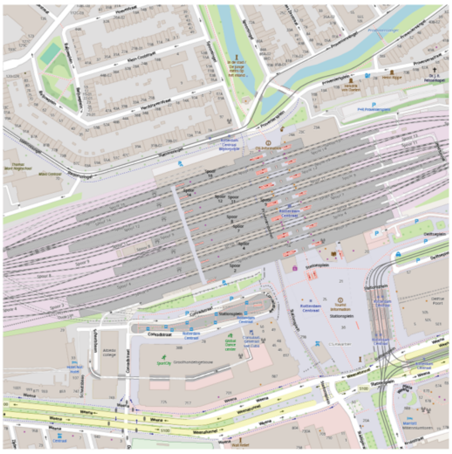


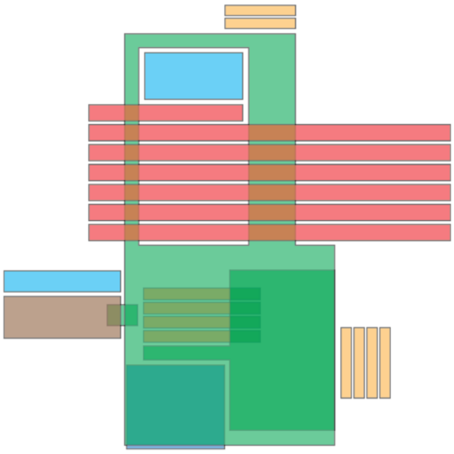


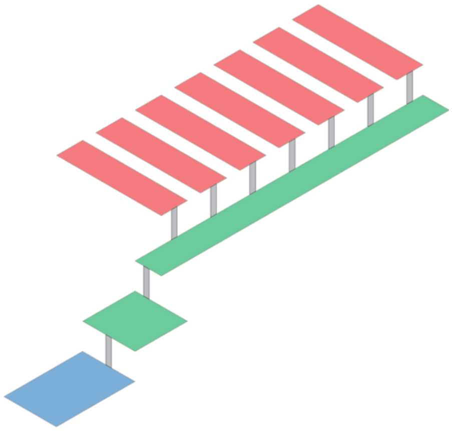


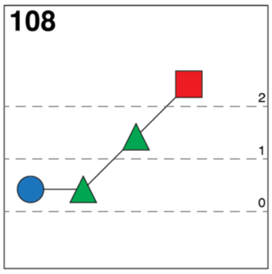
D

s75 Rotterdam Centraal



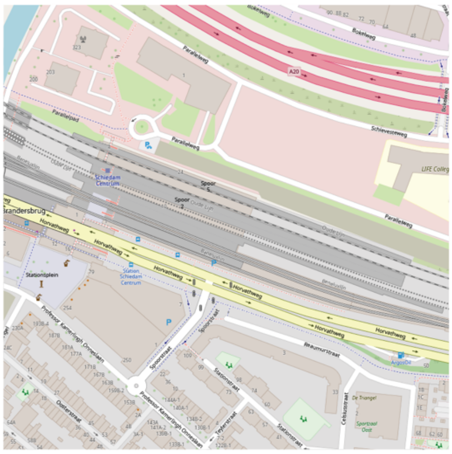


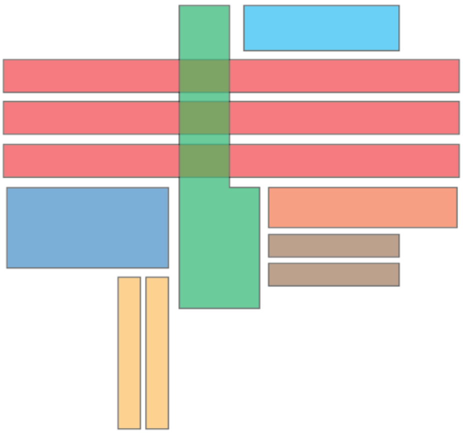


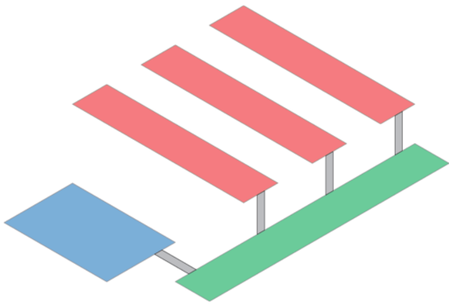


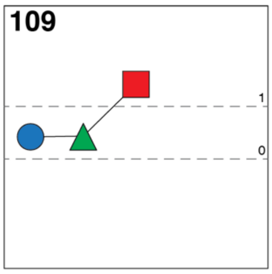
C

s76 Schiedam Centrum



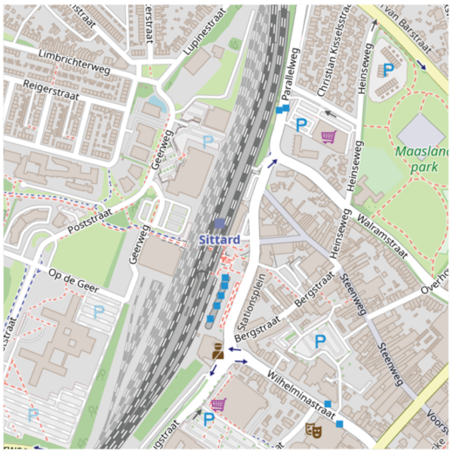


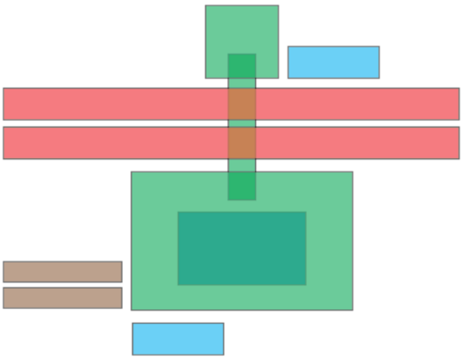


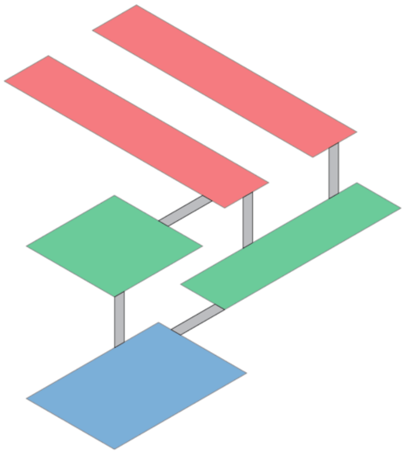


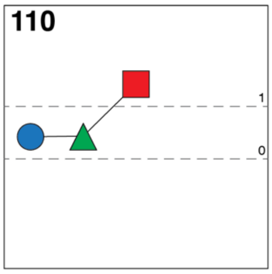
B

s77 Sittard



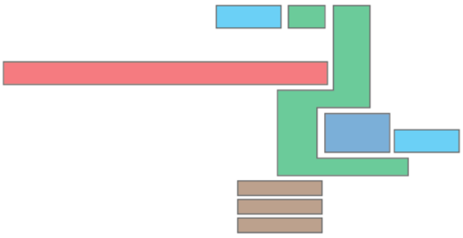


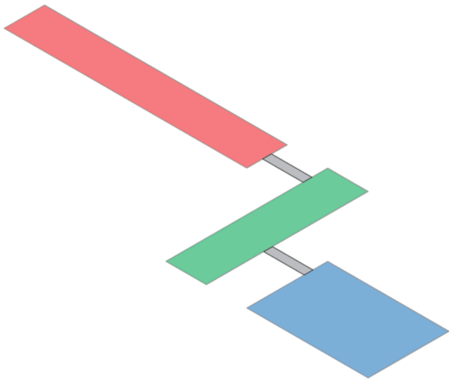


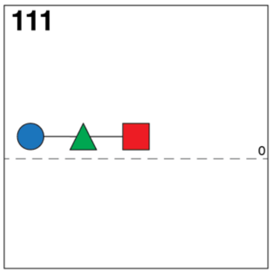


B

s78 Steenwijk







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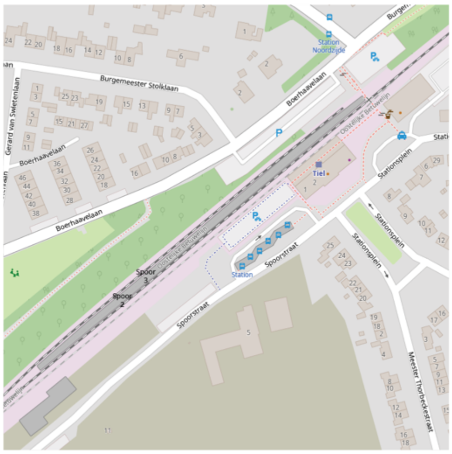
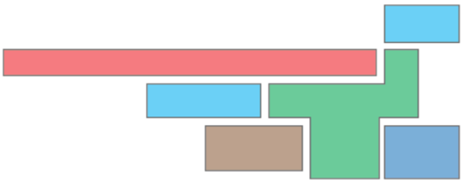
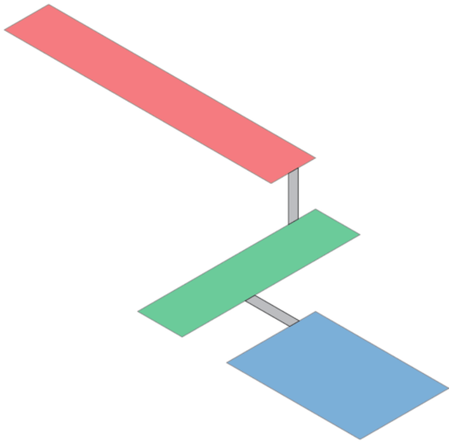
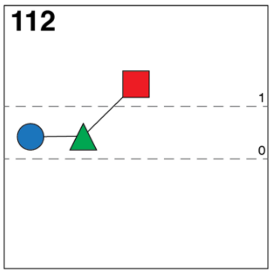
s79 Tiel









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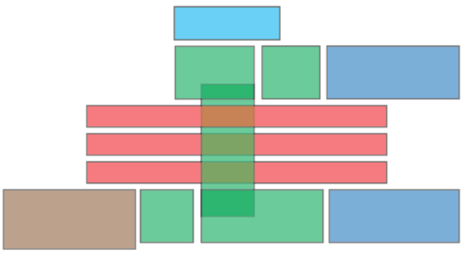
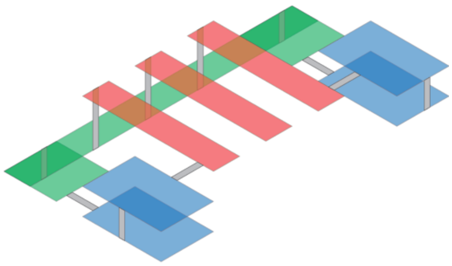
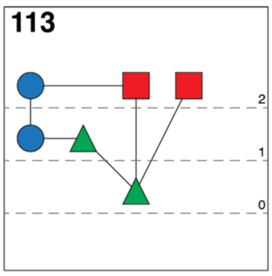
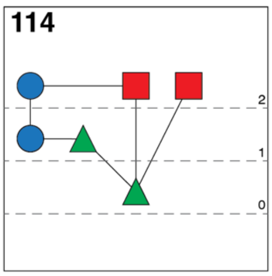
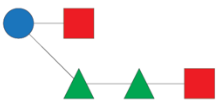
s80 Tilburg

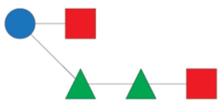






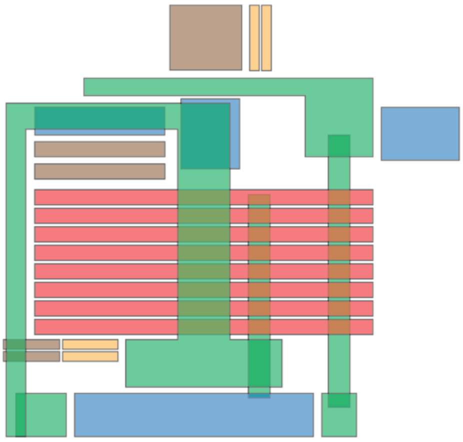


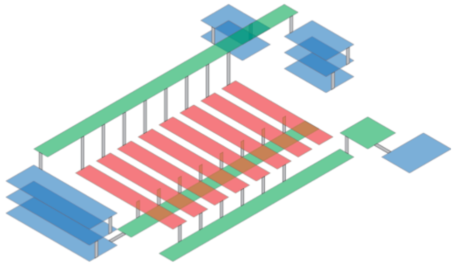


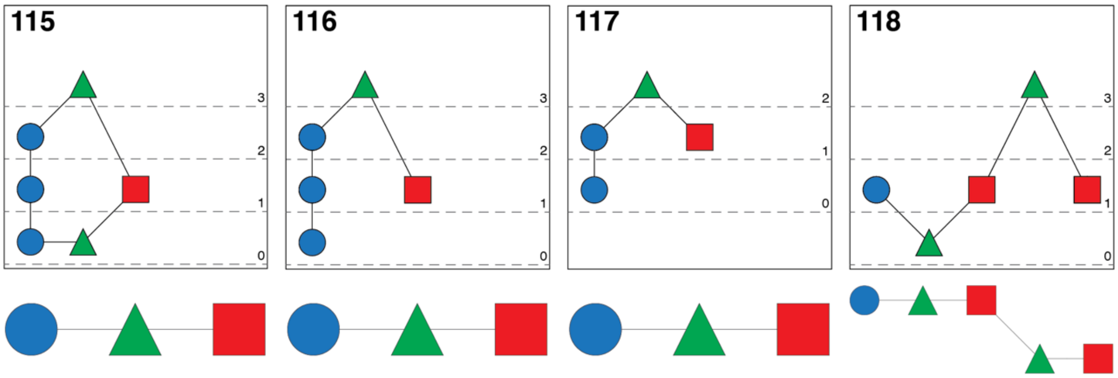


C **C**

s81 Utrecht Centraal

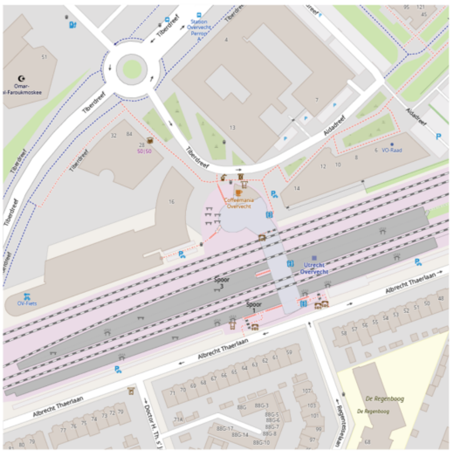


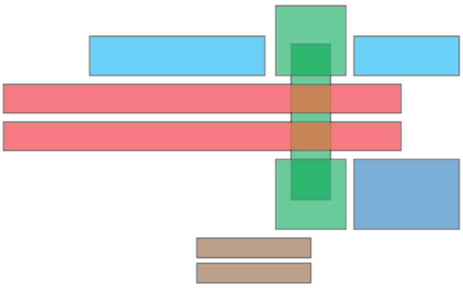


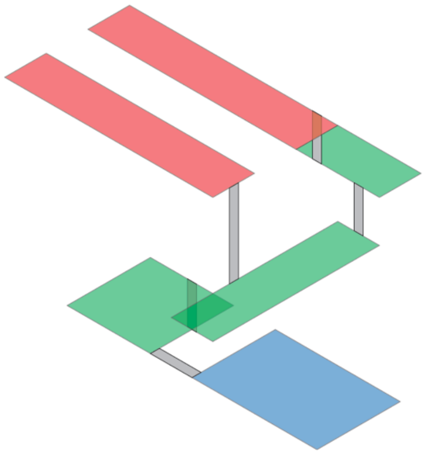


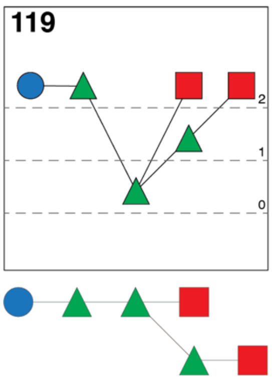
B B B D

s82 Utrecht Overvecht



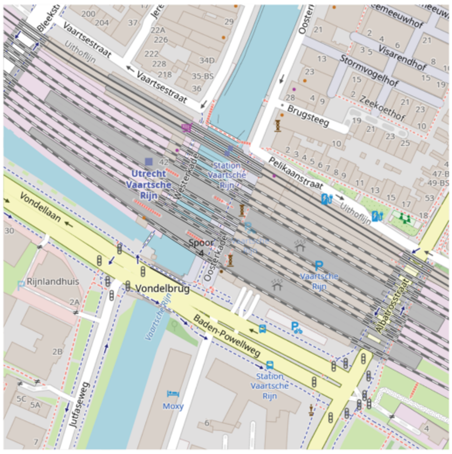


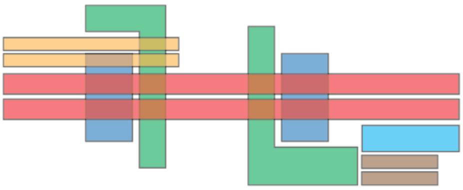


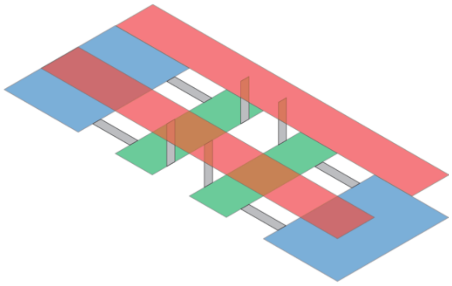


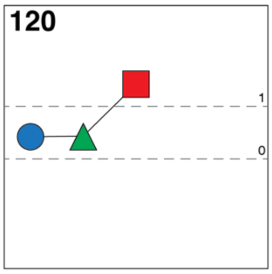
D

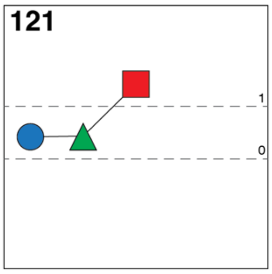
s83 Utrecht Vaartsche Rijn





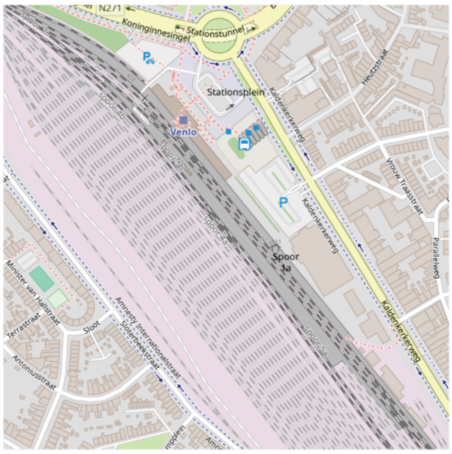


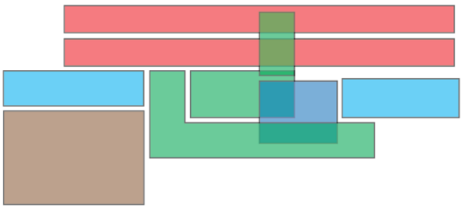


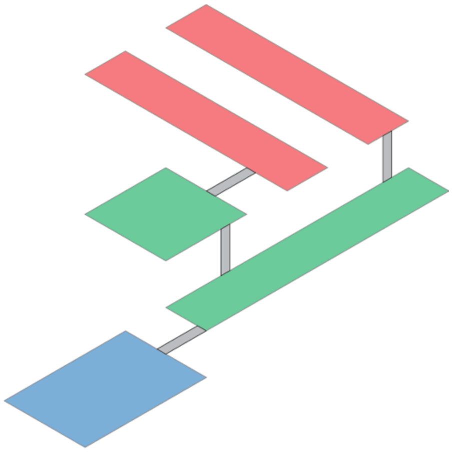


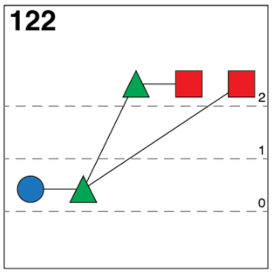
B **B**

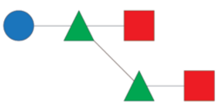
s84 Venlo





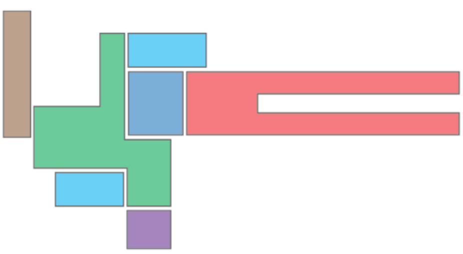


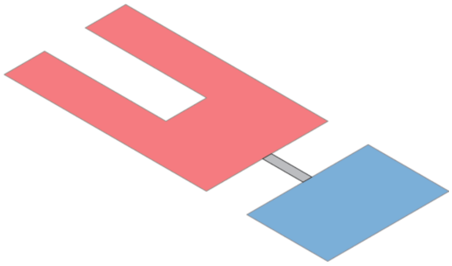


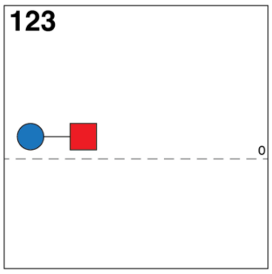


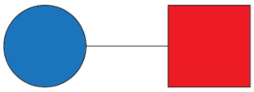
C

s85 Vlissingen



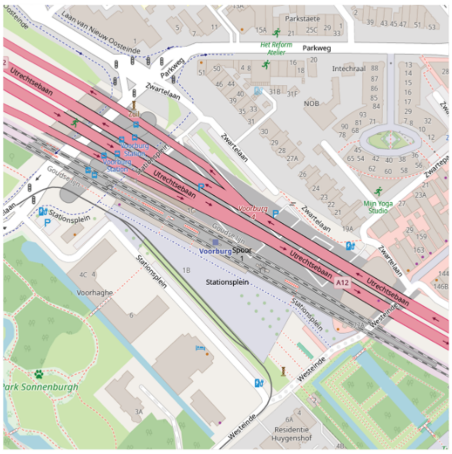


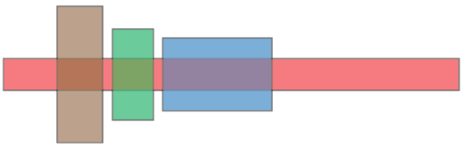


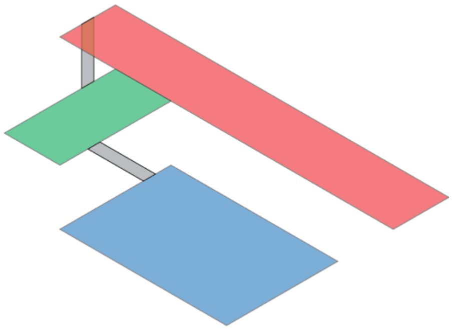


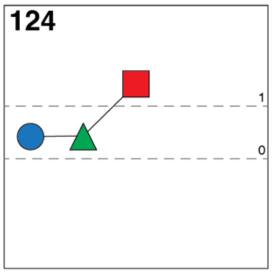
A

s86 Voorburg



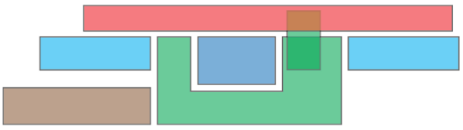


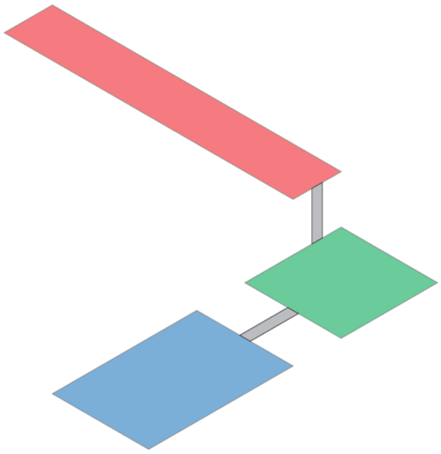


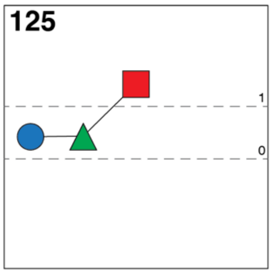


B

s87 Weert

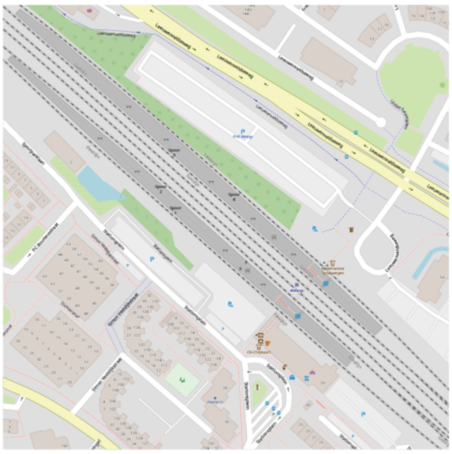


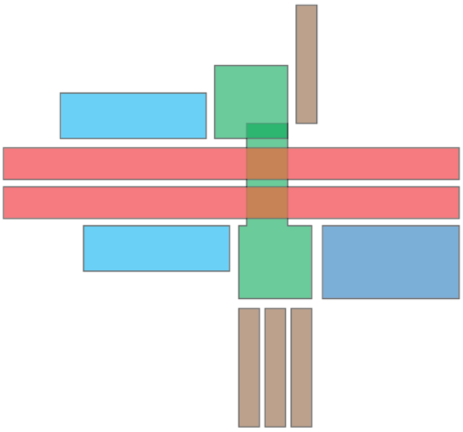


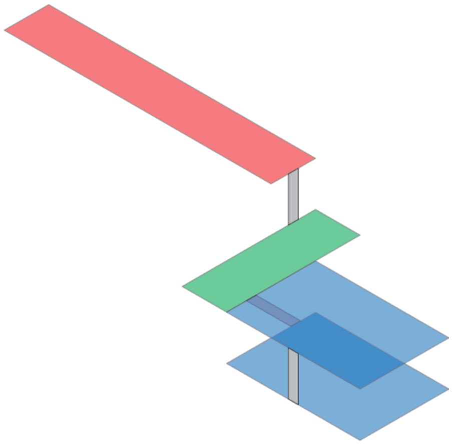


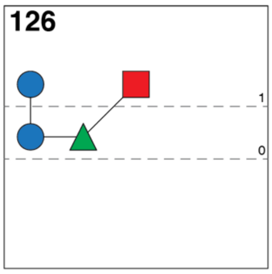
B

s88 Weesp



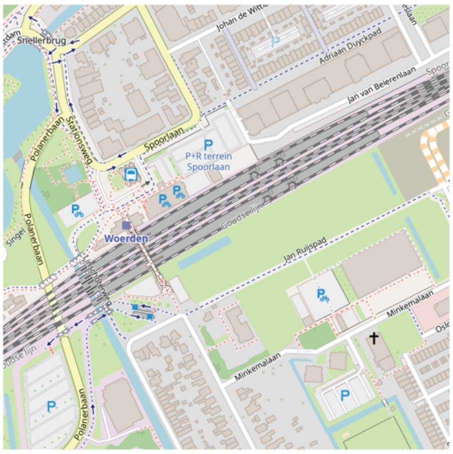


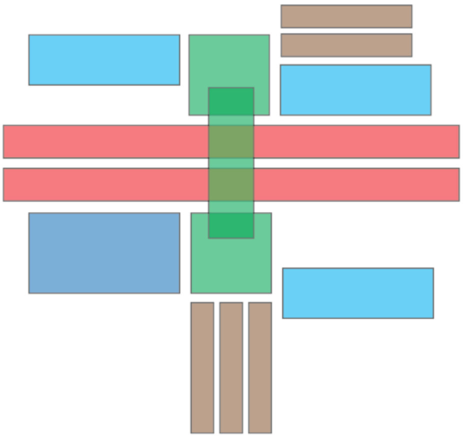


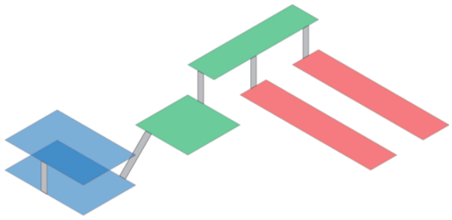


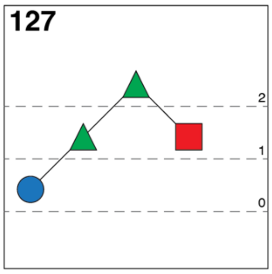
B

s89 Woerden



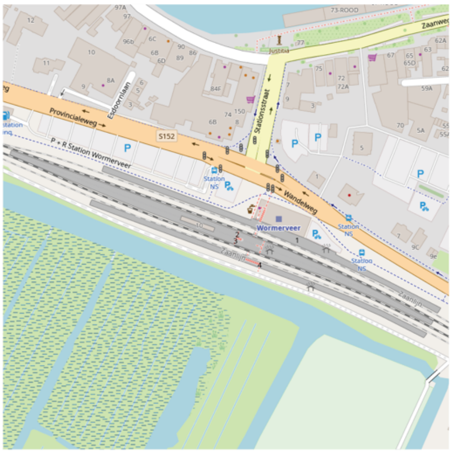


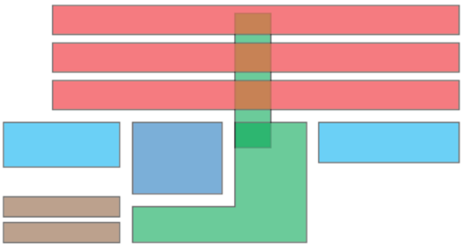


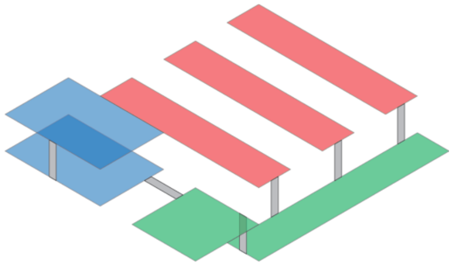


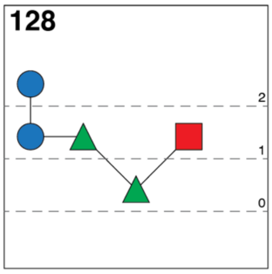
C

s90 Wormerveer









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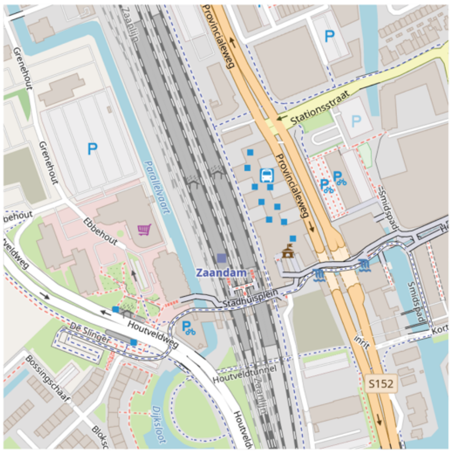
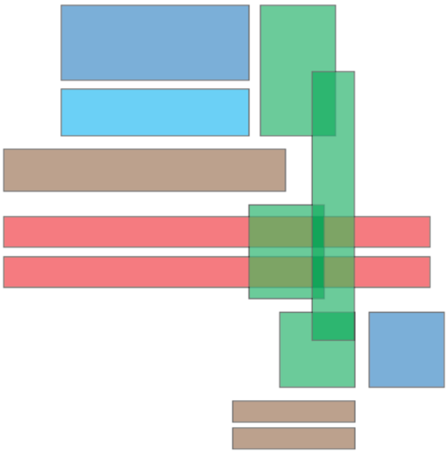
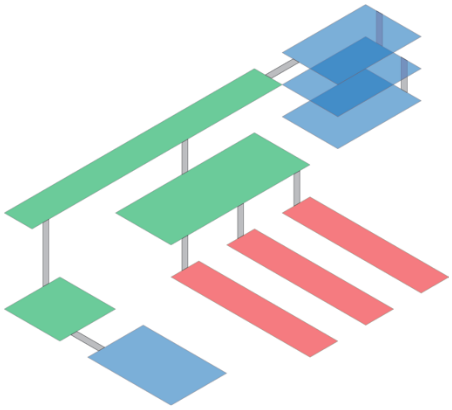
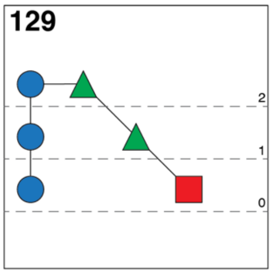
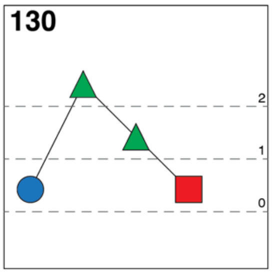
s91 Zaandam





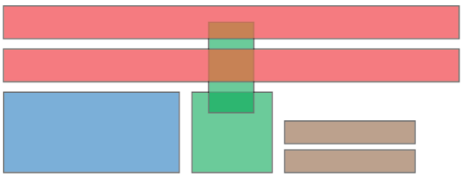


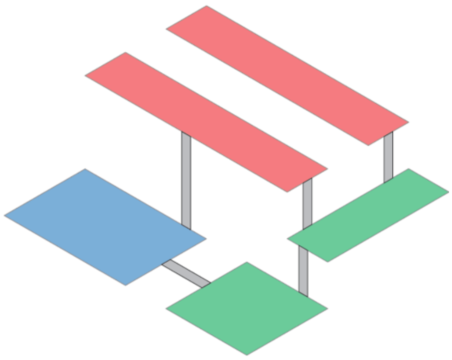


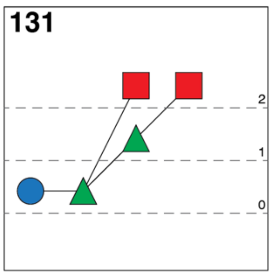


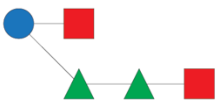
C C

s92 Zaltbommel



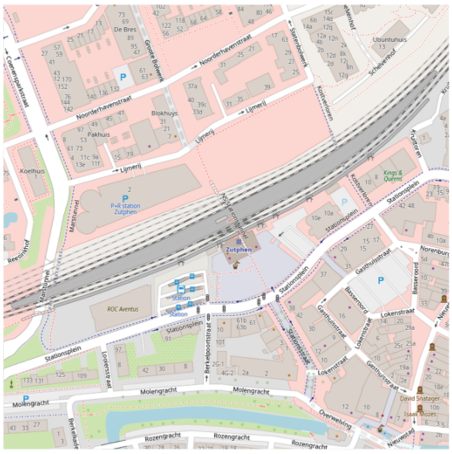


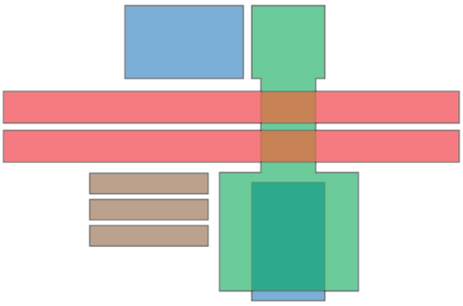


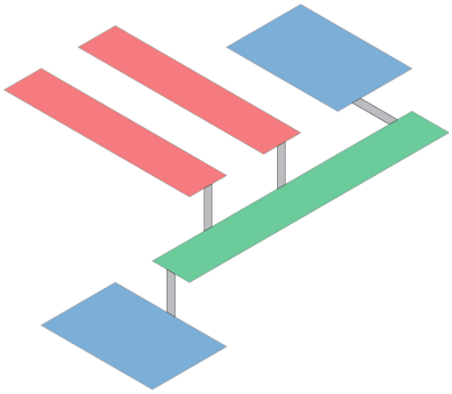


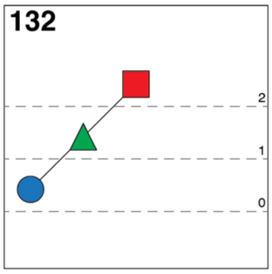
C

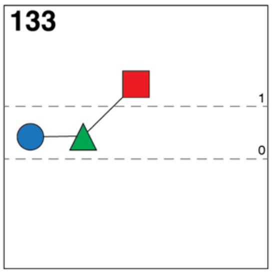
s93 Zutphen





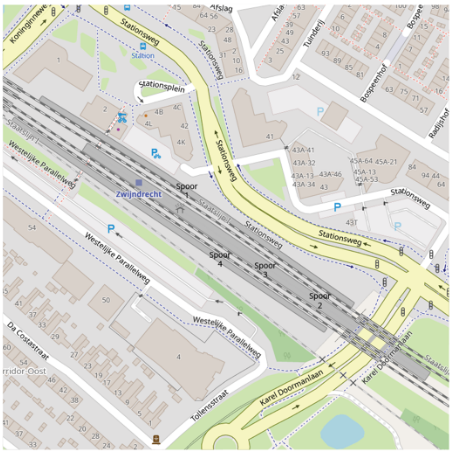


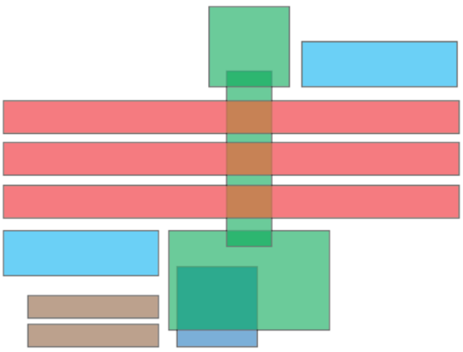


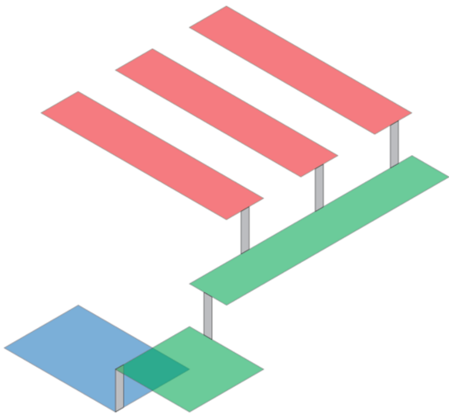


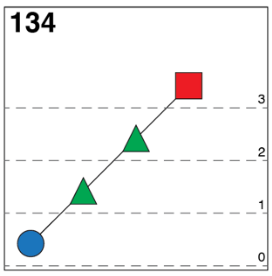
B **B**

s94 Zwijndrecht



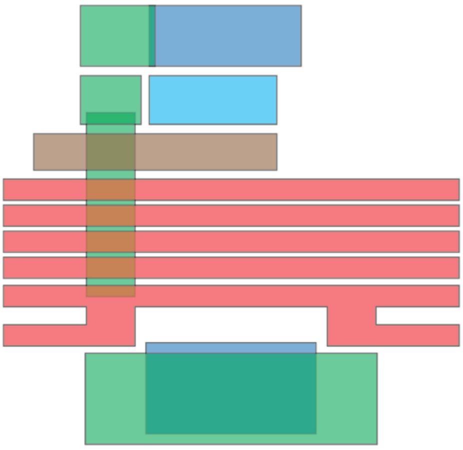


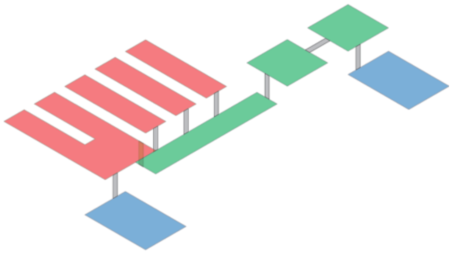


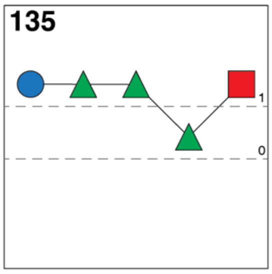


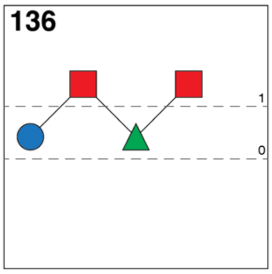
C

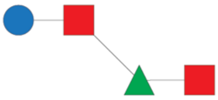
s95 Zwolle











D **C**

C.2. Multimodal Station Composition

The table below is derived from the analysis diagrams in C.1. By translating the diagrams to a table, it becomes possible to categorise the different columns according to similarities and differences among the 95 cases. A composition's multimodality [5] corresponds to the number of modes present at the station [4, 6-12]. The amount of floor present in a composition [14] are a sum of all floor categories found at the station [6-13]. The number of levels [15] and their description [16] are not present on the composition, as it is flat and does not display verticality. However, this was found to be necessary to capture for the next level of abstraction (C.3.). The number of total BPFs per station is a summation of enclosed and open BPFs [17]. The platform to BPF (enclosed) ratio [18] was used a means to categorise the composition with regards to the relationship of platforms to BPFs.

Table legend: MM (Multimodality), Tn (Train floors), Be (BPF (enclosed) floor), Bo (BPF (open) floor), Bu (Bus floor), Tm (Tram floor), Me (Metro floor), Fe (Ferry floor), LVLs (number of levels in composition), Total BPFs (Be + Bo), P-F Ratio (Platforms to BPF ratio).

Table C.2.1. *Multimodal station composition*

# [1]	Station ID [2]	Station Name [3]	Modes [4]	MM [5]	Tn [6]	Be [7]	Bo [8]	Bu [9]	Tm [10]	Me [11]	Fe [12]	TF [13]	Total Floors [14]	LVLs [15]	Levels Description [16]	Total BPFs [17]	P-F Ratio [18]
s01	AMR	Alkmaar	Tn, Bi, Bu	3	3	1	3	11	0	0	0	3	21	2	2 (0, 1)	4	3:1
s02	AMRN	Alkmaar Noord	Tn, Bi, Bu	3	2	1	3	2	0	0	0	3	11	3	3 (-1, 0, 0.5)	4	2:1
s03	AML	Almelo	Tn, Bi, Bu	3	1	1	3	5	0	0	0	3	13	2	2 (-1, 0)	4	1:1
s04	ALM	Almere Centrum	Tn, Bi, Bu	3	2	2	0	3	0	0	0	2	9	2	2 (0, 1)	2	2:2
s05	ALMB	Almere Buiten	Tn, Bi, Bu	3	2	1	5	4	0	0	0	2	14	2	2 (0, 1)	6	2:1
s06	APN	Alphen aan den Rijn	Tn, Bi, Bu	3	2	2	3	7	0	0	0	6	20	3	3 (-1, 0, 0.5)	5	2:2
s07	AMF	Amersfoort Centraal	Tn, Bi, Bu	3	3	2	3	10	0	0	0	4	22	3	3 (-1, 0, 1)	5	3:2
s08	AMFS	Amersfoort Schothorst	Tn, Bi, Bu	3	2	1	1	2	0	0	0	2	8	3	3 (-0.5, 0, 0.5)	2	2:1
s09	ASA	Amsterdam Amstel	Tn, Bi, Bu, Tm, Me	5	2	1	2	5	2	2	0	2	16	3	3 (0, 1, 2)	3	2:1
s10	ASB	Amsterdam Bijlmer ArenA	Tn, Bi, Bu, Me	4	4	1	2	10	0	1	0	1	19	2	2 (0, 1)	3	4:1
s11	ASD	Amsterdam Centraal	Tn, Bi, Bu, Tm, Me, Fe	6	6	4	2	1	8	3	2	9	35	6	6 (-3, -2, -1, -0.5, 0, 1)	6	6:4
s12	ASDM	Amsterdam Muiderpoort	Tn, Bi, Bu, Tm	4	2	1	4	2	3	0	0	1	13	2	2 (0, 1)	5	2:1
s13	RAI	Amsterdam RAI	Tn, Bi, Bu, Tm, Me	5	2	1	1	2	2	1	0	1	10	2	2 (0, 1)	2	2:1
s14	ASS	Amsterdam Sloterdijk	Tn, Bi, Bu, Tm, Me	5	5	1	3	13	2	1	0	2	27	3	3 (0, 1, 2)	4	5:1

# [1]	Station ID [2]	Station Name [3]	Modes [4]	MM [5]	Tn [6]	Be [7]	Bo [8]	Bu [9]	Tm [10]	Me [11]	Fe [12]	TF [13]	Total Floors [14]	LVLs [15]	Levels Description [16]	Total BPFs [17]	P-F Ratio [18]
s15	ASDZ	Amsterdam Zuid	Tn, Bi, Bu, Tm, Me	5	2	4	1	4	4	2	0	3	20	3	3 (-1, 0, 1)	5	2:3
s16	APD	Apeldoorn	Tn, Bi, Bu	3	2	2	1	9	0	0	0	3	17	2	2 (-1, 0)	3	2:2
s17	AH	Arnhem Centraal	Tn, Bi, Bu	3	4	2	0	20	0	0	0	4	30	5	5 (-1,-0.5, 0, 0.5, 1)	2	4:2
s18	ASN	Assen	Tn, Bi, Bu	3	2	1	1	5	0	0	0	3	12	2	2 (-1, 0)	2	2:1
s19	BRN	Baarn	Tn, Bi, Bu	3	3	1	1	1	0	0	0	2	8	2	2 (-1, 0)	2	3:1
s20	BRD	Barendrecht	Tn, Bi, Bu	3	3	1	4	6	0	0	0	3	17	3	3 (0, 1, 2)	5	3:1
s21	BGN	Bergen op Zoom	Tn, Bi, Bu	3	1	1	2	4	0	0	0	4	12	2	2 (-1, 0)	3	1:1
s22	BET	Best	Tn, Bi, Bu	3	3	1	1	1	0	0	0	1	7	2	2 (-1, 0)	2	3:1
s23	BV	Beverwijk	Tn, Bi, Bu	3	2	1	0	9	0	0	0	2	14	2	2 (-1, 0)	1	2:1
s24	BHV	Bilthoven	Tn, Bi, Bu	3	1	1	3	2	0	0	0	2	9	2	2 (-1, 0)	4	1:1
s25	BTL	Boxtel	Tn, Bi, Bu	3	2	1	3	2	0	0	0	3	11	2	2 (0, 1)	4	2:1
s26	BD	Breda	Tn, Bi, Bu	3	3	2	2	1	0	0	0	2	10	2	2 (-1, 0)	4	3:2
s27	CAS	Castricum	Tn, Bi, Bu	3	1	1	3	1	0	0	0	3	9	2	2 (-1, 0)	4	1:1
s28	CL	Culemborg	Tn, Bi, Bu	3	2	1	3	1	0	0	0	3	10	3	3 (0, 0.5, 1)	4	2:1
s29	DT	Delft	Tn, Bi, Bu, Tm	4	2	3	1	6	2	0	0	3	17	3	3 (-2, -1, 0)	4	2:3
s30	GVC	Den Haag Centraal	Tn, Bi, Bu, Tm, Me	5	7	4	1	10	5	1	0	3	31	5	5 (-1, 0, 0.5, 1, 2)	5	7:4
s31	GV	Den Haag HS	Tn, Bi, Bu, Tm	4	3	1	2	2	2	0	0	1	11	2	2 (0, 1)	3	3:1
s32	HDR	Den Helder	Tn, Bi, Bu	3	2	1	2	6	0	0	0	1	12	2	2 (-1, 0)	3	2:1
s33	DV	Deventer	Tn, Bi, Bu	3	2	1	1	1	0	0	0	2	7	3	3 (-1, 0, 1)	2	2:1
s34	DDR	Dordrecht	Tn, Bi, Bu	3	3	1	1	1	0	0	0	3	9	3	3 (-1, 0, 1)	2	3:1
s35	DB	Driebergen-Zeist	Tn, Bi, Bu	3	1	1	0	9	0	0	0	1	12	3	3 (-1, 0, 1)	1	1:1
s36	ED	Ede-Wageningen	Tn, Bi, Bu	3	3	1	2	9	0	0	0	1	16	2	2 (0, 1)	3	3:1
s37	EHV	Eindhoven Centraal	Tn, Bi, Bu	3	3	2	5	13	0	0	0	1	24	3	3 (-1, 0, 1)	7	3:2
s38	EMN	Emmen	Tn, Bi, Bu	3	2	1	1	7	0	0	0	2	13	2	2 (-1, 0)	2	2:1
s39	ES	Enschede	Tn, Bi, Bu	3	2	3	3	12	0	0	0	3	23	2	2 (0, 1)	6	2:3
s40	GS	Goes	Tn, Bi, Bu	3	1	1	3	5	0	0	0	3	13	3	3 (-1, 0, 1)	4	1:1
s41	GD	Gouda	Tn, Bi, Bu	3	3	4	0	1	0	0	0	3	11	4	4 (-1, 0, 0.5, 1)	4	3:4
s42	GN	Groningen	Tn, Bi, Bu	3	3	3	1	15	0	0	0	2	24	3	3 (-1, 0, 1)	4	3:3

# [1]	Station ID [2]	Station Name [3]	Modes [4]	MM [5]	Tn [6]	Be [7]	Bo [8]	Bu [9]	Tm [10]	Me [11]	Fe [12]	TF [13]	Total Floors [14]	LVLs [15]	Levels Description [16]	Total BPFs [17]	P-F Ratio [18]
s43	GERP	Groningen Europapark	Tn, Bi, Bu	3	3	1	0	3	0	0	0	1	8	2	2 (0, 1)	1	3:1
s44	HLM	Haarlem	Tn, Bi, Bu	3	3	3	0	8	0	0	0	1	15	4	4 (-1, 0, 0.5, 1)	3	3:3
s45	HD	Harderwijk	Tn, Bi, Bu	3	1	1	1	1	0	0	0	3	7	2	2 (-1, 0)	2	1:1
s46	HAD	Heemstede-Aerdenhout	Tn, Bi, Bu	3	2	1	3	2	0	0	0	1	9	2	2 (0, 1)	4	2:1
s47	HR	Heerenveen	Tn, Bi, Bu	3	1	1	2	1	0	0	0	2	7	1	1 (0)	3	1:1
s48	HWD	Heerhugowaard	Tn, Bi, Bu	3	2	1	2	3	0	0	0	1	9	1	1 (0)	3	2:1
s49	HRL	Heerlen	Tn, Bi, Bu	3	2	1	2	1	0	0	0	2	8	2	2 (0, 1)	3	2:1
s50	HM	Helmond	Tn, Bi, Bu	3	2	1	0	5	0	0	0	3	11	3	3 (-1, -0.5, 0)	1	2:1
s51	HGL	Hengelo	Tn, Bi, Bu	3	1	2	2	3	0	0	0	1	9	3	3 (-1, 0, 1)	4	1:2
s52	HT	s-Hertogenbosch	Tn, Bi, Bu	3	3	1	2	9	0	0	0	3	18	3	3 (-1, 0, 1)	3	3:1
s53	HVS	Hilversum	Tn, Bi, Bu	3	3	1	4	1	0	0	0	2	11	2	2 (-1, 0)	5	3:1
s54	HVSP	Hilversum Sportpark	Tn, Bi, Bu	3	2	1	2	2	0	0	0	2	9	1	1 (0)	3	2:1
s55	HFD	Hoofddorp	Tn, Bi, Bu	3	2	1	0	4	0	0	0	2	9	2	2 (0, 1)	1	2:1
s56	HGV	Hoogeveen	Tn, Bi, Bu	3	2	1	1	5	0	0	0	2	11	2	2 (-1, 0)	2	2:1
s57	HN	Hoorn	Tn, Bi, Bu	3	2	1	4	1	0	0	0	3	11	2	2 (0, 1)	5	2:1
s58	HTN	Houten	Tn, Bi, Bu	3	1	1	1	4	0	0	0	2	9	2	2 (0, 1)	2	1:1
s59	HTNC	Houten Castellum	Tn, Bi, Bu	3	1	1	0	2	0	0	0	3	7	3	3 (-0.5, 0, 0.5)	1	1:1
s60	KPN	Kampen	Tn, Bi, Bu	3	1	1	1	4	0	0	0	1	8	2	2 (-1, 0)	2	1:1
s61	LW	Leeuwarden	Tn, Bi, Bu	3	3	1	1	15	0	0	0	3	23	2	2 (-1, 0)	2	3:1
s62	LEDN	Leiden Centraal	Tn, Bi, Bu	3	3	5	3	10	0	0	0	2	23	4	4 (-1, -0.5, 0, 1)	8	3:5
s63	LDL	Leiden Lammenschans	Tn, Bi, Bu	3	1	1	1	2	0	0	0	1	6	2	2 (0, 1)	2	1:1
s64	LLS	Lelystad Centrum	Tn, Bi, Bu	3	2	1	3	7	0	0	0	1	14	2	2 (0, 1)	4	2:1
s65	MAS	Maarssen	Tn, Bi, Bu	3	1	1	1	1	0	0	0	2	6	2	2 (0, 1)	2	1:1
s66	MT	Maastricht	Tn, Bi, Bu	3	3	1	1	1	0	0	0	3	9	3	3 (-1, 0, 1)	2	3:1
s67	MP	Meppel	Tn, Bi, Bu	3	2	1	1	5	0	0	0	3	12	4	4 (-1, -0.5, 0, 0.5)	2	2:1
s68	MBD	Middelburg	Tn, Bi, Bu	3	2	1	2	4	0	0	0	3	12	2	2 (-1, 0)	3	2:1
s69	NDB	Naarden-Bussum	Tn, Bi, Bu	3	2	1	2	4	0	0	0	3	12	2	2 (-1, 0)	3	2:1
s70	NM	Nijmegen	Tn, Bi, Bu	3	2	2	1	10	0	0	0	2	17	2	2 (-1, 0)	3	2:1

# [1]	Station ID [2]	Station Name [3]	Modes [4]	MM [5]	Tn [6]	Be [7]	Bo [8]	Bu [9]	Tm [10]	Me [11]	Fe [12]	TF [13]	Total Floors [14]	LVLs [15]	Levels Description [16]	Total BPFs [17]	P-F Ratio [18]
s71	O	Oss	Tn, Bi, Bu	3	2	1	1	2	0	0	0	1	7	3	3 (-0.5, 0, 0.5)	2	2:1
s72	RSW	Rijswijk	Tn, Bi, Bu	3	2	2	3	4	0	0	0	3	14	2	2 (-1, 0)	5	2:2
s73	RM	Roermond	Tn, Bi, Bu	3	2	1	1	9	0	0	0	2	15	2	2 (-1, 0)	2	2:1
s74	RSD	Roosendaal	Tn, Bi, Bu	3	2	1	2	6	0	0	0	2	13	2	2 (-1, 0)	3	2:1
s75	RTD	Rotterdam Centraal	Tn, Bi, Bu, Tm, Me	5	7	1	2	1	6	4	0	3	24	4	4 (-1, 0, 1, 2)	3	7:1
s76	SDM	Schiedam Centrum	Tn, Bi, Bu, Tm, Me	5	3	1	1	2	2	2	0	1	12	2	2 (0, 1)	2	3:1
s77	STD	Sittard	Tn, Bi, Bu	3	2	1	2	1	0	0	0	3	9	2	2 (-1, 0)	3	2:1
s78	SWK	Steenwijk	Tn, Bi, Bu	3	1	1	2	3	0	0	0	3	10	1	1 (0)	3	1:1
s79	TL	Tiel	Tn, Bi, Bu	3	1	1	2	1	0	0	0	1	6	2	2 (0, 0.5)	3	1:1
s80	TB	Tilburg	Tn, Bi, Bu	3	3	2	1	1	0	0	0	3	10	3	3 (-0.5, 0, 1)	3	2:2
s81	UT	Utrecht Centraal	Tn, Bi, Bu, Tm	4	8	3	1	13	4	0	0	6	35	4	4 (-1, 0, 1, 2)	4	8:3
s82	UTO	Utrecht Overvecht	Tn, Bi, Bu	3	2	1	2	2	0	0	0	3	10	3	3 (-1, -0.5, 0)	3	2:1
s83	UTVR	Utrecht Vaartsche Rijn	Tn, Bi, Bu, Tm	4	2	2	1	2	2	0	0	2	11	2	2 (0, 1)	3	2:2
s84	VL	Venlo	Tn, Bi, Bu	3	2	1	2	6	0	0	0	3	14	3	3 (-1, 0, 0.5)	3	2:1
s85	VS	Vlissingen	Tn, Bi, Bu, Fe	4	2	1	2	1	0	0	1	1	8	1	1 (0)	3	2:1
s86	VB	Voorburg	Tn, Bi, Bu	3	1	1	0	1	0	0	0	1	4	2	2 (0, 1)	1	1:1
s87	WT	Weert	Tn, Bi, Bu	3	1	1	2	1	0	0	0	1	6	2	2 (0, 1)	3	1:1
s88	WP	Weesp	Tn, Bi, Bu	3	2	1	2	3	0	0	0	1	9	2	2 (0, 1)	3	2:1
s89	WD	Woerden	Tn, Bi, Bu	3	2	1	3	5	0	0	0	3	14	4	4 (-0.5, 0, 0.5, 1)	4	2:1
s90	WM	Wormerveer	Tn, Bi, Bu	3	3	1	2	2	0	0	0	2	10	3	3 (-1, 0, 1)	3	3:1
s91	ZD	Zaandam	Tn, Bi, Bu	3	2	2	1	3	0	0	0	4	12	3	3 (0, 1, 2)	3	2:1
s92	ZBM	Zaltbommel	Tn, Bi, Bu	3	2	1	0	2	0	0	0	2	7	3	3 (0, 1, 2)	1	2:1
s93	ZP	Zutphen	Tn, Bi, Bu	3	2	2	0	3	0	0	0	1	8	3	3 (-1, 0, 1)	2	2:2
s94	ZWD	Zwijndrecht	Tn, Bi, Bu	3	3	1	2	2	0	0	0	3	11	4	4 (-1, 0, 0.5, 1)	3	3:1
s95	ZL	Zwolle	Tn, Bi, Bu	3	5	2	1	1	0	0	0	3	12	2	2 (-1, 0)	3	5:2

C.3. Intermodal Configuration

The table below is derived from the analysis diagrams in C.1. and table C.2. Columns [1-13] are the stations' composition values, which are utilised to combine with the extracted values from the arrangement configuration diagrams in C.1. By translating the diagrams to a table, it is possible to reduce the number of total floor from the composition [9] to arrangement (only considering Tn, Be, and TF) for BT intermodality [14-20]. TF1-TF5 [15-19] represent the combination of transfer floors according to their category (S: square, C: corridor, W: sidewalk, L: landing, B: BPF) in order to sum total floors in configuration [20]. Additionally, the configuration was assessed according to the platform setup [21] and positional relationship between BPFs and train platforms [22] to categorise the configurations.

Table legend: MM (Multimodality), Tn (Train floors), Be (BPF (enclosed) floor), LVLs (number of levels in composition), Total BPFs (Be + Bo), P-F Ratio (Platforms to BPF ratio), BT TF (Bicycle-Train Transfer Floors), TF (Transfer Floor), Arr. Floors (Total floor in arrangement configuration).

Table C.3.1. *Intermodal configuration*

# [1]	Station ID [2]	MM [4]	Tn [5]	Be [6]	Bo [7]	TF [8]	Total Floors [9]	LVLs [10]	Levels Description [11]	Total BPFs [12]	P-F Ratio [13]	BT TF [14]	T1 [15]	T2 [16]	T3 [17]	T4 [18]	T5 [19]	Arr. Floors [20]	Platform Setup [21]	Positional Relationship [22]
s01	AMR	3	3	1	3	3	21	2	2 (0, 1)	4	3:1	2	S	C				6	side+island	flat
s02	AMRN	3	2	1	3	3	11	3	3 (-1, 0, 0.5)	4	2:1	3	S	C	S			6	sides	upwards
s03	AML	3	1	1	3	3	13	2	2 (-1, 0)	4	1:1	1	C					3	island	upwards
s04	ALM	3	2	2	0	2	9	2	2 (0, 1)	2	2:2	1	S					5	island	upwards
s05	ALMB	3	2	1	5	2	14	2	2 (0, 1)	6	2:1	1	W					4	sides	upwards
s06	APN	3	2	2	3	6	20	3	3 (-1, 0, 0.5)	5	2:2	2	S	C				6	side+island	upwards
s07	AMF	3	3	2	3	4	22	3	3 (-1, 0, 1)	5	3:2	4	S	C	S	W		9	island	upwards
s08	AMFS	3	2	1	1	2	8	3	3 (-0.5, 0, 0.5)	2	2:1	2	S	C				5	side+island	upwards
s09	ASA	5	2	1	2	2	16	3	3 (0, 1, 2)	3	2:1	1	C					4	island	upwards
s10	ASB	4	4	1	2	1	19	2	2 (0, 1)	3	4:1	1	W					6	island	upwards
s11	ASD	6	6	4	2	9	35	6	6 (-3, -2, -1, -0.5, 0, 1)	6	6:4	4	C	C	C	W		14	island	upwards
s12	ASDM	4	2	1	4	1	13	2	2 (0, 1)	5	2:1	1	S					4	island	upwards
s13	RAI	5	2	1	1	1	10	2	2 (0, 1)	2	2:1	1	S					4	island	upwards
s14	ASS	5	5	1	3	2	27	3	3 (0, 1, 2)	4	5:1	2	W	S				8	island	mixed
s15	ASDZ	5	2	3	2	3	20	3	3 (-1, 0, 1)	5	2:3	3	W	C	W			8	island	upwards

# [1]	Station ID [2]	MM [4]	Tn [5]	Be [6]	Bo [7]	TF [8]	Total Floors [9]	LVLs [10]	Levels Description [11]	Total BPFs [12]	P-F Ratio [13]	BT TF [14]	T1 [15]	T2 [16]	T3 [17]	T4 [18]	T5 [19]	Arr. Floors [20]	Platform Setup [21]	Positional Relationship [22]
s16	APD	3	2	2	1	3	17	2	2 (-1, 0)	3	2:2	2	S	C				6	side+island	mixed
s17	AH	3	4	2	0	4	30	5	5 (-1,-0.5, 0, 0.5, 1)	2	4:2	2	S	C				8	island	mixed
s18	ASN	3	2	1	1	3	12	2	2 (-1, 0)	2	2:1	2	L	C				5	side+island	upwards
s19	BRN	3	3	1	1	2	8	2	2 (-1, 0)	2	3:1	2	S	C				6	side+island	flat
s20	BRD	3	3	1	4	3	17	3	3 (0, 1, 2)	5	3:1	1	C					5	island	flat
s21	BGN	3	1	1	2	4	12	1	1 (0)	3	1:1	1	S					3	island	flat
s22	BET	3	3	1	1	1	7	2	2 (-1, 0)	2	3:1	1	C					5	side+island	downwards
s23	BV	3	2	1	0	2	14	2	2 (-1, 0)	1	2:1	2	S	C				5	island	upwards
s24	BHV	3	1	1	3	2	9	2	2 (-1, 0)	4	1:1	1	W					3	island	upwards
s25	BTL	3	2	1	3	3	11	2	2 (0, 1)	4	2:1	2	S	C				5	island	flat
s26	BD	3	3	2	2	2	10	2	2 (-1, 0)	4	3:2	1	C					6	island	upwards
s27	CAS	3	1	1	3	3	9	2	2 (-1, 0)	4	1:1	2	S	C				4	island	flat
s28	CL	3	2	1	3	3	10	3	3 (0, 0.5, 1)	4	2:1	2	S	C				5	sides	upwards
s29	DT	4	2	3	1	3	17	3	3 (-2, -1, 0)	4	2:3	2	W	B				7	island	downwards
s30	GVC	5	7	4	1	3	31	4	4 (-1, 0, 0.5, 1)	5	7:4	1	C					12	terminal	mixed
s31	GV	4	3	1	2	1	11	2	2 (0, 1)	3	3:1	1	W					5	side+island	flat
s32	HDR	3	2	1	2	1	12	2	2 (-1, 0)	3	2:1	1	S					4	terminal	upwards
s33	DV	3	2	1	1	2	7	3	3 (-1, 0, 1)	2	2:1	2	L	W				5	side+island	upwards
s34	DDR	3	3	1	1	3	9	3	3 (-1, 0, 1)	2	3:1	2	S	C				6	terminal+islands	flat
s35	DB	3	1	1	0	1	12	3	3 (-1, 0, 1)	1	1:1	1	W					3	island	upwards
s36	ED	3	3	1	2	1	16	2	2 (0, 1)	3	3:1	1	W					5	side+island	upwards
s37	EHV	3	3	2	5	1	24	3	3 (-1, 0, 1)	7	3:2	1	C					6	island	upwards
s38	EMN	3	2	1	1	2	13	2	2 (-1, 0)	2	2:1	1	S					4	sides	upwards
s39	ES	3	2	3	3	3	23	2	2 (0, 1)	6	2:3	2	S	S				7	through-terminal	mixed
s40	GS	3	1	1	3	3	13	2	2 (-1, 0)	4	1:1	1	C					3	island	upwards
s41	GD	3	3	4	0	3	11	4	4 (-1, 0, 0.5, 1)	4	3:4	3	S	C	S			10	side+island	upwards
s42	GN	3	3	3	1	2	24	3	3 (-1, 0, 1)	4	3:3	2	W	S				8	through-terminal	mixed
s43	GERP	3	3	1	0	1	8	2	2 (0, 1)	1	3:1	1	W					5	side+island	upwards

# [1]	Station ID [2]	MM [4]	Tn [5]	Be [6]	Bo [7]	TF [8]	Total Floors [9]	LVLs [10]	Levels Description [11]	Total BPFs [12]	P-F Ratio [13]	BT TF [14]	T1 [15]	T2 [16]	T3 [17]	T4 [18]	T5 [19]	Arr. Floors [20]	Platform Setup [21]	Positional Relationship [22]
s44	HLM	3	3	3	0	1	15	4	4 (-1, 0, 0.5, 1)	3	3:3	1	C					7	side+island	mixed
s45	HD	3	1	1	1	3	7	2	2 (-1, 0)	2	1:1	2	W	W				4	island	flat
s46	HAD	3	2	1	3	1	9	2	2 (0, 1)	4	2:1	1	W					4	sides	upwards
s47	HR	3	1	1	2	2	7	1	1 (0)	3	1:1	1	W					3	island	flat
s48	HWD	3	2	1	2	1	9	1	1 (0)	3	2:1	1	W					4	sides	flat
s49	HRL	3	2	1	2	2	8	2	2 (0, 1)	3	2:1	1	W					4	island	downwards
s50	HM	3	2	1	0	3	11	3	3 (-1, -0.5, 0)	1	2:1	1	W					4	side+island	upwards
s51	HGL	3	1	2	2	1	9	3	3 (-1, 0, 1)	4	1:2	1	C					4	island	upwards
s52	HT	3	3	1	2	3	18	3	3 (-1, 0, 1)	3	3:1	2	S	C				6	side+island	upwards
s53	HVS	3	3	1	4	2	11	2	2 (-1, 0)	5	3:1	1	W					5	side+island	upwards
s54	HVSP	3	2	1	2	2	9	1	1 (0)	3	2:1	2	W	W				5	sides	flat
s55	HFD	3	2	1	0	2	9	2	2 (0, 1)	1	2:1	1	W					4	island	upwards
s56	HGV	3	2	1	1	2	11	2	2 (-1, 0)	2	2:1	2	S	C				5	sides	flat
s57	HN	3	2	1	4	3	11	2	2 (0, 1)	5	2:1	2	S	C				5	side+island	flat
s58	HTN	3	1	1	1	2	9	2	2 (0, 1)	2	1:1	0						2	island	upwards
s59	HTNC	3	1	1	0	3	7	3	3 (-0.5, 0, 0.5)	1	1:1	2	W	W				4	island	flat
s60	KPN	3	1	1	1	1	8	2	2 (-1, 0)	2	1:1	1	S					3	terminal	upwards
s61	LW	3	3	1	1	3	23	2	2 (-1, 0)	2	3:1	1	S					5	through-terminal	upwards
s62	LEDN	3	3	5	3	2	23	4	4 (-1, -0.5, 0, 1)	8	3:5	1	C					9	terminal+islands	upwards
s63	LDL	3	1	1	1	1	6	2	2 (0, 1)	2	1:1	1	C					3	sides	upwards
s64	LLS	3	2	1	3	1	14	2	2 (0, 1)	4	2:1	1	S					4	island	upwards
s65	MAS	3	1	1	1	2	6	2	2 (0, 1)	2	1:1	2	S	C				4	island	flat
s66	MT	3	3	1	1	3	9	3	3 (-1, 0, 1)	2	3:1	2	S	C				6	terminal+islands	upwards
s67	MP	3	2	1	1	3	12	4	4 (-1, -0.5, 0, 0.5)	2	2:1	2	S	C				5	side+island	flat
s68	MBD	3	2	1	2	3	12	2	2 (-1, 0)	3	2:1	2	S	C				5	sides	flat
s69	NDB	3	2	1	2	3	12	2	2 (-1, 0)	3	2:1	2	S	C				5	sides	flat
s70	NM	3	2	2	1	2	17	2	2 (-1, 0)	3	2:1	3	W	S	C			7	side+island	upwards
s71	O	3	2	1	1	1	7	3	3 (-0.5, 0, 0.5)	2	2:1	1	W					4	side+island	flat

# [1]	Station ID [2]	MM [4]	Tn [5]	Be [6]	Bo [7]	TF [8]	Total Floors [9]	LVLs [10]	Levels Description [11]	Total BPFs [12]	P-F Ratio [13]	BT TF [14]	T1 [15]	T2 [16]	T3 [17]	T4 [18]	T5 [19]	Arr. Floors [20]	Platform Setup [21]	Positional Relationship [22]
s72	RSW	3	2	2	3	3	14	2	2 (-1, 0)	5	2:2	2	S	S				6	island	downwards
s73	RM	3	2	1	1	2	15	2	2 (-1, 0)	2	2:1	2	S	C				5	side+island	flat
s74	RSD	3	2	1	2	2	13	2	2 (-1, 0)	3	2:1	2	S	C				5	side+island	flat
s75	RTD	5	7	1	2	3	24	4	4 (-1, 0, 1, 2)	3	7:1	2	S	C				10	side+island	upwards
s76	SDM	5	3	1	1	1	12	2	2 (0, 1)	2	3:1	1	C					5	sides	upwards
s77	STD	3	2	1	2	3	9	2	2 (-1, 0)	3	2:1	1	C					4	side+island	upwards
s78	SWK	3	1	1	2	3	10	1	1 (0)	3	1:1	1	W					3	island	flat
s79	TL	3	1	1	2	1	6	2	2 (0, 0.5)	3	1:1	1	W					3	island	upwards
s80	TB	3	3	2	1	3	10	3	3 (-0.5, 0, 1)	3	3:2	3	S	C	S			8	side+island	upwards
s81	UT	4	8	4	0	6	35	4	4 (-1, 0, 1, 2)	4	8:4	5	W	S	C	C	W	17	island	mixed
s82	UTO	3	2	1	2	3	10	3	3 (-1, -0.5, 0)	3	2:1	3	S	C	S			6	side+island	flat
s83	UTVR	4	2	2	1	2	11	2	2 (0, 1)	3	2:2	2	W	W				6	island	upwards
s84	VL	3	2	1	2	3	14	3	3 (-1, 0, 0.5)	3	2:1	2	S	C				5	side+island	upwards
s85	VS	4	2	1	2	1	8	1	1 (0)	3	2:1	0						3	terminal	flat
s86	VB	3	1	1	0	1	4	2	2 (0, 1)	1	1:1	1	W					3	island	upwards
s87	WT	3	1	1	2	1	6	2	2 (0, 1)	3	1:1	1	S					3	island	upwards
s88	WP	3	2	1	2	1	9	2	2 (0, 1)	3	2:1	1	C					4	sides	upwards
s89	WD	3	2	1	3	3	14	4	4 (-0.5, 0, 0.5, 1)	4	2:1	2	S	C				5	island	upwards
s90	WM	3	3	1	2	2	10	3	3 (-1, 0, 1)	3	3:1	2	S	C				6	side+island	flat
s91	ZD	3	2	2	1	4	12	3	3 (0, 1, 2)	3	2:1	3	W	L	W			7	island	mixed
s92	ZBM	3	2	1	0	2	7	3	3 (0, 1, 2)	1	2:1	2	S	C				5	sides	upwards
s93	ZP	3	2	2	0	1	8	3	3 (-1, 0, 1)	2	2:2	1	C					5	side+island	upwards
s94	ZWD	3	3	1	2	3	11	4	4 (-1, 0, 0.5, 1)	3	3:1	2	S	C				6	side+island	upwards
s95	ZL	3	5	2	1	3	12	2	2 (-1, 0)	3	5:2	3	C	S	W			10	terminal+islands	upwards

C.4. BT Floor Articulation and Trajectory

The table below is derived from the analysis diagrams in C.1. By translating the diagrams to a table, it becomes possible to categorise the different columns according to similarities and differences among the 136 cases of BT Floor across the 95 cases (stations). In this table, the intermodal configuration is narrowed down from the arrangement of all BPFs to all platforms to each BPF to all platforms (articulation) [7, 8] when considering changes in level, and from each BPF to the farthest platform(s) when considering number of transfer floors (trajectory) [10, 11]. The grade [12] reduced the assessment of each case into a single letter, derived from the max number of floor between BPF and the farthest platform [11]. The link column was added to note cases where some links do not seem straightforward, such as connection from one platform to another being the result of walking over train tracks (T).

Table legend: BPF LVLs (number of level in BPF), LVLs (number of levels in articulation), Art. (Articulation pattern code), Level Change (minimum and maximum number of changes in level throughout BT floor), Traj. (BT floor trajectory pattern code), Floors (minimum and maximum number of floors between bicycle floor and farthest train floor), Grade (BT floor circulation metric), Link (type of link (O: orientation, R: road, T: train tracks).

Table C.4.1. *BT floor articulation and trajectory*

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Grade [12]	Link [13]
						min [7]	max [8]		min [10]	max [11]		
001	AMR	Alkmaar	2	2	a20	0	2	t05	1	1	**B**	O
002	AMRN	Alkmaar Noord	1	3	a56	1	3	t11	1	3	**D**	
003	AML	Almelo	1	2	a10	1	1	t04	1	1	**B**	
004	ALM	Almere Centrum (1)	1	2	a10	1	1	t04	1	1	**B**	R
005	ALM	Almere Centrum (2)	1	2	a02	1	1	t01	0	0	**A**	
006	ALMB	Almere Buiten	1	2	a10	1	1	t04	1	1	**B**	
007	APN	Alphen aan den Rijn (1)	1	3	a10	1	1	t04	1	1	**B**	
008	APN	Alphen aan den Rijn (2)	3	3	a39	1	1	t09	2	2	**C**	R
009	AMF	Amersfoort Centraal (1)	1	3	a49	3	3	t09	2	2	**C**	
010	AMF	Amersfoort Centraal (2)	1	3	a60	3	3	t13	3	3	**D**	R
011	AMFS	Amersfoort Schothorst	1	3	a33	1	2	t08	1	2	**C**	
012	ASA	Amsterdam Amstel	1	3	a19	2	2	t04	1	1	**B**	
013	ASB	Amsterdam Bijlmer ArenA	1	2	a10	1	1	t04	1	1	**B**	
014	ASD	Amsterdam Centraal (1)	1	2	a38	1	1	t09	2	2	**C**	
015	ASD	Amsterdam Centraal (2)	2	3	a44	2	2	t09	2	2	**C**	
016	ASD	Amsterdam Centraal (3)	1	5	a61	4	4	t13	3	3	**D**	
017	ASD	Amsterdam Centraal (4)	1	3	a48	2	2	t09	2	2	**C**	R
018	ASDM	Amsterdam Muiderpoort	1	2	a10	1	1	t04	1	1	**B**	
019	RAI	Amsterdam RAI	1	2	a10	1	1	t04	1	1	**B**	
020	ASS	Amsterdam Sloterdijk	1	3	a30	1	1	t08	1	2	**C**	R
021	ASDZ	Amsterdam Zuid (1)	1	3	a19	2	2	t04	1	1	**B**	
022	ASDZ	Amsterdam Zuid (2)	1	3	a46	2	2	t09	2	2	**C**	R
023	ASDZ	Amsterdam Zuid (3)	1	3	a19	2	2	t04	1	1	**B**	
024	APD	Apeldoorn (1)	1	2	a10	1	1	t04	1	1	**B**	

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Grade [12]	Link [13]
						min [7]	max [8]		min [10]	max [11]		
025	APD	Apeldoorn (2)	1	2	a27	0	2	t08	1	2	**C**	O
026	AH	Arnhem Centraal (1)	1	3	a17	2	2	t04	1	1	**B**	
027	AH	Arnhem Centraal (2)	1	3	a52	2	2	t10	1	1	**C**	
028	ASN	Assen	1	2	a21	1	1	t05	1	1	**B**	
029	BRN	Baarn	1	2	a27	0	2	t08	1	2	**C**	O
030	BRD	Barendrecht	1	2	a17	2	2	t04	1	1	**B**	
031	BGN	Bergen op Zoom	1	1	a07	0	0	t04	1	1	**B**	T
032	BET	Best	1	2	a12	1	1	t04	1	1	**B**	
033	BV	Beverwijk	1	2	a50	3	3	t09	2	2	**C**	
034	BHV	Bilthoven	1	2	a10	1	1	t04	1	1	**B**	
035	BTL	Boxtel	1	2	a41	2	2	t09	2	2	**C**	
036	BD	Breda (1)	1	2	a10	1	1	t04	1	1	**B**	
037	BD	Breda (2)	1	2	a10	1	1	t04	1	1	**B**	
038	CAS	Castricum	2	2	a43	2	2	t09	2	2	**C**	
039	CL	Culemborg	1	3	a29	1	1	t08	1	2	**C**	
040	DT	Delft (1)	1	2	a03	1	1	t01	0	0	**A**	
041	DT	Delft (2)	1	2	a40	1	1	t09	2	2	**C**	
042	DT	Delft (3)	1	2	a40	1	1	t09	2	2	**C**	
043	GVC	Den Haag Centraal (1)	1	2	a13	1	1	t04	1	1	**B**	O
044	GVC	Den Haag Centraal (2)	1	1	a07	0	0	t04	1	1	**B**	O
045	GVC	Den Haag Centraal (3)	2	3	a14	1	1	t04	1	1	**B**	O
046	GVC	Den Haag Centraal (4)	1	2	a13	1	1	t04	1	1	**B**	O
047	GV	Den Haag HS	2	2	a11	2	2	t04	1	1	**B**	
048	HDR	Den Helder	1	2	a13	1	1	t04	1	1	**B**	O
049	DV	Deventer	1	3	a45	2	2	t09	2	2	**C**	
050	DDR	Dordrecht	2	3	a28	0	2	t08	1	2	**C**	O
051	DB	Driebergen-Zeist	2	3	a04	0	1	t02	0	1	**B**	
052	ED	Ede-Wageningen	2	2	a11	1	1	t04	1	1	**B**	
053	EHV	Eindhoven Centraal (1)	1	3	a19	2	2	t04	1	1	**B**	
054	EHV	Eindhoven Centraal (2)	1	2	a10	1	1	t04	1	1	**B**	
055	EMN	Emmen	1	2	a37	1	1	t09	1	2	**C**	T
056	ES	Enschede (1)	1	2	a10	1	1	t04	1	1	**B**	
057	ES	Enschede (2)	2	2	a10	1	1	t04	1	1	**B**	
058	ES	Enschede (3)	1	1	a07	0	0	t04	1	1	**B**	T
059	GS	Goes	1	2	a10	1	1	t04	1	1	**B**	
060	GD	Gouda (1)	2	4	a58	2	3	t12	2	2	**D**	
061	GD	Gouda (2)	2	4	a58	2	3	t12	2	2	**D**	
062	GD	Gouda (3)	1	3	a32	1	2	t08	1	2	**C**	
063	GD	Gouda (4)	2	4	a58	2	3	t12	2	2	**D**	
064	GN	Groningen (1)	2	2	a09	0	1	t04	1	1	**B**	O
065	GN	Groningen (2)	1	2	a02	1	1	t01	0	0	**A**	
066	GN	Groningen (3)	3	1	a08	0	0	t04	1	1	**B**	R
067	GERP	Groningen Europapark	1	2	a10	1	1	t04	1	1	**B**	
068	HLM	Haarlem (1)	1	3	a19	2	2	t04	1	1	**B**	

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Grade [12]	Link [13]
						min [7]	max [8]		min [10]	max [11]		
069	HLM	Haarlem (2)	1	2	a10	1	1	t04	1	1	**B**	
070	HLM	Haarlem (3)	3	2	a05	0	2	t03	0	1	**B**	
071	HD	Harderwijk	2	2	a42	2	2	t09	2	2	**C**	
072	HAD	Heemstede-Aerdenhout	1	2	a10	1	1	t04	1	1	**B**	
073	HR	Heerenveen	1	1	a07	0	0	t04	1	1	**B**	T
074	HWD	Heerhugowaard	1	1	a07	0	0	t04	1	1	**B**	T
075	HRL	Heerlen	1	2	a12	1	1	t04	1	1	**B**	
076	HM	Helmond	2	3	a22	1	2	t05	1	1	**B**	O
077	HGL	Hengelo (1)	1	3	a19	2	2	t04	1	1	**B**	
078	HGL	Hengelo (2)	2	2	a11	1	1	t04	1	1	**B**	
079	HT	s-Hertogenbosch	1	3	a49	3	3	t09	2	2	**C**	
080	HVS	Hilversum	1	2	a10	1	1	t04	1	1	**B**	
081	HVSP	Hilversum Sportpark	1	1	a26	0	0	t08	1	2	**C**	T
082	HFD	Hoofddorp	1	2	a10	1	1	t04	1	1	**B**	
083	HGV	Hoogeveen	1	2	a27	0	2	t08	1	2	**C**	O
084	HN	Hoorn	1	2	a36	0	2	t09	1	2	**C**	O,T
085	HTN	Houten	1	2	a02	1	1	t01	0	0	**A**	
086	HTNC	Houten Castellum	2	3	a42	2	2	t09	2	2	**C**	
087	KPN	Kampen	1	2	a13	1	1	t04	1	1	**B**	O
088	LW	Leeuwarden	1	2	a13	1	1	t04	1	1	**B**	O
089	LEDN	Leiden Centraal (1)	1	3	a19	2	2	t04	1	1	**B**	
090	LEDN	Leiden Centraal (2)	1	2	a10	1	1	t04	1	1	**B**	
091	LEDN	Leiden Centraal (3)	1	2	a10	1	1	t04	1	1	**B**	
092	LEDN	Leiden Centraal (4)	1	3	a19	2	2	t04	1	1	**B**	
093	LEDN	Leiden Centraal (5)	1	3	a19	2	2	t04	1	1	**B**	
094	LDL	Leiden Lammenschans	1	2	a10	1	1	t04	1	1	**B**	
095	LLS	Lelystad Centrum	1	2	a10	1	1	t04	1	1	**B**	R
096	MAS	Maarssen	1	2	a41	2	2	t09	2	2	**C**	
097	MT	Maastricht	1	3	a34	1	3	t08	1	2	**C**	O
098	MP	Meppel	2	4	a35	1	3	t08	1	2	**C**	O
099	MDB	Middelburg	1	2	a27	0	2	t08	1	2	**C**	O
100	NDB	Naarden-Bussum	1	2	a27	0	2	t08	1	2	**C**	O
101	NM	Nijmegen (1)	1	2	a54	1	3	t10	1	3	**D**	O
102	NM	Nijmegen (2)	1	2	a54	1	3	t10	1	3	**D**	R
103	O	Oss	2	3	a06	1	1	t03	0	1	**B**	T
104	RSW	Rijswijk (1)	1	2	a12	1	1	t04	1	1	**B**	O
105	RSW	Rijswijk (2)	1	2	a12	1	1	t04	1	1	**B**	
106	RM	Roermond	1	2	a27	0	2	t08	1	2	**C**	O
107	RSD	Roosendaal	1	2	a53	0	2	t10	1	3	**D**	O
108	RTD	Rotterdam Centraal	1	3	a45	2	2	t09	2	2	**C**	
109	SDM	Schiedam Centrum	1	2	a10	1	1	t04	1	1	**B**	
110	STD	Sittard	1	2	a10	1	1	t04	1	1	**B**	
111	SWK	Steenwijk	1	1	a07	0	0	t04	1	1	**B**	T
112	TL	Tiel	1	1	a10	1	1	t04	1	1	**B**	

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Grade [12]	Link [13]
						min [7]	max [8]		min [10]	max [11]		
113	TB	Tilburg (1)	2	2	a24	0	2	t07	0	2	**C**	
114	TB	Tilburg (2)	2	2	a24	0	2	t07	0	2	**C**	
115	UT	Utrecht Centraal (1)	3	4	a15	1	2	t04	1	1	**B**	
116	UT	Utrecht Centraal (2)	3	4	a16	2	2	t04	1	1	**B**	
117	UT	Utrecht Centraal (3)	2	3	a18	2	2	t04	1	1	**B**	
118	UT	Utrecht Centraal (4)	1	3	a55	2	4	t10	1	3	**D**	
119	UTO	Utrecht Overvecht	1	3	a57	2	3	t12	2	3	**D**	
120	UTVR	Utrecht Vaartsche Rijn (1)	1	2	a10	1	1	t04	1	1	**B**	
121	UTVR	Utrecht Vaartsche Rijn (2)	1	2	a10	1	1	t04	1	1	**B**	
122	VL	Venlo	1	3	a31	1	1	t08	1	2	**C**	O
123	VS	Vlissingen	1	1	a01	0	0	t01	0	0	**A**	
124	VB	Voorburg	1	2	a10	1	1	t04	1	1	**B**	
125	WT	Weert	1	2	a10	1	1	t04	1	1	**B**	
126	WP	Weesp	2	2	a11	1	1	t04	1	1	**B**	
127	WD	Woerden	2	4	a49	3	3	t09	2	2	**C**	
128	WM	Wormerveer	2	3	a43	2	2	t09	2	2	**C**	
129	ZD	Zaandam (1)	3	3	a47	2	2	t09	2	2	**C**	
130	ZD	Zaandam (2)	1	3	a48	3	3	t09	2	2	**C**	
131	ZBM	Zaltbommel	1	3	a25	1	2	t07	0	2	**C**	
132	ZP	Zutphen (1)	1	3	a19	2	2	t04	1	1	**B**	
133	ZP	Zutphen (2)	1	2	a10	1	1	t04	1	1	**B**	
134	ZWD	Zwijndrecht	1	4	a51	3	3	t09	2	2	**C**	
135	ZL	Zwolle (1)	1	2	a59	2	2	t13	3	3	**D**	
136	ZL	Zwolle (2)	1	2	a23	1	3	t06	0	2	**C**	

C.5. Circulation Grade

This table is Table C.4 reordered according to grade [13]. This table is the written form of Figure 4.11. where each articulation pattern can be checked here for patterns that have more than one case. Here, all cases in this research are ranked according to their grade, which translates to their trajectory [9] and articulation [6].

Table legend: BPF LVLs (number of level in BPF), LVLs (number of levels in articulation), Art. (Articulation pattern code), Level Change (minimum and maximum number of changes in level throughout BT floor), Traj. (BT floor trajectory pattern code), Floors (minimum and maximum number of floors between bicycle floor and farthest train floor), Grade (BT floor circulation metric), Link (type of link (O: orientation, R: road, T: train tracks).

Table C.5.1. *BT floor circulation grade*

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Link [13]	Grade [12]
						min [7]	max [8]		min [10]	max [11]		
123	VS	Vlissingen	1	1	a01	0	0	t01	0	0		**A**
005	ALM	Almere Centrum (2)	1	2	a02	1	1	t01	0	0		**A**
065	GN	Groningen (2)	1	2	a02	1	1	t01	0	0		**A**
085	HTN	Houten	1	2	a02	1	1	t01	0	0		**A**
040	DT	Delft (1)	1	2	a03	1	1	t01	0	0		**A**
051	DB	Driebergen-Zeist	2	3	a04	0	1	t02	0	1		**B**
070	HLM	Haarlem (3)	3	2	a05	0	2	t03	0	1		**B**
103	O	Oss	2	3	a06	1	1	t03	0	1	T	**B**
031	BGN	Bergen op Zoom	1	1	a07	0	0	t04	1	1	T	**B**
044	GVC	Den Haag Centraal (2)	1	1	a07	0	0	t04	1	1	O	**B**
058	ES	Enschede (3)	1	1	a07	0	0	t04	1	1	T	**B**
073	HR	Heerenveen	1	1	a07	0	0	t04	1	1	T	**B**
074	HWD	Heerhugowaard	1	1	a07	0	0	t04	1	1	T	**B**
111	SWK	Steenwijk	1	1	a07	0	0	t04	1	1	T	**B**
066	GN	Groningen (3)	3	1	a08	0	0	t04	1	1	R	**B**
064	GN	Groningen (1)	2	2	a09	0	1	t04	1	1	O	**B**
003	AML	Almelo	1	2	a10	1	1	t04	1	1		**B**
004	ALM	Almere Centrum (1)	1	2	a10	1	1	t04	1	1	R	**B**
006	ALMB	Almere Buiten	1	2	a10	1	1	t04	1	1		**B**
007	APN	Alphen aan den Rijn (1)	1	3	a10	1	1	t04	1	1		**B**
013	ASB	Amsterdam Bijlmer ArenA	1	2	a10	1	1	t04	1	1		**B**
018	ASDM	Amsterdam Muiderpoort	1	2	a10	1	1	t04	1	1		**B**
019	RAI	Amsterdam RAI	1	2	a10	1	1	t04	1	1		**B**
024	APD	Apeldoorn (1)	1	2	a10	1	1	t04	1	1		**B**
034	BHV	Bilthoven	1	2	a10	1	1	t04	1	1		**B**
036	BD	Breda (1)	1	2	a10	1	1	t04	1	1		**B**
037	BD	Breda (2)	1	2	a10	1	1	t04	1	1		**B**
054	EHV	Eindhoven Centraal (2)	1	2	a10	1	1	t04	1	1		**B**
056	ES	Enschede (1)	1	2	a10	1	1	t04	1	1		**B**
057	ES	Enschede (2)	2	2	a10	1	1	t04	1	1		**B**

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Link [13]	Grade [12]
						min [7]	max [8]		min [10]	max [11]		
059	GS	Goes	1	2	a10	1	1	t04	1	1		**B**
067	GERP	Groningen Europapark	1	2	a10	1	1	t04	1	1		**B**
069	HLM	Haarlem (2)	1	2	a10	1	1	t04	1	1		**B**
072	HAD	Heemstede-Aerdenhout	1	2	a10	1	1	t04	1	1		**B**
080	HVS	Hilversum	1	2	a10	1	1	t04	1	1		**B**
082	HFD	Hoofddorp	1	2	a10	1	1	t04	1	1		**B**
090	LEDN	Leiden Centraal (2)	1	2	a10	1	1	t04	1	1		**B**
091	LEDN	Leiden Centraal (3)	1	2	a10	1	1	t04	1	1		**B**
094	LDL	Leiden Lammenschans	1	2	a10	1	1	t04	1	1		**B**
095	LLS	Lelystad Centrum	1	2	a10	1	1	t04	1	1	R	**B**
109	SDM	Schiedam Centrum	1	2	a10	1	1	t04	1	1		**B**
110	STD	Sittard	1	2	a10	1	1	t04	1	1		**B**
112	TL	Tiel	1	1	a10	1	1	t04	1	1		**B**
120	UTVR	Utrecht Vaartsche Rijn (1)	1	2	a10	1	1	t04	1	1		**B**
121	UTVR	Utrecht Vaartsche Rijn (2)	1	2	a10	1	1	t04	1	1		**B**
124	VB	Voorburg	1	2	a10	1	1	t04	1	1		**B**
125	WT	Weert	1	2	a10	1	1	t04	1	1		**B**
133	ZP	Zutphen (2)	1	2	a10	1	1	t04	1	1		**B**
047	GV	Den Haag HS	2	2	a11	2	2	t04	1	1		**B**
052	ED	Ede-Wageningen	2	2	a11	1	1	t04	1	1		**B**
078	HGL	Hengelo (2)	2	2	a11	1	1	t04	1	1		**B**
126	WP	Weesp	2	2	a11	1	1	t04	1	1		**B**
032	BET	Best	1	2	a12	1	1	t04	1	1		**B**
075	HRL	Heerlen	1	2	a12	1	1	t04	1	1		**B**
104	RSW	Rijswijk (1)	1	2	a12	1	1	t04	1	1	O	**B**
105	RSW	Rijswijk (2)	1	2	a12	1	1	t04	1	1		**B**
043	GVC	Den Haag Centraal (1)	1	2	a13	1	1	t04	1	1	O	**B**
046	GVC	Den Haag Centraal (4)	1	2	a13	1	1	t04	1	1	O	**B**
048	HDR	Den Helder	1	2	a13	1	1	t04	1	1	O	**B**
087	KPN	Kampen	1	2	a13	1	1	t04	1	1	O	**B**
088	LW	Leeuwarden	1	2	a13	1	1	t04	1	1	O	**B**
045	GVC	Den Haag Centraal (3)	2	3	a14	1	1	t04	1	1	O	**B**
115	UT	Utrecht Centraal (1)	3	4	a15	1	2	t04	1	1		**B**
116	UT	Utrecht Centraal (2)	3	4	a16	2	2	t04	1	1		**B**
026	AH	Arnhem Centraal (1)	1	3	a17	2	2	t04	1	1		**B**
030	BRD	Barendrecht	1	2	a17	2	2	t04	1	1		**B**
117	UT	Utrecht Centraal (3)	2	3	a18	2	2	t04	1	1		**B**
012	ASA	Amsterdam Amstel	1	3	a19	2	2	t04	1	1		**B**
021	ASDZ	Amsterdam Zuid (1)	1	3	a19	2	2	t04	1	1		**B**
023	ASDZ	Amsterdam Zuid (3)	1	3	a19	2	2	t04	1	1		**B**
053	EHV	Eindhoven Centraal (1)	1	3	a19	2	2	t04	1	1		**B**
068	HLM	Haarlem (1)	1	3	a19	2	2	t04	1	1		**B**
077	HGL	Hengelo (1)	1	3	a19	2	2	t04	1	1		**B**
089	LEDN	Leiden Centraal (1)	1	3	a19	2	2	t04	1	1		**B**

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Link [13]	Grade [12]
						min [7]	max [8]		min [10]	max [11]		
092	LEDN	Leiden Centraal (4)	1	3	a19	2	2	t04	1	1		**B**
093	LEDN	Leiden Centraal (5)	1	3	a19	2	2	t04	1	1		**B**
132	ZP	Zutphen (1)	1	3	a19	2	2	t04	1	1		**B**
001	AMR	Alkmaar	2	2	a20	0	2	t05	1	1	O	**B**
028	ASN	Assen	1	2	a21	1	1	t05	1	1		**B**
076	HM	Helmond	2	3	a22	1	2	t05	1	1	O	**B**
136	ZL	Zwolle (2)	1	2	a23	1	3	t06	0	2		**C**
113	TB	Tilburg (1)	2	2	a24	0	2	t07	0	2		**C**
114	TB	Tilburg (2)	2	2	a24	0	2	t07	0	2		**C**
131	ZBM	Zaltbommel	1	3	a25	1	2	t07	0	2		**C**
081	HVSP	Hilversum Sportpark	1	1	a26	0	0	t08	1	2	T	**C**
025	APD	Apeldoorn (2)	1	2	a27	0	2	t08	1	2	O	**C**
029	BRN	Baarn	1	2	a27	0	2	t08	1	2	O	**C**
083	HGV	Hoogeveen	1	2	a27	0	2	t08	1	2	O	**C**
099	MDB	Middelburg	1	2	a27	0	2	t08	1	2	O	**C**
100	NDB	Naarden-Bussum	1	2	a27	0	2	t08	1	2	O	**C**
106	RM	Roermond	1	2	a27	0	2	t08	1	2	O	**C**
050	DDR	Dordrecht	2	3	a28	0	2	t08	1	2	O	**C**
039	CL	Culemborg	1	3	a29	1	1	t08	1	2		**C**
020	ASS	Amsterdam Sloterdijk	1	3	a30	1	1	t08	1	2	R	**C**
122	VL	Venlo	1	3	a31	1	1	t08	1	2	O	**C**
062	GD	Gouda (3)	1	3	a32	1	2	t08	1	2		**C**
011	AMFS	Amersfoort Schothorst	1	3	a33	1	2	t08	1	2		**C**
097	MT	Maastricht	1	3	a34	1	3	t08	1	2	O	**C**
098	MP	Meppel	2	4	a35	1	3	t08	1	2	O	**C**
084	HN	Hoorn	1	2	a36	0	2	t09	1	2	O,T	**C**
055	EMN	Emmen	1	2	a37	1	1	t09	1	2	T	**C**
014	ASD	Amsterdam Centraal (1)	1	2	a38	1	1	t09	2	2		**C**
008	APN	Alphen aan den Rijn (2)	3	3	a39	1	1	t09	2	2	R	**C**
041	DT	Delft (2)	1	2	a40	1	1	t09	2	2		**C**
042	DT	Delft (3)	1	2	a40	1	1	t09	2	2		**C**
035	BTL	Boxtel	1	2	a41	2	2	t09	2	2		**C**
096	MAS	Maarssen	1	2	a41	2	2	t09	2	2		**C**
071	HD	Harderwijk	2	2	a42	2	2	t09	2	2		**C**
086	HTNC	Houten Castellum	2	3	a42	2	2	t09	2	2		**C**
038	CAS	Castricum	2	2	a43	2	2	t09	2	2		**C**
128	WM	Wormerveer	2	3	a43	2	2	t09	2	2		**C**
015	ASD	Amsterdam Centraal (2)	2	3	a44	2	2	t09	2	2		**C**
049	DV	Deventer	1	3	a45	2	2	t09	2	2		**C**
108	RTD	Rotterdam Centraal	1	3	a45	2	2	t09	2	2		**C**
022	ASDZ	Amsterdam Zuid (2)	1	3	a46	2	2	t09	2	2	R	**C**
129	ZD	Zaandam (1)	3	3	a47	2	2	t09	2	2		**C**
017	ASD	Amsterdam Centraal (4)	1	3	a48	2	2	t09	2	2	R	**C**
130	ZD	Zaandam (2)	1	3	a48	3	3	t09	2	2		**C**

# [1]	Station ID [2]	Station Facility (Number) [3]	BPF LVLs [4]	LVLs [5]	Art. [6]	Level Change		Traj. [9]	Floors		Link [13]	Grade [12]
						min [7]	max [8]		min [10]	max [11]		
009	AMF	Amersfoort Centraal (1)	1	3	a49	3	3	t09	2	2		**C**
079	HT	s-Hertogenbosch	1	3	a49	3	3	t09	2	2		**C**
127	WD	Woerden	2	4	a49	3	3	t09	2	2		**C**
033	BV	Beverwijk	1	2	a50	3	3	t09	2	2		**C**
134	ZWD	Zwijndrecht	1	4	a51	3	3	t09	2	2		**C**
027	AH	Arnhem Centraal (2)	1	3	a52	2	2	t10	1	1		**C**
107	RSD	Roosendaal	1	2	a53	0	2	t10	1	3	O	**D**
101	NM	Nijmegen (1)	1	2	a54	1	3	t10	1	3	O	**D**
102	NM	Nijmegen (2)	1	2	a54	1	3	t10	1	3	R	**D**
118	UT	Utrecht Centraal (4)	1	3	a55	2	4	t10	1	3		**D**
002	AMRN	Alkmaar Noord	1	3	a56	1	3	t11	1	3		**D**
119	UTO	Utrecht Overvecht	1	3	a57	2	3	t12	2	3		**D**
060	GD	Gouda (1)	2	4	a58	2	3	t12	2	2		**D**
061	GD	Gouda (2)	2	4	a58	2	3	t12	2	2		**D**
063	GD	Gouda (4)	2	4	a58	2	3	t12	2	2		**D**
135	ZL	Zwolle (1)	1	2	a59	2	2	t13	3	3		**D**
010	AMF	Amersfoort Centraal (2)	1	3	a60	3	3	t13	3	3	R	**D**
016	ASD	Amsterdam Centraal (3)	1	5	a61	4	4	t13	3	3		**D**