

# Standardised Design Explanatory Note and Case Study

April 2020



Education





# 1.0 Introduction

This document has been created as an explanatory note of a new, replicable approach to the planning and design of room types for Public and High Schools. The overarching intention is that School Infrastructure has a consistent education planning grid (referred to as a planning grid) which can be applied to both a Public School or High School, whilst providing teaching flexibility for both explicit and open learning spaces. The standardisation of the planning grid will set a high minimum education standard whilst also becoming recognised as a replicable product for the purpose of design, statutory approval, cost planning and delivery.

A repeatable product approach will result in education consistency, project certainty and the ability to rapidly build high quality schools through the manufacture of building components or entire school buildings.

A consistent product approach enables a manufactured and on-site assembly response to the construction of new school buildings which is referred to as Design for Manufacture and Assembly (DfMA).

A DfMA approach is reliant upon a standardised and replicable approach to design which the planning grid enables. Replication and repeatability, as well as industry knowledge of the product, will ultimately drive greater productivity in the design and delivery of school buildings across all of NSW. It will also enable SINSW to meet the ever increasing demand for new teaching spaces in a manner which delivers greater value for money.

## 1.1 Proof of Concept

To develop this thinking, the principles of the planning grid and a DfMA approach have been applied to the Chatswood PS as a Case Study. This document articulates the planning grid, DfMA principles and findings when aligned planning and structural grids are overlayed onto the current Chatswood PS design.

The following sections of this report outlines the:

1. Case Study purpose and methodology
2. DfMA approach, process and principles
3. Sustainability objectives
4. Design standardisation; and
5. Chatswood Case Study

## 2.0 Case Study Purpose and Methodology

The purpose of the Case Study is that it becomes a reference document which;

1. Illustrates and explains the SINSW standardised education planning grid
2. Demonstrates the flexibility and alignment of Design for Manufacture and Assembly buildability options (volumetric, modular and component)
3. Illustrates the application of these principles to a Case Study project

The case study document can be used a guide for architects, engineers, contractors and manufactures to understand and inform how to apply both volumetric and component DfMA approaches to a standardised education planning grid.

Chatswood PS was chosen as a Case Study due to the regularity of the building forms and the challenging site access both of which are aligned with a DfMA approach.



## 2.1 Scope of the Study

Woods Bagot has been collaborating with School Infrastructure on a method of standardising the design and construction of future schools, using the EFSG to create a DfMA kit of parts. School Infrastructure provided Woods Bagot with a masterplan by Architectus for Chatswood Primary school as a way of testing the kit of parts by adapting the original design to suit DfMA principles. The vision was to maintain the previous architects architectural expression and form, only modifying the layout and structure to suit DfMA principles.

This study takes the masterplan and concept design already produced and demonstrates a possible DfMA approach. It keeps the masterplan, access, overall massing and general planning layouts as per the Concept Design.

The study reviews possible DfMA layouts with the ability to flex between open plan learning environments and enclosed rooms. The study aims to apply the standard planning module and explores possible structural column locations to suit either volumetric or component-based DfMA construction methods.



## 3.0 Understanding Design for Manufacture and Assembly (DfMA)

DfMA can be delivered in two forms (1) volumetric in which it is manufactured off-site, assembled in a factory, transported to site and craned into location as a complete module and (2) a component 'kit of parts' in which the building elements including floor panels, walls, portal frames, roof trusses etc are manufactured off-site, transported to site as building components and assembled as a 'kit of parts', on site. Both forms of DfMA have the same design process however the forms are appropriate for differing sites which is largely contingent upon site access. Volumetric DfMA is well suited to easily accessed sites and regional locations for school and ancillary buildings up to 3 storeys whilst the component 'kit of parts' is suited to all sites, particularly sites with access restrictions and for school buildings up to 6 storeys.



DfMA is a process and an approach to design that uses Building Information Management (BIM) technology and focuses on accessing off-site manufacture and efficient on-site assembly of a standardised range of a building components (referred to as a ‘kit of parts’). DfMA provides variety and customisation, can be scaled according to project or portfolio demand and is reliant upon a multiple-source supply chain.

BIM which is an intelligent 3D model-based process, gives architecture, engineering and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure. It is also the digital platform most commonly used by manufacturers as they create shop drawings for fabrication. The DfMA process leads to various improvements that each contribute to reduced costs, tighter overall scheduling and improved safety and sustainability outcomes. The use of BIM as the common digital platform, supports an open source of procurement.

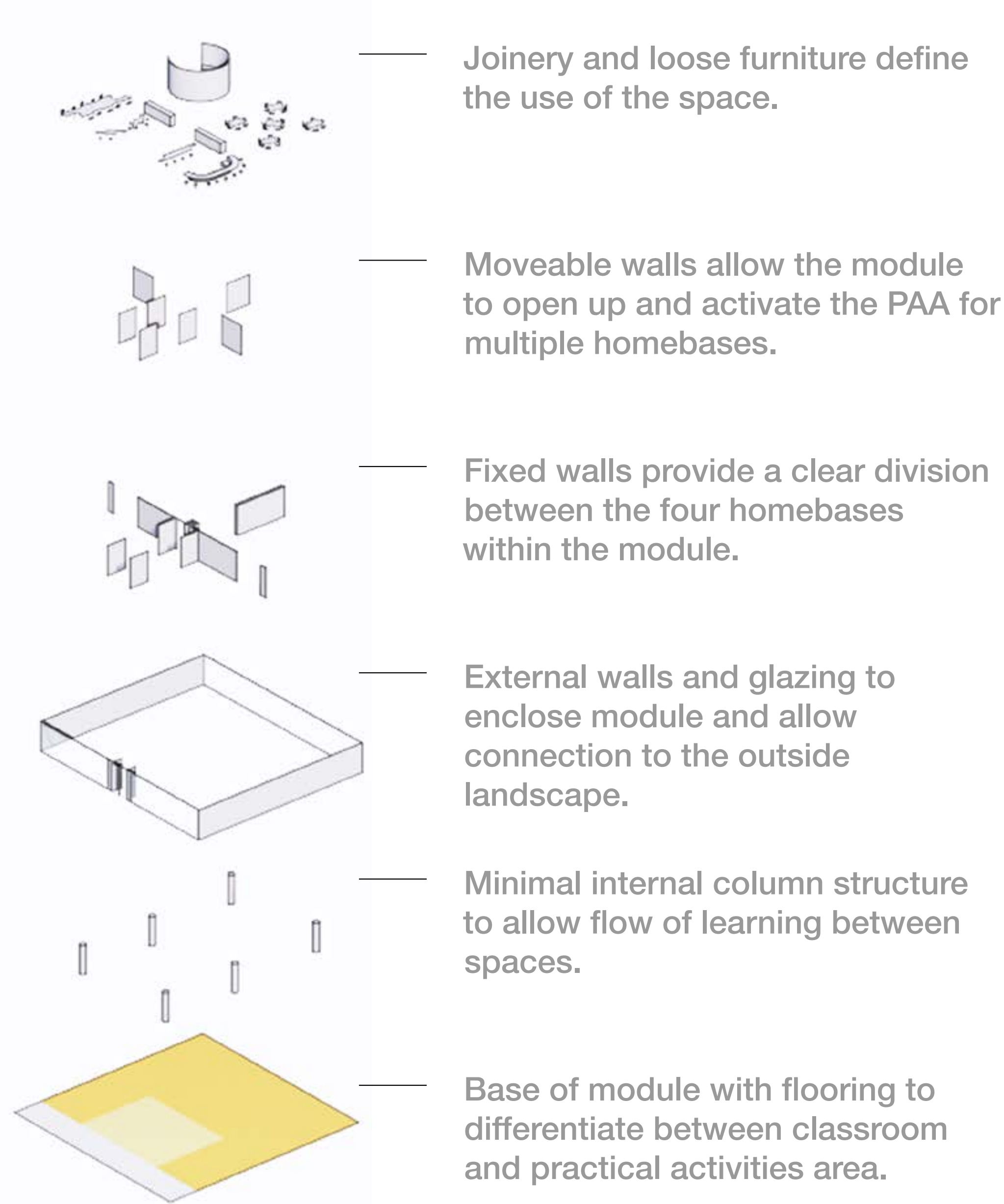
### 3.1

## The DfMA ‘Kit of Parts’

A DfMA ‘kit of parts’ includes volumetric / modular construction and component parts.

The practical application of these types of DfMA is determined by the construction response required for each project. For example, the replacement of single-storey and two storey demountables or construction of new classrooms in greenfield sites is well suited to volumetric / modular DfMA, such as Jordan Springs.

More difficult to access, inner urban sites and taller buildings are better suited to component parts or a hybrid of both. Overall however, DfMA in both forms, is very well suited to steeply sloping sites.



# 3.2

## The Benefits of DfMA

The benefits of DfMA are well documented and include:



### Time Savings

DfMA construction is ~30% faster

Early investment in the design and engineering of the kit of parts allows for on-site time savings.



### Improved safety

DfMA improves site safety

Assembly of parts requires less labour, reducing the number of on-site trades and site complexity.



### Improved sustainability

DfMA reduces waste & emissions

Of-site bulk manufacturing reduces instances waste & emissions.



### Improved productivity

DfMA enables greater productivity & output

The discipline of early design decisions & elimination of redesign increases productivity.



### Upskills the workforce

DfMA affords opportunities for local upskilling

Take-up of DfMA will facilitate upskilling to advanced manufacturing practices.



### Opportunity to reduce cost

DfMA standardisation reduces cost

Sustained and widespread application, a DfMA approach can reduce the cost of construction.



## 4.0 Sustainability Objectives

The SINSW 2030 sustainability priorities focus on five discrete themes and objectives are outlined below.

| Theme             | 2030 Objective                                                                                                                                                            |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Energy & Carbon   | SINSW is targeting carbon neutrality by 2030 and we will continuously reduce our greenhouse gas emissions footprint and support communities to reduce their footprints.   |
| Water             | By 2030, SINSW will implement integrated water management across our portfolio to improve the complex relationship between water users and water resources.               |
| Waste & Materials | SINSW will responsibly select resources and manage wastes throughout the life cycle of our facilities in a way that benefits and protects people and the environment.     |
| Place             | SINSW will enhance our natural and cultural environments and their connection to schools to improve community health and wellbeing.                                       |
| Resilience        | By 2030, SINSW will have a portfolio of infrastructure assets which are resilient to the effects of climate change and the emerging needs of our schools and communities. |



DfMA is an important enabler of the SINSW sustainability objectives. The themes to which DfMA are most applicable and the SINSW response to these are:

### Energy & Carbon:

- Developing standardised elements in BIM models and enabling fabrication in a factory environment can assist with reducing and tracking the carbon footprint

### Waste & Materials:

- Dismantling or removal of components to reconfigure buildings or to deploy elsewhere expends lesser resources and waste than creating new buildings
- Identifying and using materials more efficiently in component designs and testing in the BIM models can reduce site waste

SINSW are therefore supportive of the use of sustainable building materials such as mass timber (glulam and cross laminated) which is supported by the maximum structural beam dimensions as outlined in section 6.0 DfMA buildability principles and ‘kit of parts’.

## 5.0 Design Standardisation

Optimisation of a DfMA approach and process is reliant upon a number of key principles however the most critical principle is Design Standardisation.

The success of a DfMA strategy is reliant upon a fully coordinated approach to design which starts with a standardised approach to the design of all projects. A standardised design enables building manufacturers to fabricate the components of the design to a level of certainty, precision and productivity typically associated with car manufacturing. This increase in productivity will ultimately deliver benefits to the manufacturing, design and construction industries whilst also delivering a consistently high standard of education facilities and best practice learning environments in NSW.



Since October 2019, SINSW been testing and refining a standardised design in the form of an education planning grid. This 'grid' supports education outcomes first and then informs structural design, building services and the manufacturing of building elements. After numerous case study applications involving internal education experts and external construction and manufacturing experts, SINSW have a standardised approach which is aligned with both volumetric and component DfMA solutions. The DfMA component approach and education planning grid was developed initially as a case study on the Meadowbank PS and HS. In this document, it has been applied to the Chatswood PS.

Design standardisation enables contractors, designers and manufacturers to become familiar with the product including technical and performance standards. A 'product' which can be repeated time and again, enables greater efficiencies in time, cost and quality.

SINSW have created a standardised and repeatable education planning grid of 9m x 9m which supports preferred pedagogical typologies including explicit and open style learning. The dimensions of the grid are described in more detail and illustrated the below sections.

## 5.1 Education Planning Grid Principles & Objectives

The identification of a ‘standardised’ planning grid is both in response to the need to create a minimum high standard for all teaching spaces and also to provide clarity and consistency to the SINSW approach to designing and building schools.

The principles and objectives for establishing a repeatable and standardised planning grid, were very clear from the outset and included the following:

- Providing a consistent and equitable yet high minimum standard for NSW education
- Complying with all EFSG standards and all pedagogy typologies
- Enabling flexibility for locally based teachers to choose their preferred learning environment (explicit or open and agile) through the selection and arrangement of loose furniture and acoustically attenuated sliding doors; and
- Enabling the school to adapt and budget for changes to learning spaces, over time, through furniture and fit-out selections as opposed to wholesale building renovation or replacement.



The standardised planning grid is to be aligned with the building structure which therefore, enables a ‘long life’ to the structure and a ‘loose fit’ to the interior fit-out. Thus the interior fit-out can be adapted over time as required. The objectives underpinning this approach include:

- Utilising furniture choices and sliding walls to enable flexibility of room types ultimately reduces the time, disruption and expenditure on school refurbishments; and
- Providing consistency and clarity of the end product will result in consistent design and building standards which, over time, result in a reduction in cost and time as the design and construction industry develops a greater understanding of the SINSW ‘product’.

The planning grid has been careful to consider the need for teachers, particularly in Public Schools, to enable personalisation of their teaching spaces and to ensure their well-being is being considered in the design.

## 5.2 Planning Grid Principles

### Principle 1: A fixed planning & structural grid with internal flexibility

A fixed grid ensures speed and ease for design the design phase as planning and structure are integrated into the grid, allowing a focus on usability, internal flexibility and facade design.

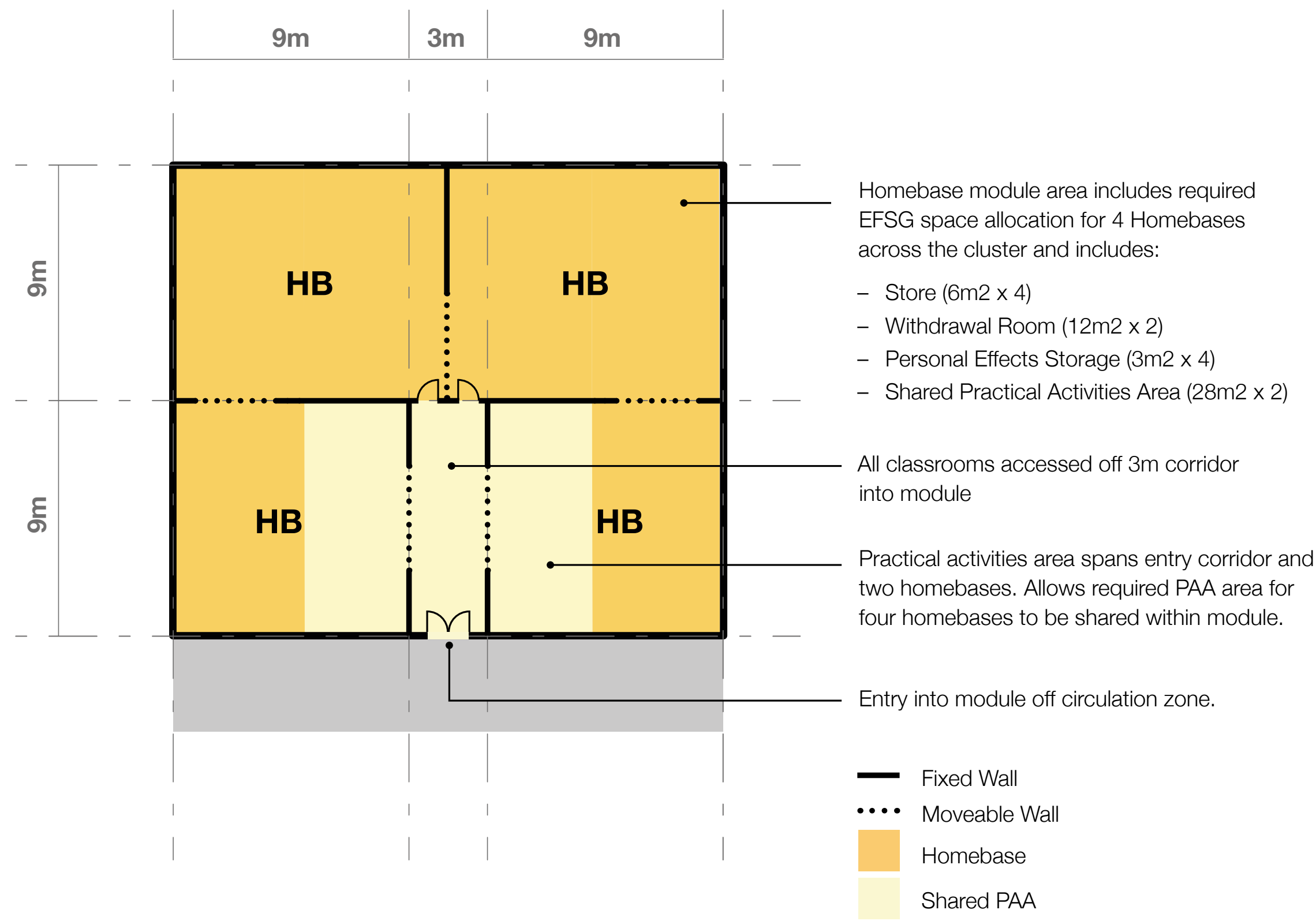
### Principle 2: One grid to suit all room types, school configurations and building materials

The planning grid is a layout of consistent dimensions and areas which enables the flexibility for both open, flexible teaching spaces and learning environments, as well explicit teaching spaces. Rather than a binary approach of explicit learning or future-focused learning environments, the planning grid supports both teaching environments with the adaptability, via sliding doors, for teachers to choose their preferred approach.

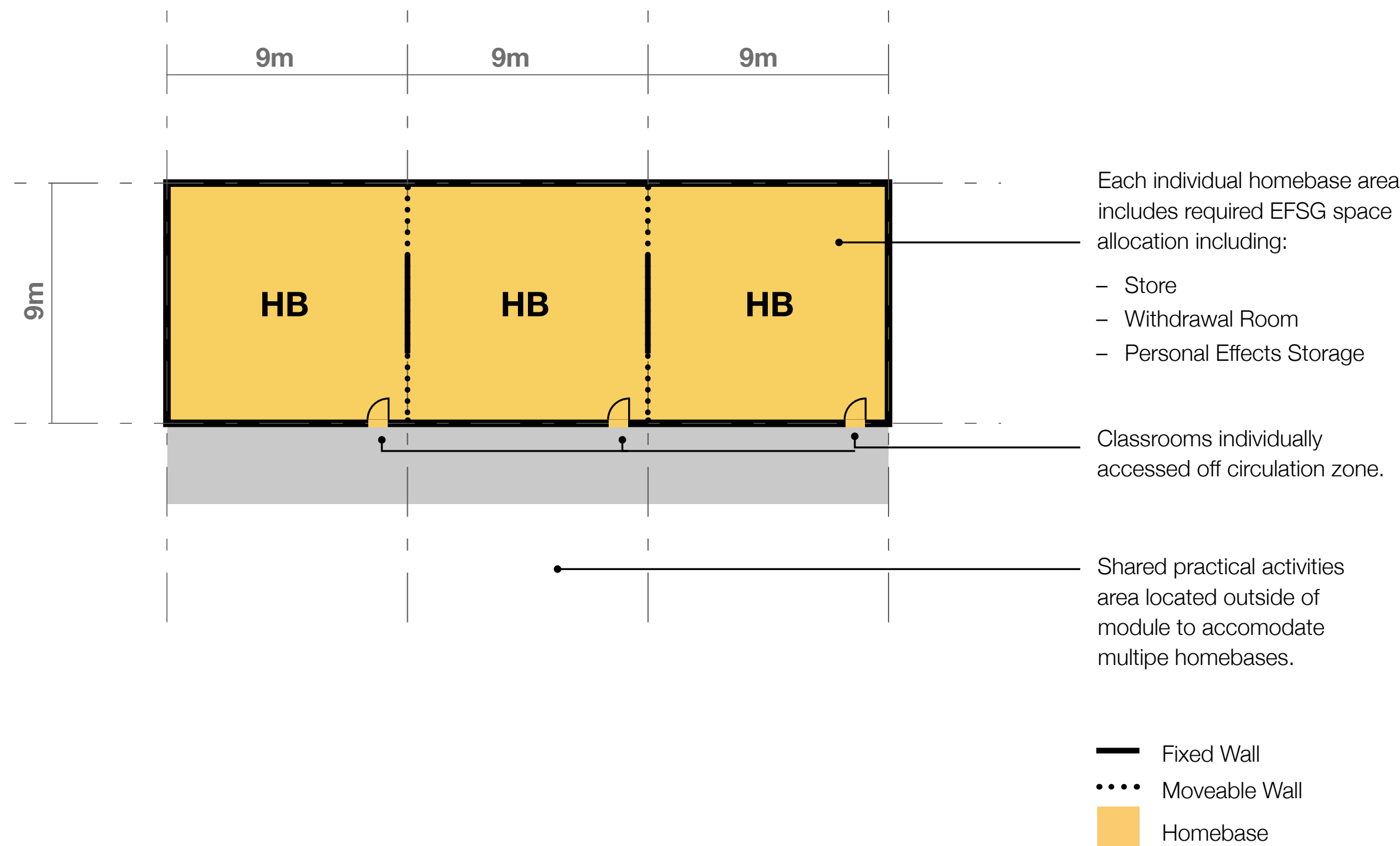
The grid principles of the primary school planning grid are shown on the following slides

← Meadowbank School  
Woods Bagot

5.2 Homebase Module Type 1



5.2 Homebase Module Type 2

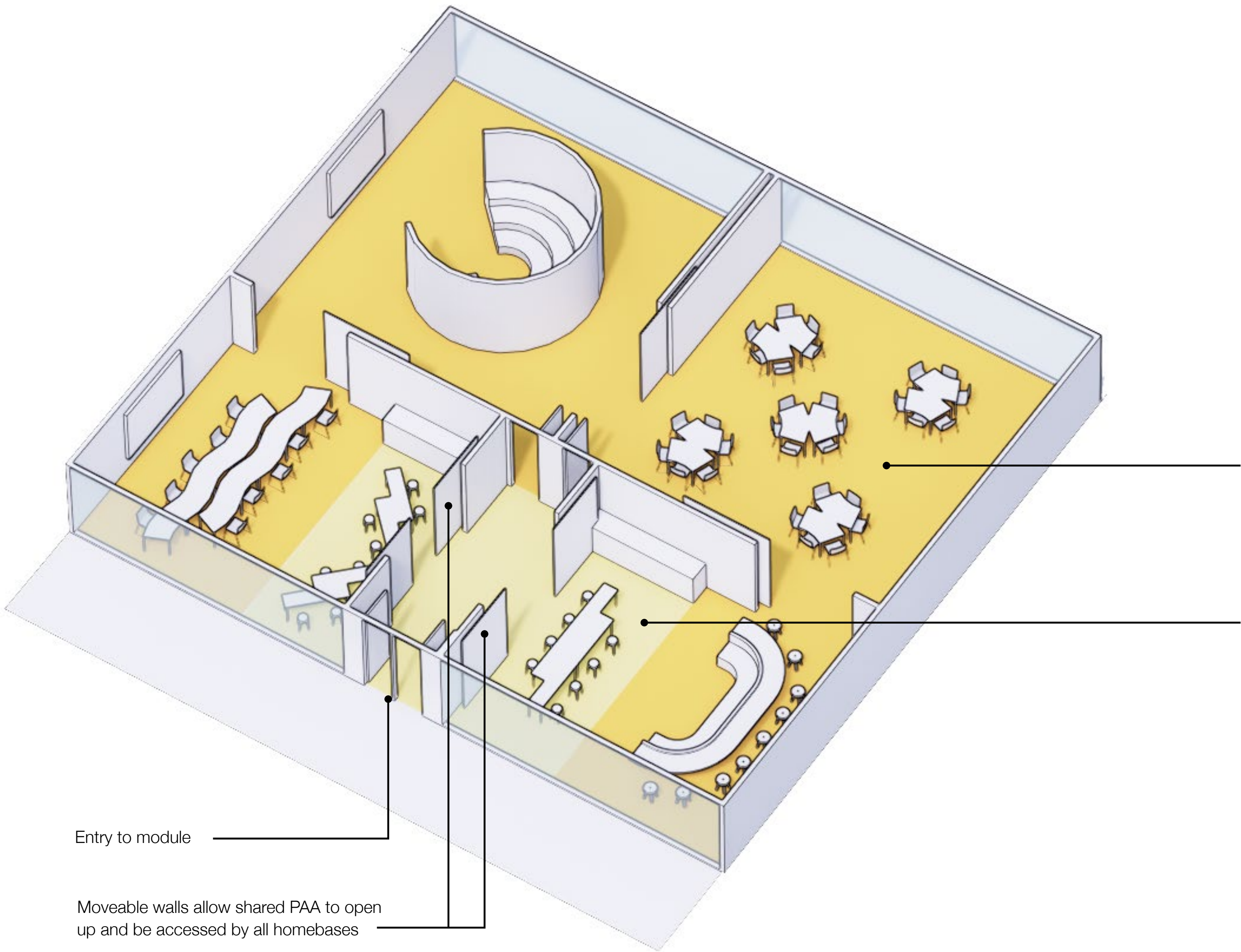


## 5.3 Functional Relationships

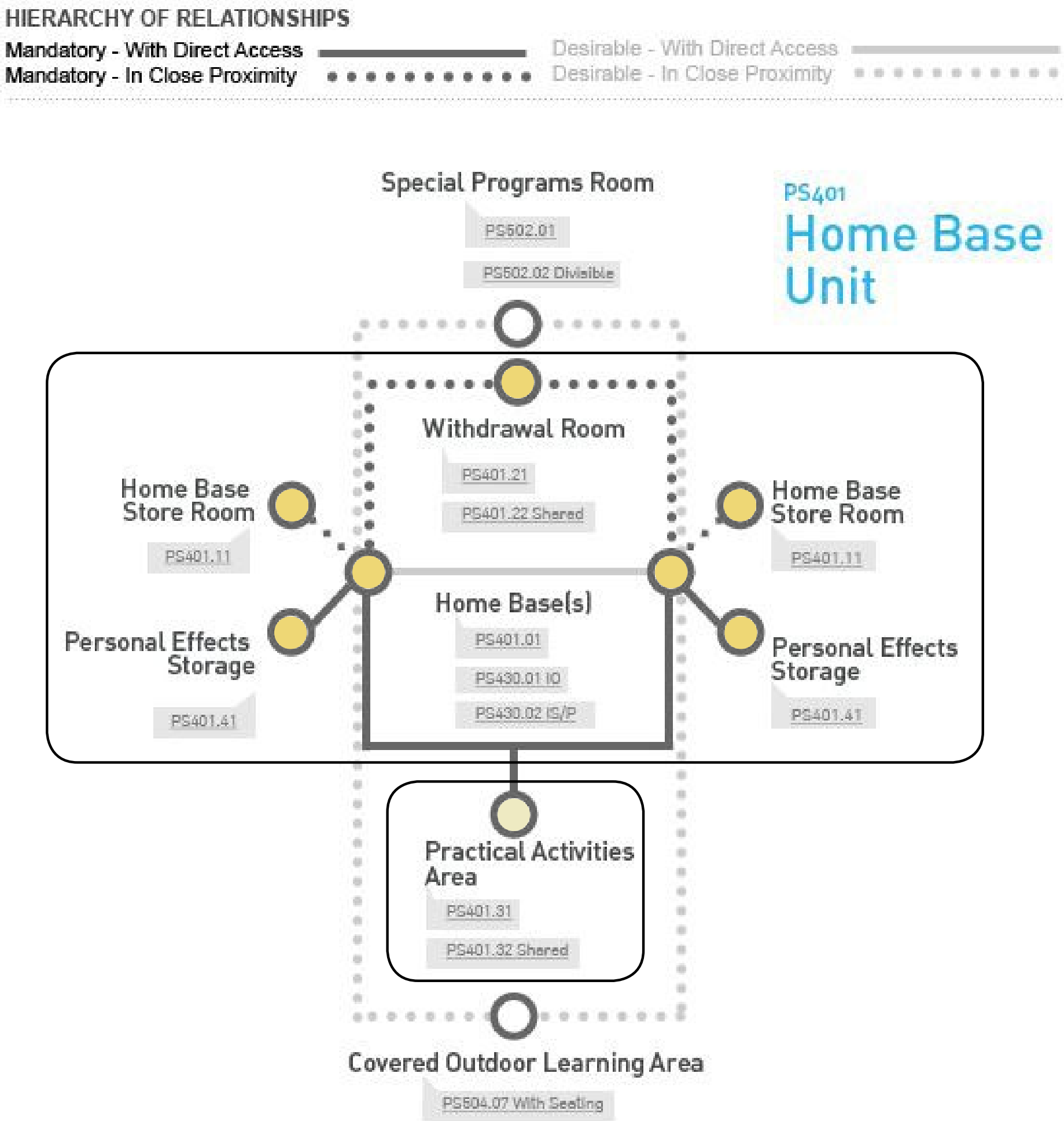
The functional relationships as determined by the EFSG and pedagogy typologies, are supported by the planning grid. The functional relationships for primary schools are shown in the following diagram



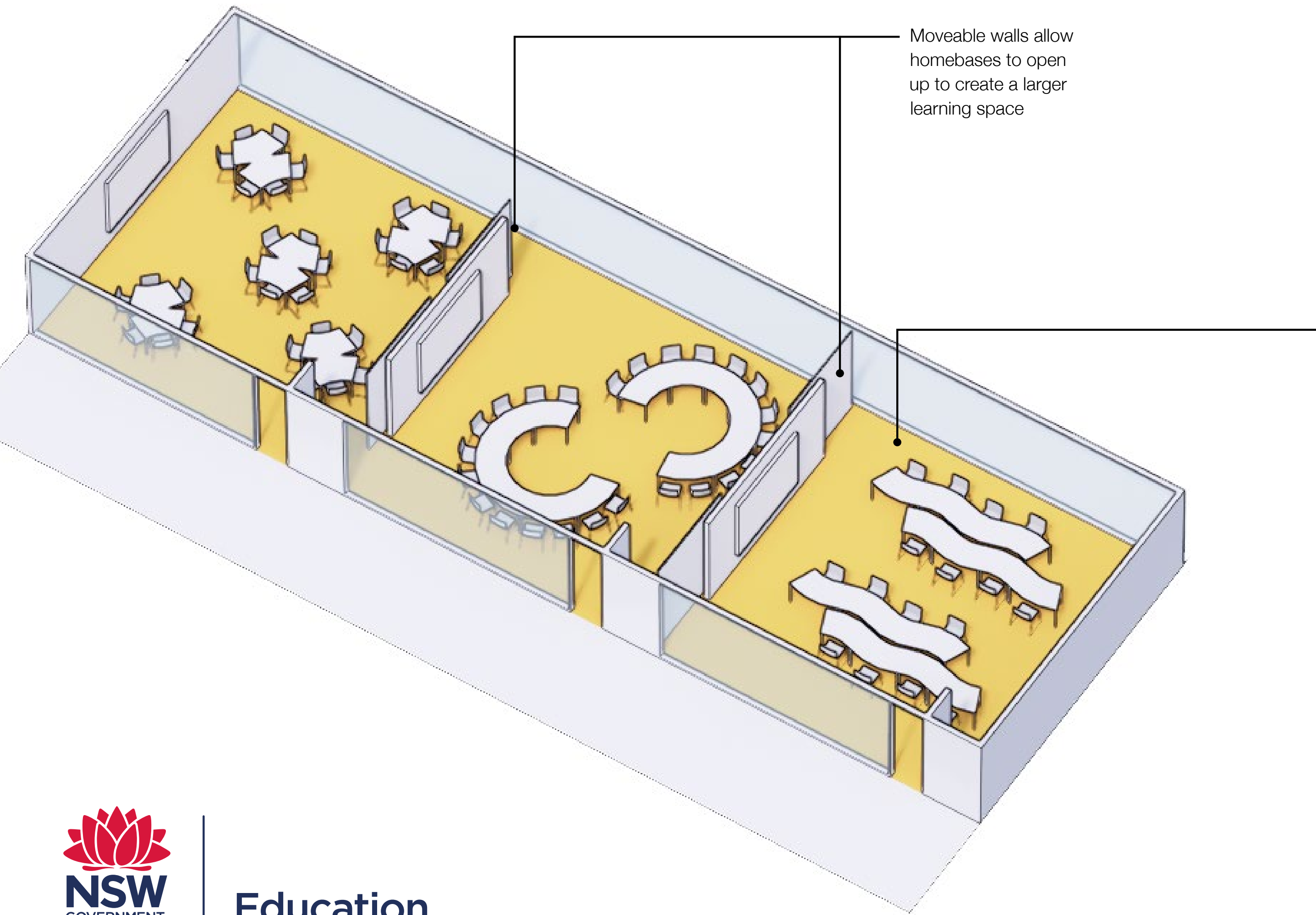
5.3 Homebase Module Type 1



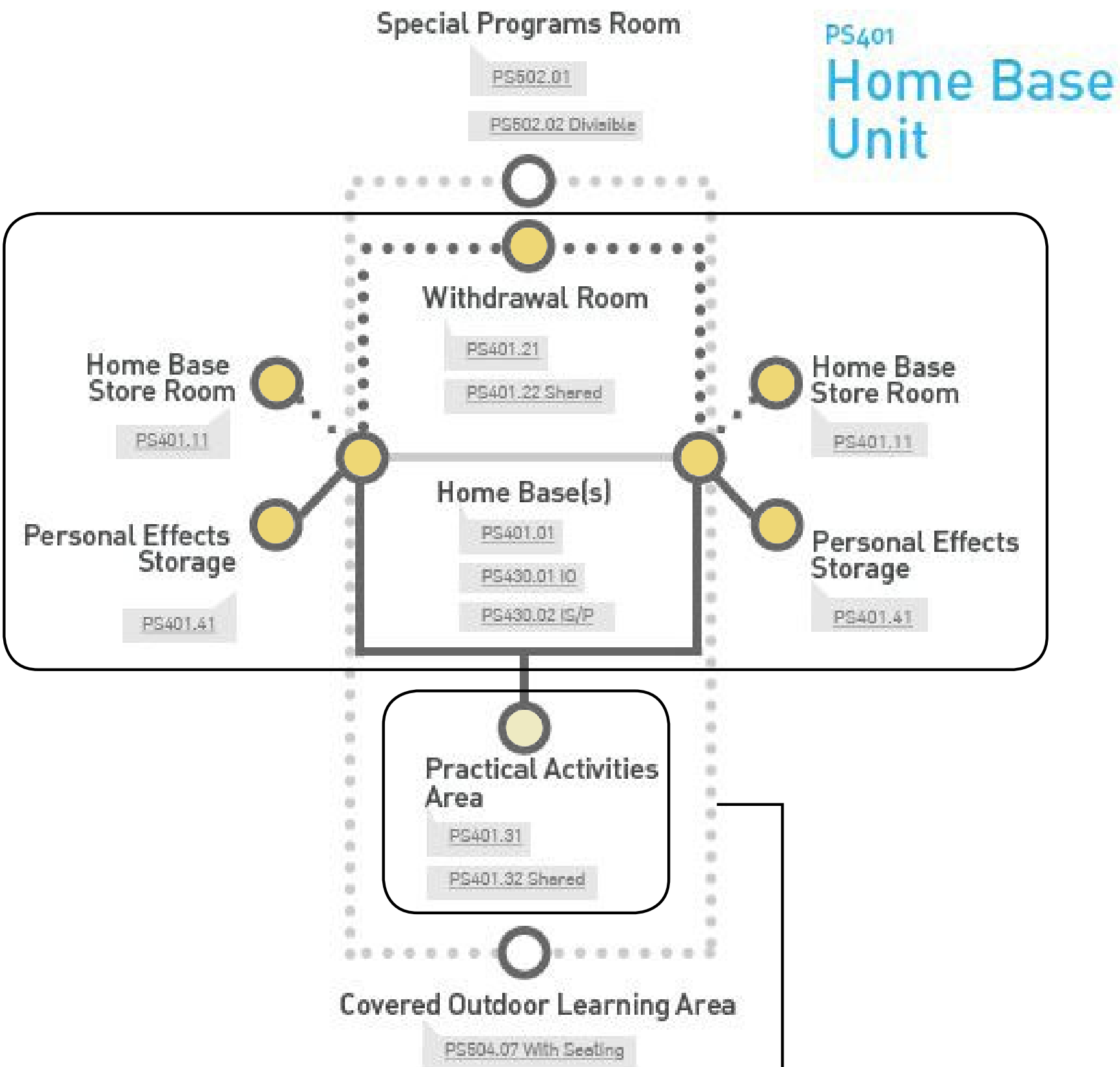
EFSG HOMEBASE UNIT RELATIONSHIPS



5.3 Homebase Module Type 2



EFSG HOMEBASE UNIT RELATIONSHIPS





## 6.0 DfMA Buildability Principles and 'Kit of Parts'

The DfMA buildability principles outlined the following section explain how the 9m x 9m education planning grid supports both volumetric and component DfMA solutions. The 'kit of parts' are all the components which are informed by the education planning grid and DfMA structural response.

# 6.1

## Planning Grid and Structure Buildability Principles

The 9m x 9m education planning grid was chosen as the dimensions which best support a standardised approach to the room types and floor plate designs of Public and High Schools. The 9m dimension also provides flexibility for volumetric and component DfMA and supports the SINSW sustainability strategy.

### Overarching DfMA buildability principles and objectives included:

- Nominating a maximum beam length which supports a clear span for teaching and learning spaces
- Enabling a sustainable building material response through maximum beam lengths; and
- Supporting volumetric / modular transportation logistics

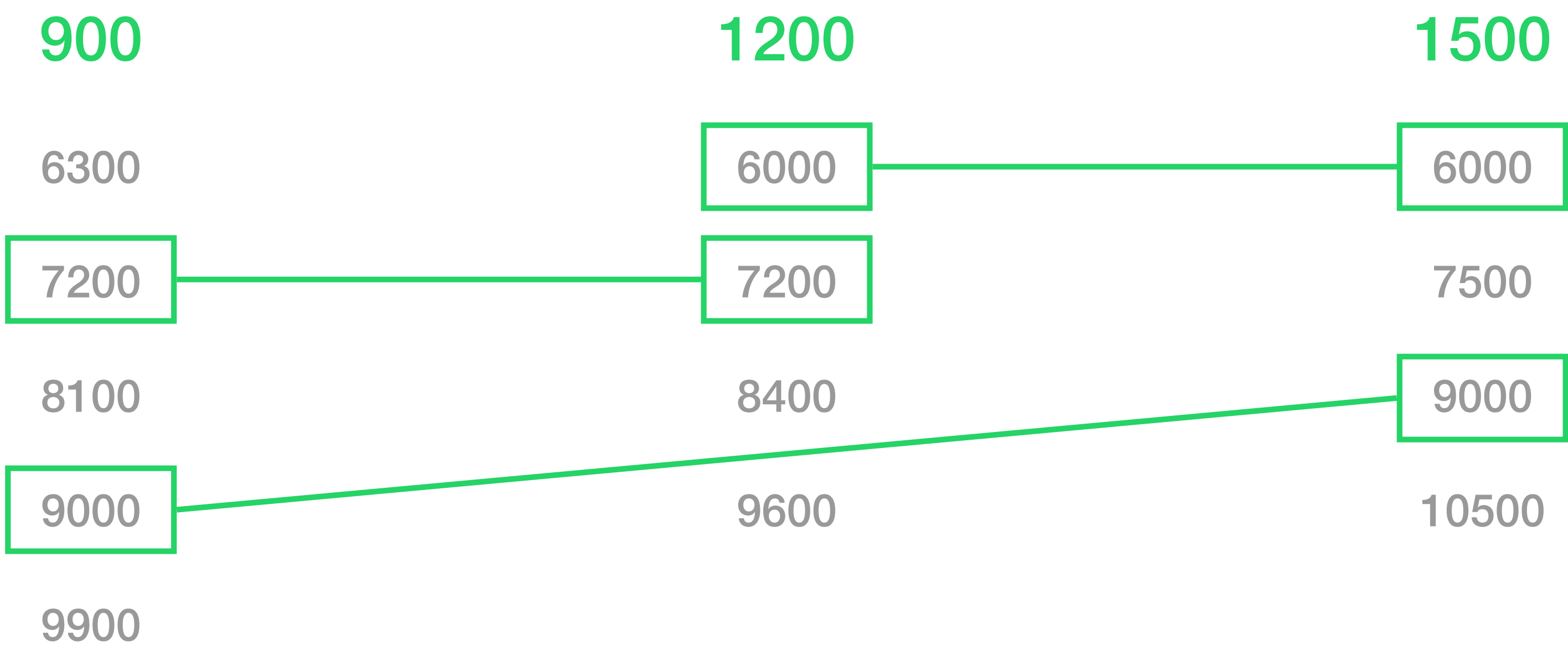
### The maximum 9m grid length:

- Supports the range of room types and learning spaces
- Supports the selection of mass timber construction including glulam beams
- Enables volumetric manufacturing for modules to be transported at dimensions of 9m x 3m and 9m x 4.5m whilst supporting the education planning grid principles; and
- Supports the traditional, standardised dimensions of external and internal panelised wall, façade and flooring systems

Standardising the planning grid to a 9m x 9m dimension enables standardisation of other parts including columns, beams, facades, wet areas etc. It is the first critical step in creating a standardised and repeatable approach to the design and delivery of school projects.

Most building elements (eg. floor panels, plasterboard, timber panels) are manufactured in some multiple of 900mm, 1200mm and 1500mm wide modules

To minimise waste and streamline the construction process (due to removing the need to cut elements to size on site), multiples of these numbers have been examined to find commonalities and determine the best size for the main classroom grid.



The diagram below takes the common multiples found in typical building element sizes, testing the various classroom sizes that can be created. As shown, 7.2m x 9.0m creates a classroom size that achieves the minimum standard requirements outlined in the EFSG. However this size and layout does not provide sufficient space for a variety of learning settings. The 9.0m x 9.0m creates a larger space which provides space that allows a variety of learning settings while also supporting the opportunity for future flexibility.

6.0m x 6.0m = 36.0m<sup>2</sup>

6.0m x 7.2m = 43.2m<sup>2</sup>

6.0m x 9.0m = 54.0m<sup>2</sup>

7.2m x 9.0m = 64.8m<sup>2</sup>

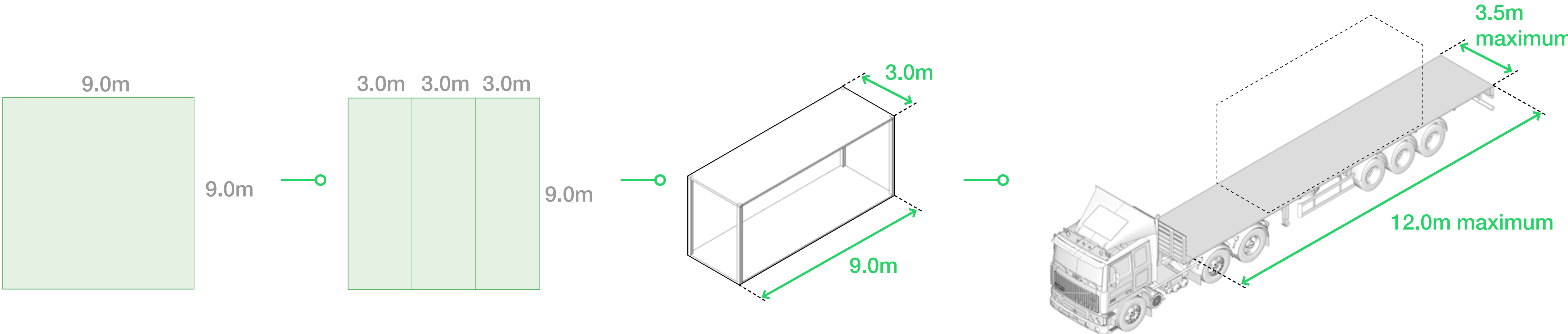
9.0m x 9.0m = 81.0m<sup>2</sup>

EFSG minimum standard which doesn't provide sufficient space for a wide variety of learning settings

Allows for a variety of learning settings to occur simultaneously and provides future flexibility

Desired grid.

The 9.0m x 9.0m classroom size can also be easily broken down into 3.0 x 9.0m modules. This allows ease in transport of all premanufactured elements to site.



## 6.2 DfMA ‘Kit of Parts’

DfMA is considered in terms of volumetric and component all of which are referred to as a ‘kit of parts’. An itemised list for the main ‘parts’ in each of the DfMA responses (volumetric, component and a hybrid of both) are listed below:

### Volumetric / modular & component ‘kit of parts’ definition

Definition of volumetric / modular and building component DfMA ‘kit of parts’

| Volumetric DfMA                                                                                                                                                                                     | Component DfMA                                                                                                                                                                                                                                        | Hybrid DfMA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>A DfMA solution of mostly finished modules including:</p> <ul style="list-style-type: none"><li>• Structure</li><li>• External Finishes</li><li>• Services</li><li>• Internal Finishes</li></ul> | <p>A DfMA solution using a number of manufactured components such as:</p> <ul style="list-style-type: none"><li>• Columns &amp; Beams</li><li>• Wall Panels</li><li>• Floor Panels</li><li>• Façade Panels</li><li>• Roof trusses or panels</li></ul> | <p>A DfMA combination of volumetric modules, pods and components such as:</p> <ul style="list-style-type: none"><li>• amenity/core modules</li><li>• post and beam structure</li><li>• floor &amp; roof panels</li><li>• façade panels</li></ul> <p>OR</p> <ul style="list-style-type: none"><li>• bathroom pods</li><li>• services riser pods</li><li>• precast lift and stair cores</li><li>• post and beam structure</li><li>• floor &amp; roof panels</li><li>• façade panels</li></ul> |
|                                                                                                                |                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

When considering the structural grid response to the education planning grid dimensions, the following considerations were assessed.

## Component DfMA structural grid considerations for ‘part’ sizes:

### 1. Column Grid

- The smaller the grids the smaller all elements will be and the more cost efficient the structure will be on a per m2 rate
- Smaller grids however provide less flexibility to use of the space and columns may interfere with open space learning environments
- The 9m x 9m grid supports the SINSW explicit and open, flexible learning spaces

### 2. Primary Beams

- The longer the spans the larger and deeper the beams are which will effect floor to floor heights and coordination of services reticulating through ceiling areas
- Timber and steel typically have similar beam depths
- Beams should be limited to be no deeper than 900mm whilst still providing for penetrations through beams for reticulation of services.
- Spans should be limited to 9m which supports all material responses including glulam beams which supports the SINSW sustainability objectives

### 3. Secondary Beams

- Secondary beams that span between primary beams can be used to provide additional support to floor panels reducing their thickness and therefore cost
- Consideration should be given to the depth of beams to ensure services can reticulate and ceilings are maintained at an acceptable height
- Secondary beams should be kept to a maximum depth of 500mm and therefore should not span any longer than 9m which also suits glulam beams

### 4. Floor (and roof) Panels

- Floor panels can be concrete, steel or timber.
- Floor panels can be solid (like concrete and Cross laminated Timber) or cassettes (using steel or timber joists)
- Floor panels can span a maximum of 9m between primary beams however this will result in thicker floors (say 200-250mm) which will be more expensive
- Floor panels can be supported over secondary beams, reducing their span, being thinner (say 120-180mm) and more cost effective
  - › Floor cassettes will typically span a maximum 9m between primary beams without the need for secondary beams, however they will be thicker (say 400mm thick).

Volumetric DfMA structural grid considerations for ‘part’ sizes:

5. Transport restrictions

- Transport logistics have a significant influence on the sizing and design of volumetric modules
- Considerations for optimal transport dimensions for a typical low loader truck travelling between 12am and 5am and requiring a permit include:
  - › A maximum width of the module is 4.8m however a 4.5m width supports the 9m x 9m grid
  - › A maximum length of 18.0m which also supports the 9m grid
- › A maximum height of 4.1m
- Considerations for efficient transport dimensions for a typical semi-trailer truck travel between 10am and 4pm and not requiring a permit include:
  - › A maximum width up to 3.5m
  - › A maximum length of 16.0m
  - › A maximum height of 3.0m

Whilst Volumetric DfMA has more limitations than Component DfMA due to transport logistics, it is an appropriate response to many school building projects located in greenfield and regional sites. Bearing this in mind, the education planning grid has been tested for suitability for both volumetric and component DfMA solutions. This is evident in the case study assesement for the Chatswood Public School.

## 7.0 Case Study: Chatswood Primary School



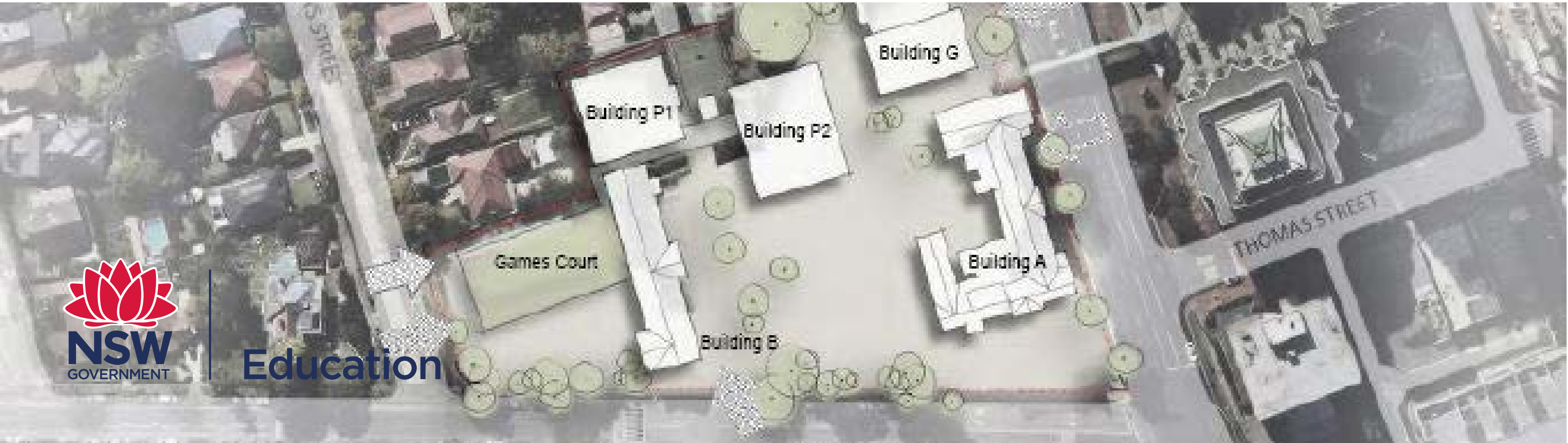
## 7.1 Site Location



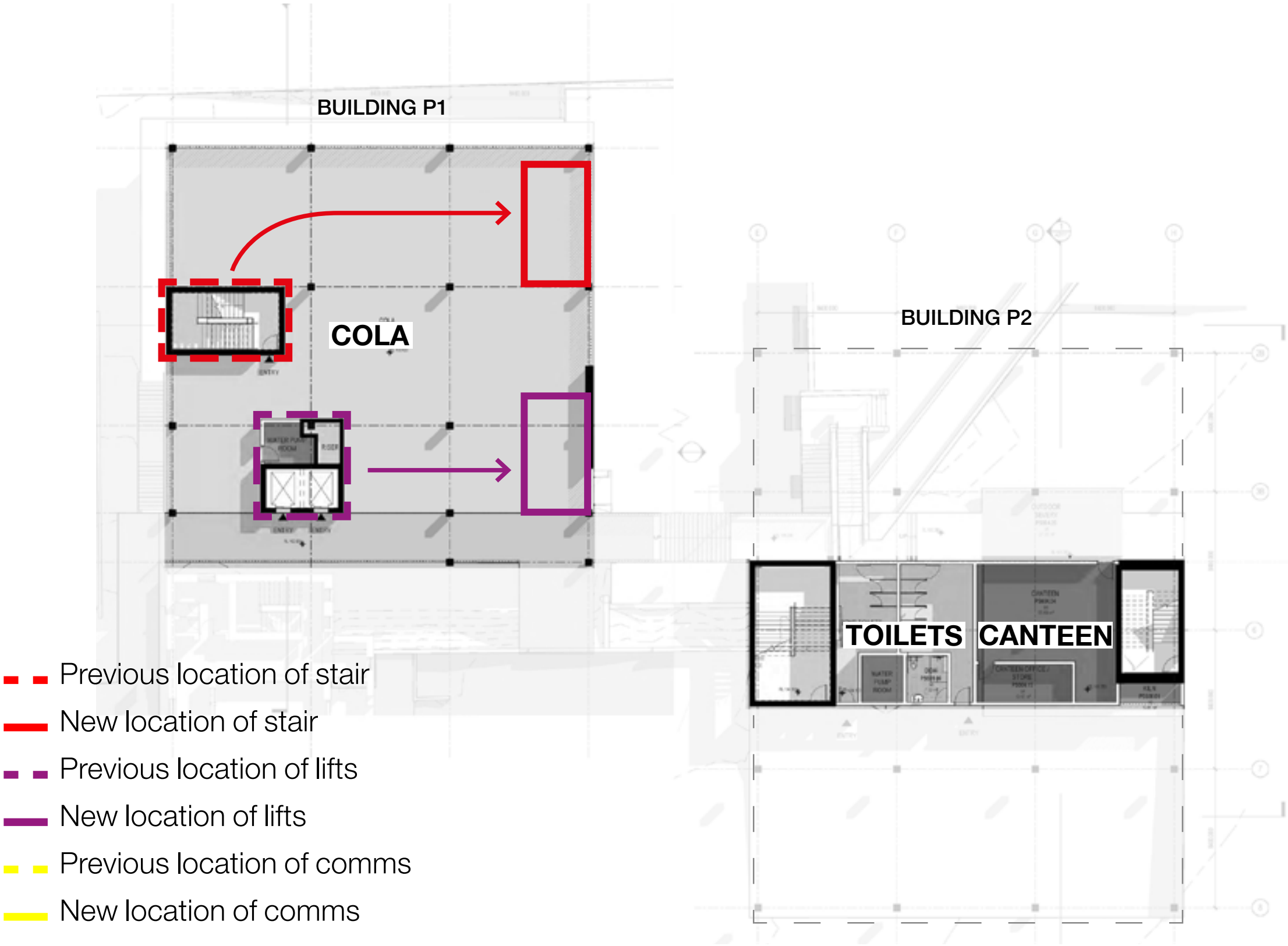
**07 Concept Design**  
Pacific Highway  
View of Lower from James Street



**7.2**  
Original Concept  
by Architectus



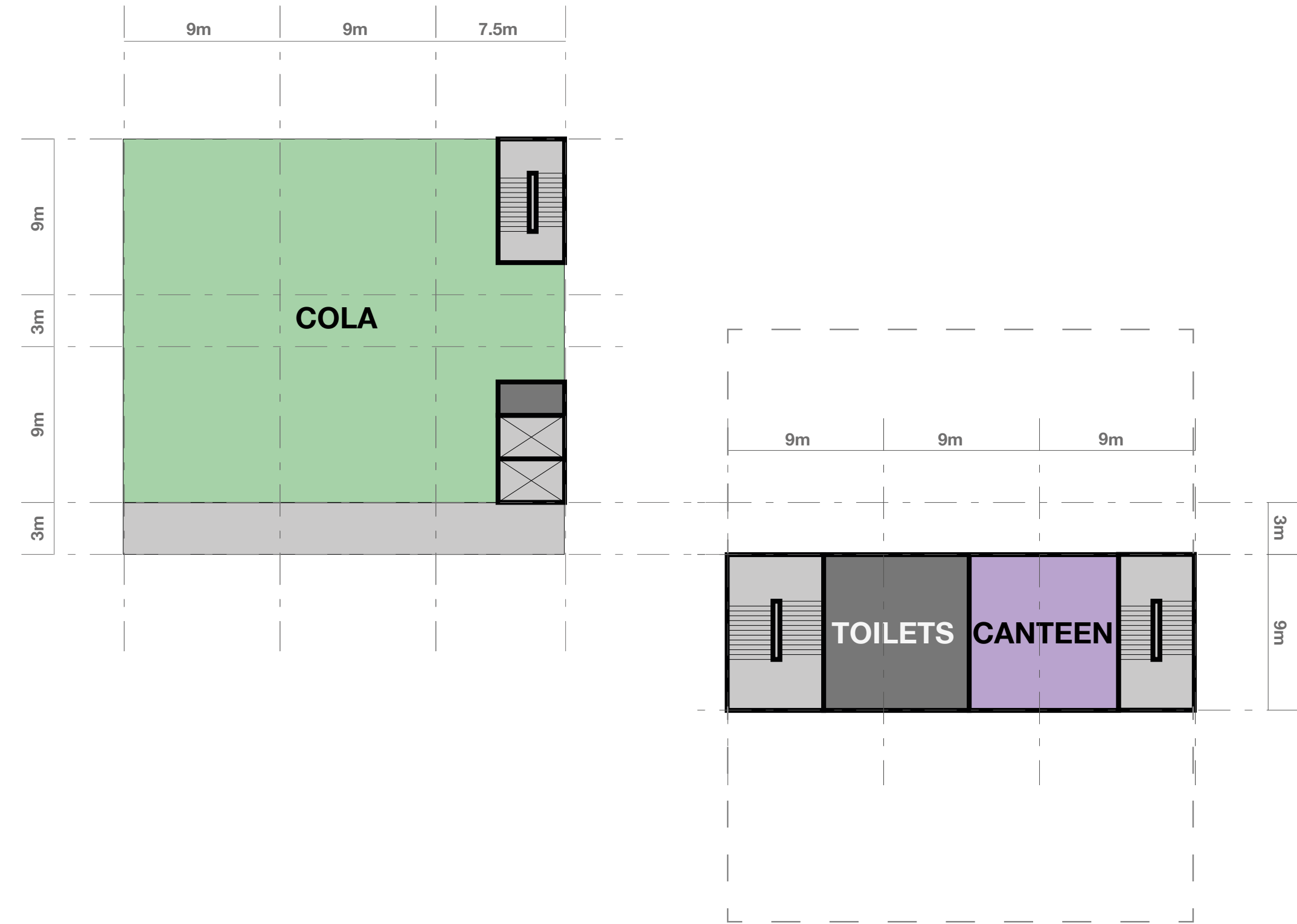
## Changes to Ground Plan



The stair core and lift cores are relocated to the eastern side of Building P1 in order to free up the floor plate to apply flexible layouts. The COLA is retained and is now a more contiguous open space with greater staff surveillance.

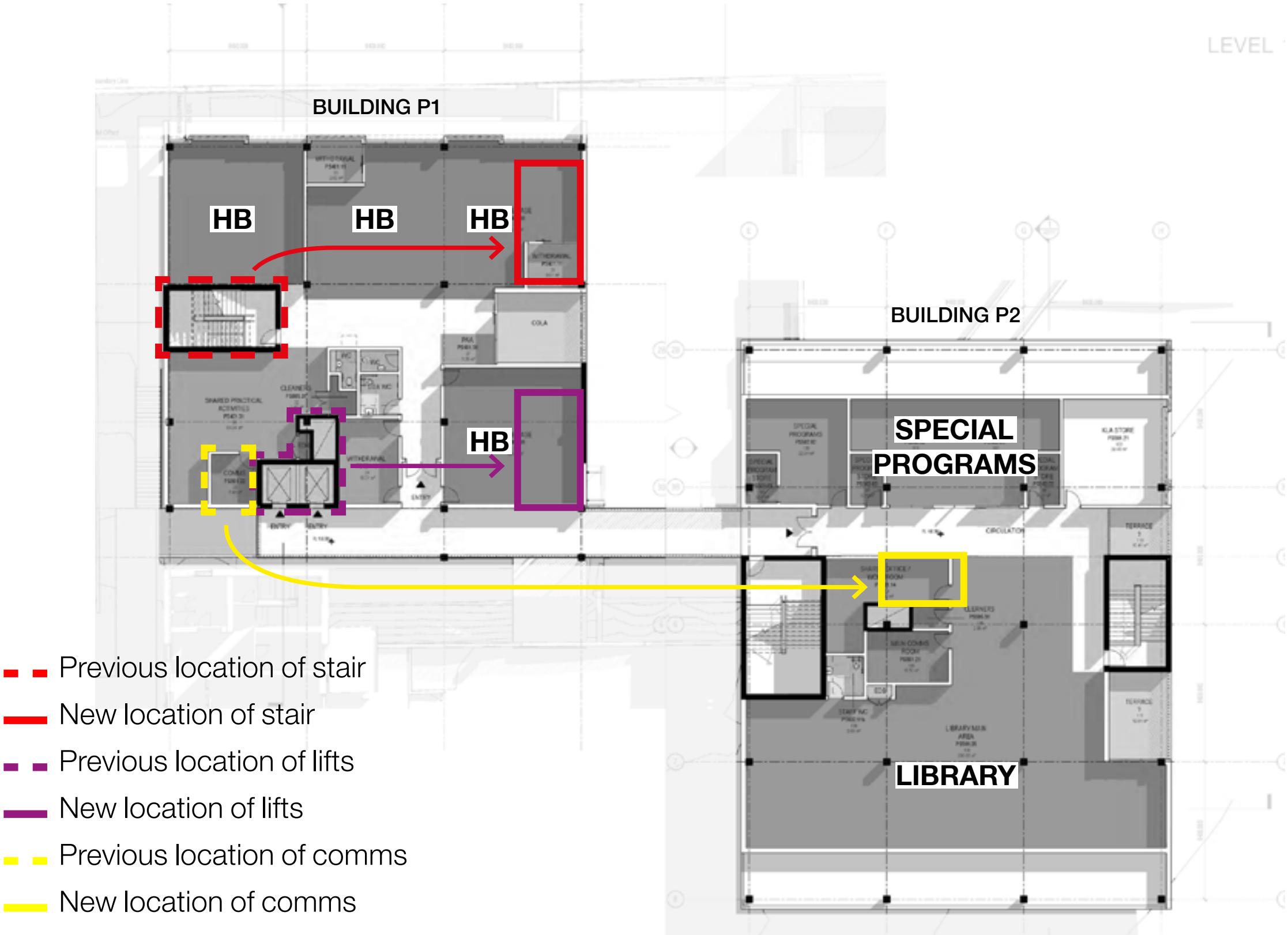
Building P2 is retained unchanged. With an exploration into a Fire Engineered solution, it may be possible to reduce the number of stairs in Building P2.

## Proposed Ground Plan



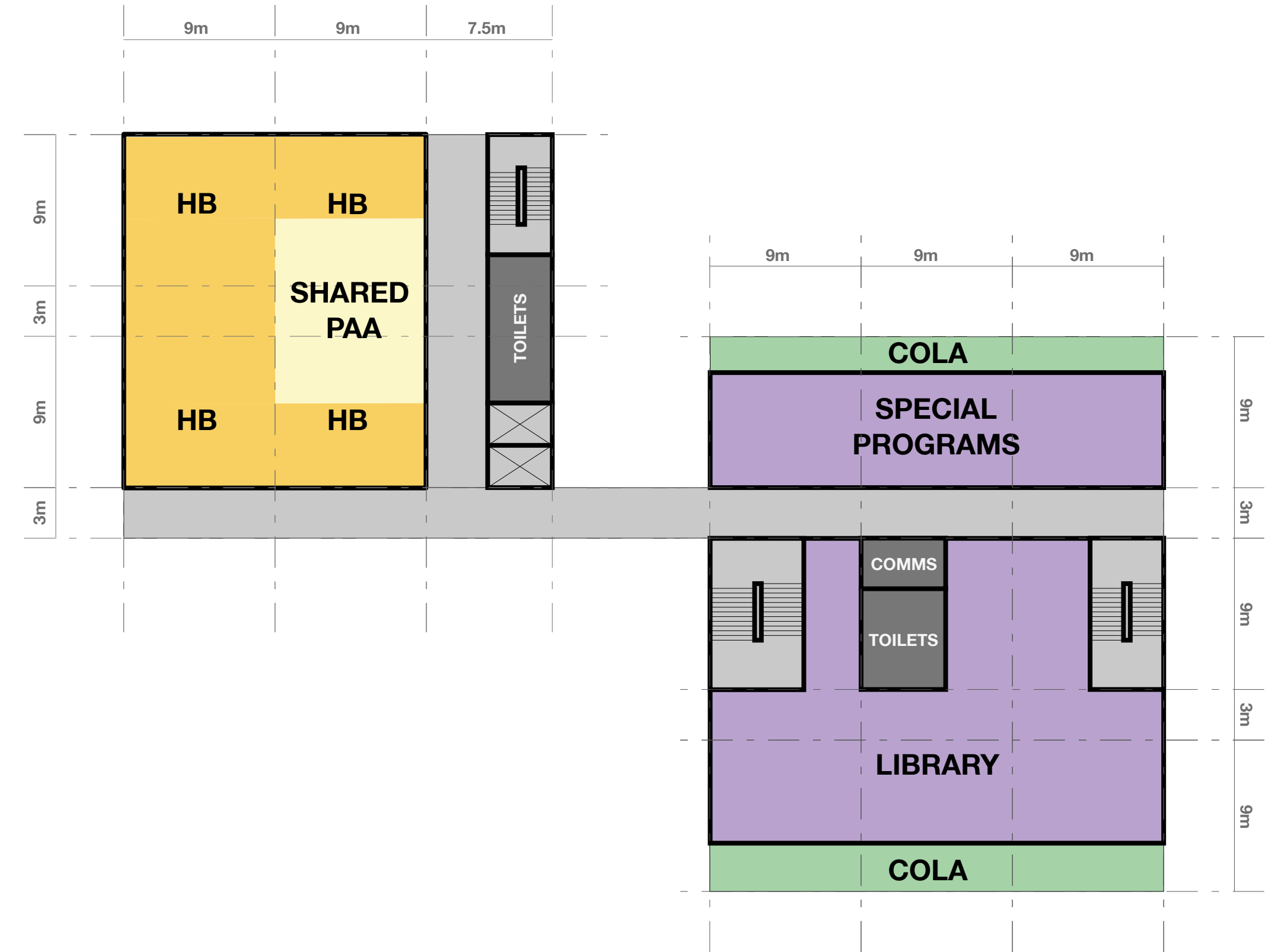
The 9m x 9m grid rationalises internal spaces, allowing services and circulation to be grouped, creating a clear distinction between learning spaces, circulation zones and service cores.

Changes to Level 1



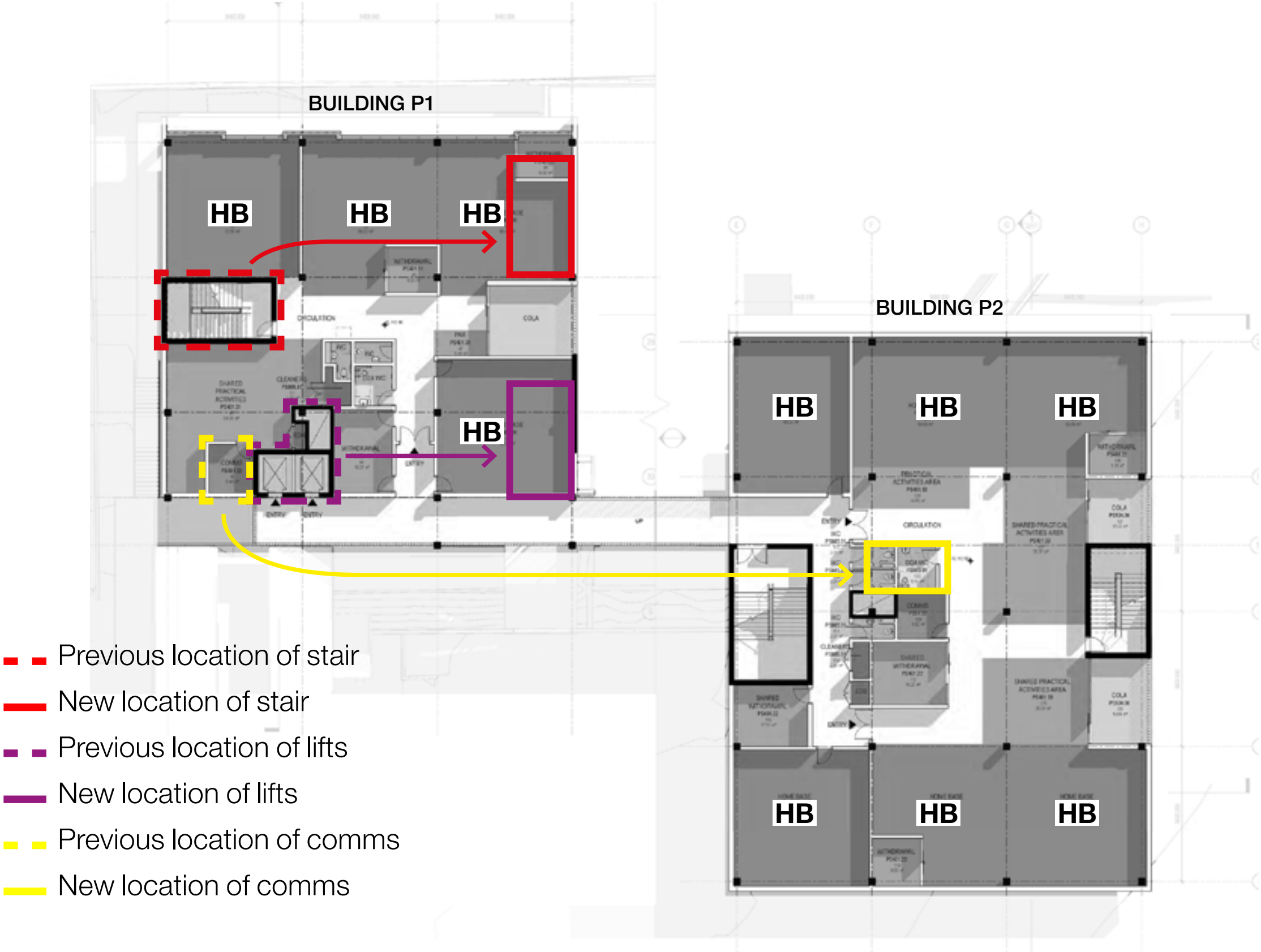
As with the Ground Floor, the cores are relocated to the east and the comms room is located into building P2. The special Programs and Library and associated COLAs remain unchanged.

Proposed Level 1



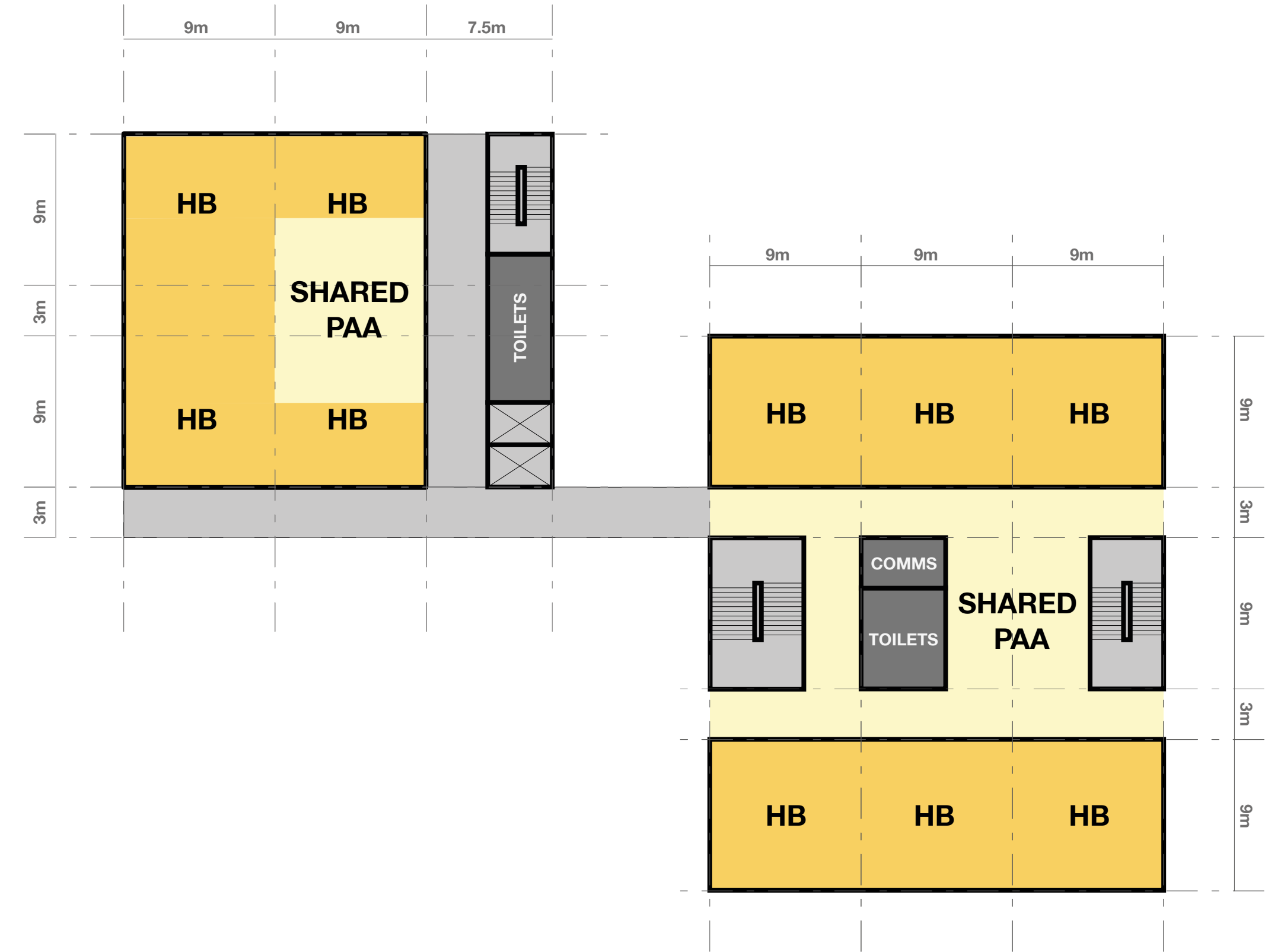
A cluster of 4 Homebases is provided in Building P1 with access from the corridor to the east. And toilets are provided within the core to create a flexible floor plate.

Changes to Level 2 & 3



As with the previous Levels, the cores are consolidated.

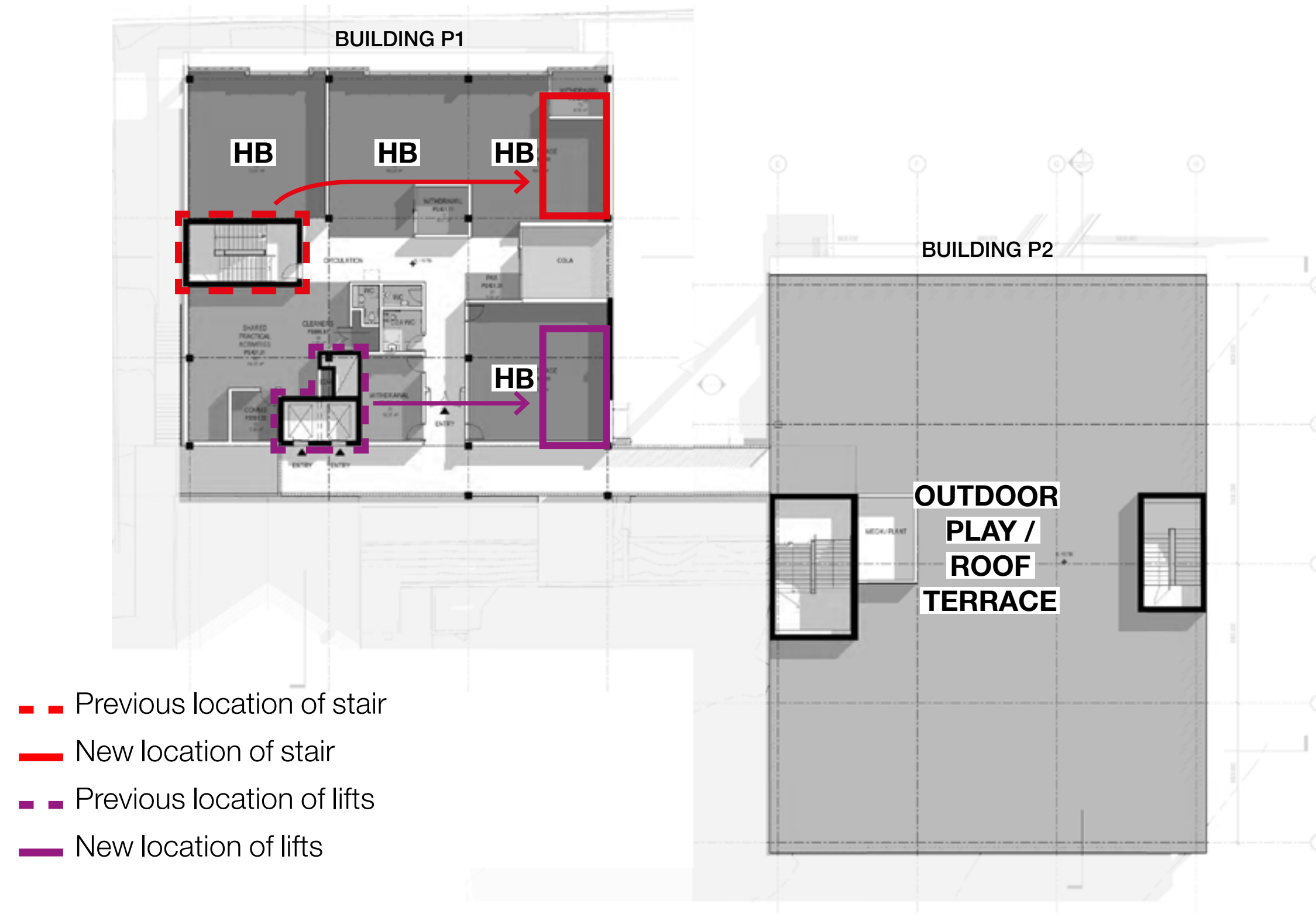
Proposed Level 2 & 3



Building P1 features the cluster of 4 Homebase type and Building P2 has the linear group of 3 Homebases on the north and south facades creating a central shared Practical Activities Area large enough to cater for all 6 rooms.

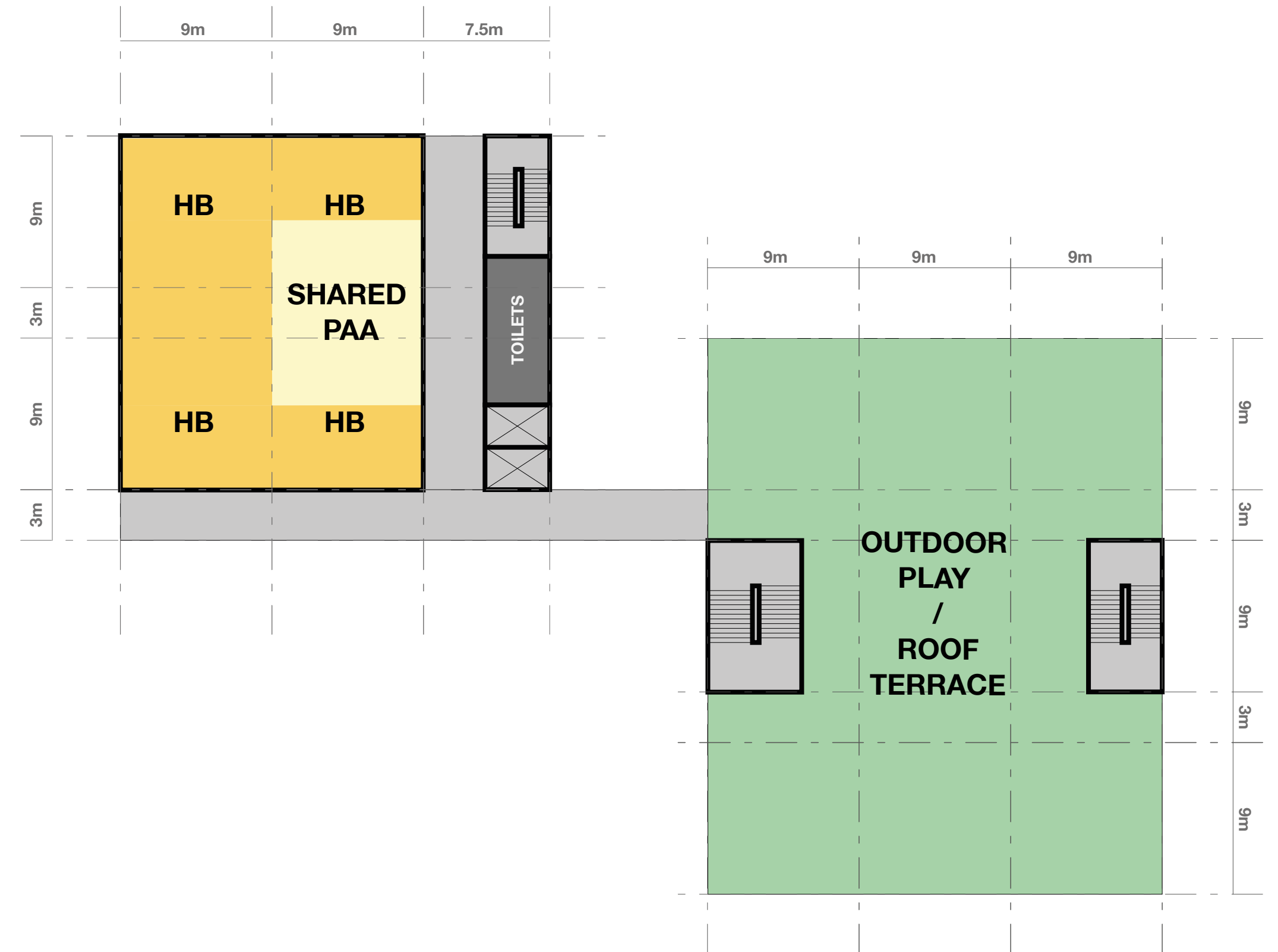
Each room in the linear cluster is large enough to accommodate the space for withdrawal rooms (not provided as enclosed rooms), the Personal Effects Storage and the Stores.

## Changes to Level 4



The typical core layout continues from the previous levels and the Outdoor roof play space is retained.

## Proposed Level 4



Constructability

Rationalisation of the planning grid enables a more efficient and repeatable facade and structural response which in turn improves program, delivery and cost efficiencies. A rationalised grid supports a range of materials for structural and facade treatments which are responsive to the context and micro-climate environment.

Concrete framed structure



Steel framed structure



Cross laminated timber



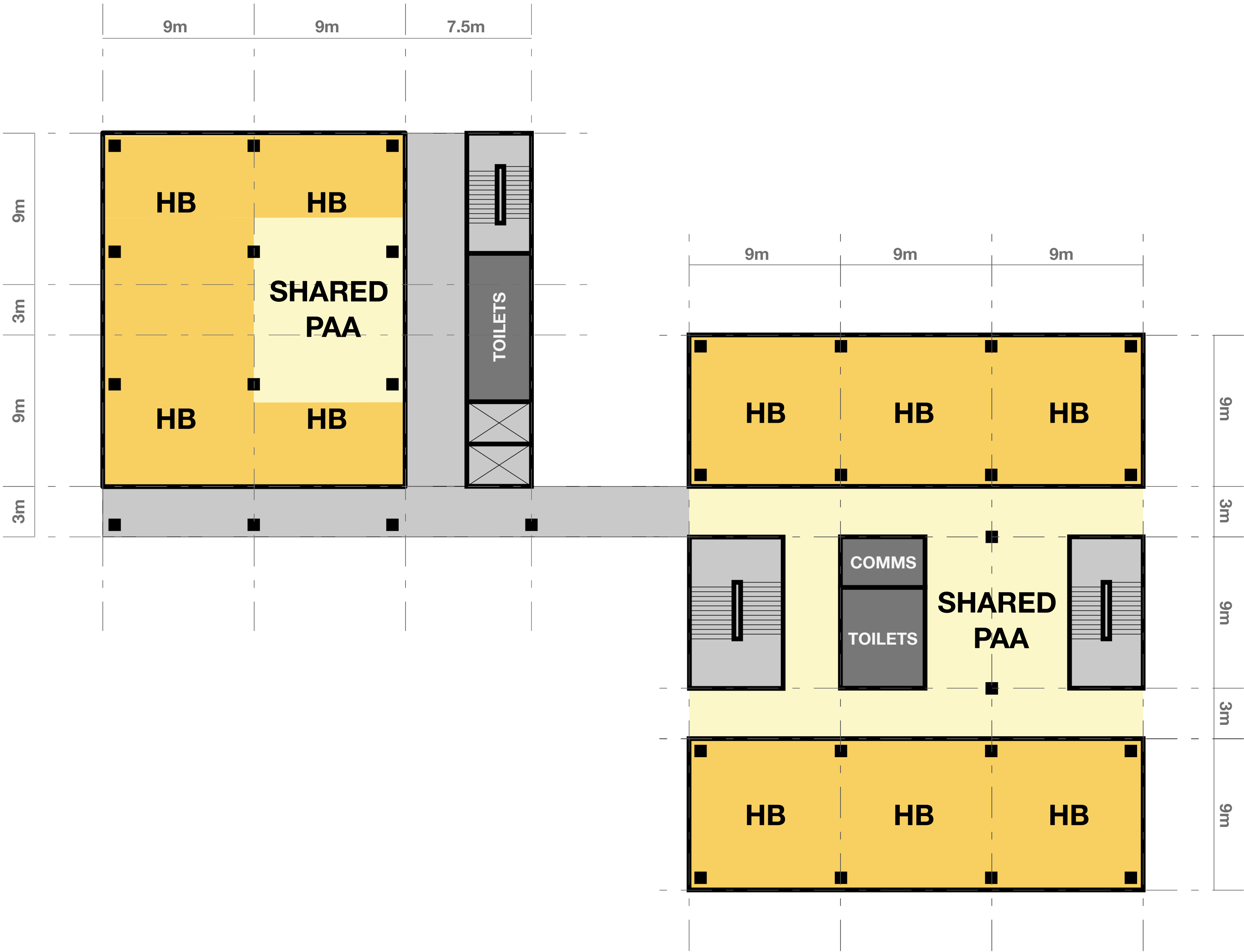
Prefabricated volumetric



Concrete, steel or cross laminated timber construction

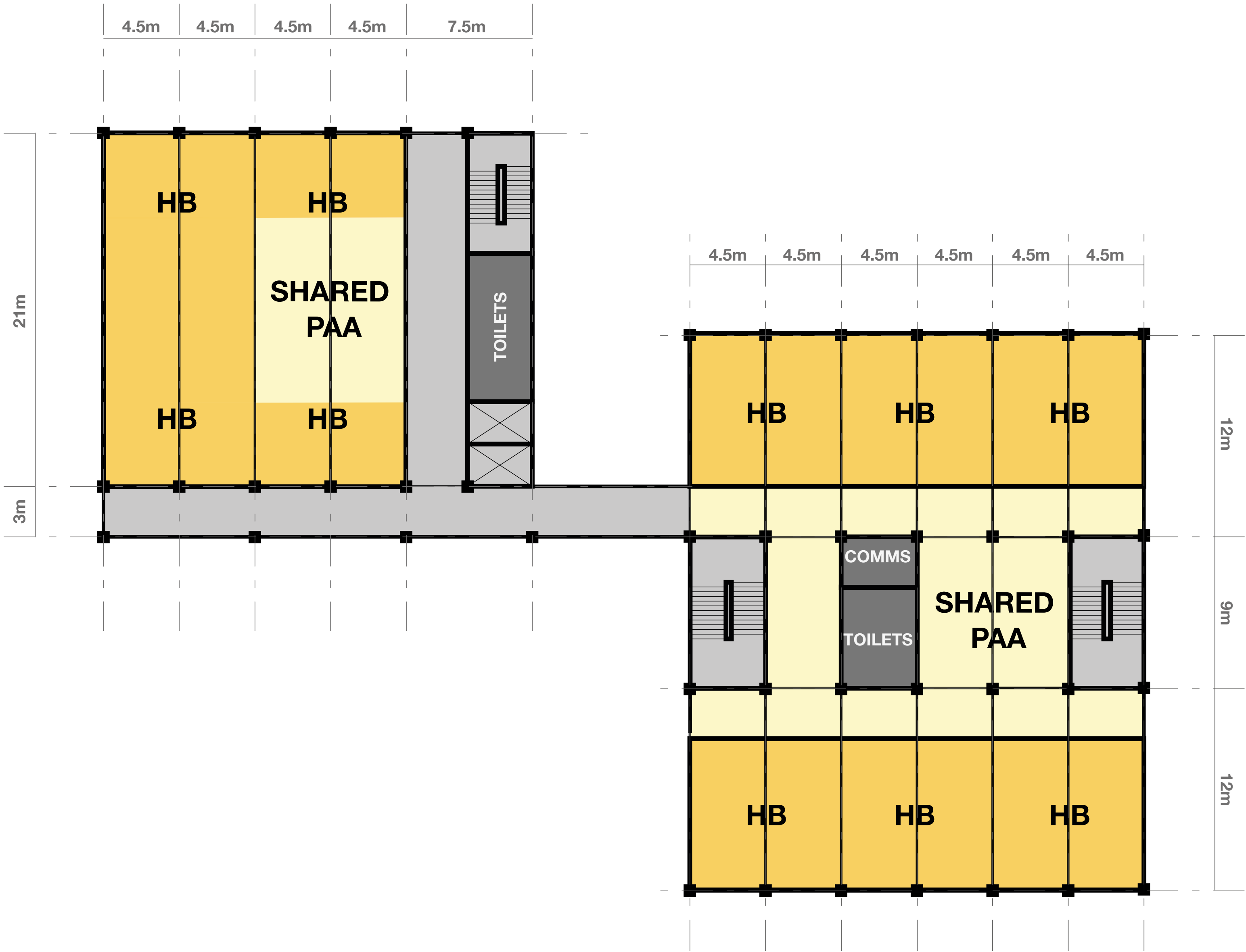
The DfMA approach allows the capabilities of a variety of construction methods. The placement of columns at a maximum of 9.0m apart means that there is no interference in any learning spaces and. Concrete and stell construction methods benefit from the standardisation of column placement but also allow facade design to be suited to each individual location.

Cross laminate construction is an evironmentally sustainable methodology that uses the same column placement as concrete and steel. It provides an opportunity to bring the aesthetics of the outdoor, into the classroom.



Volumetric DfMA

The volumetric prefabricated method allows for modules to be fabricated off site with on-site assembly. Large modules of 21m x 4.5m and 12m x 4.5m create flexibility for future changes and larger open areas.





Education