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1. Introduction

Objective

This study is to develop a Heritage Information Modeling (HIM) prototype for the Victoria Peak Fire Station (VPFS) to help the heritage conservation and facility management of Historic assets managed by ArchSD. It is a pilot project for the adoption of HIM. The process of HIM shall be or will be applicable to other heritage projects of similar nature.

Selection of the project

1.1 Surrounding Area

The fire station is located on the Peak which is a major attraction of Hong Kong with over seven million visitors every year. It offers spectacular views of the city and Victoria Harbour. Other than its value of tourism, the Peak also has its own story. Standing at 552 metres above sea level, the Peak is the highest mountain on Hong Kong Island and a natural signalling post for incoming cargo ships in the nineteenth century. The more privileged early residents, however, found it the perfect retreat from Hong Kong scorching summer heat. Further development of the Peak did not really occur until Alexander Findlay Smith, who had worked for Scotland's Highland Railway, managed to petition the Governor, Sir John Pope-Hennessy, in 1881 to operate tram routes. One of them connected the south of Murray Barracks to Victoria Gap on the Peak. The Peak had attracted its prestigious residents since the 19th century. The selection of this site for the HIM study is based on its enriched historic background.

1.2 Fire Station

Victoria Peak Fire Station was built as a school in 1915, with the popular Arts and Crafts architectural style of the Edwardian period found in UK. . Its unusual 'sun-trap' butterfly plan was feature beloved by Arts and Crafts architects. To fulfil a need in the district, the school turned into the fire station in 1967 to continued service to the community.

Other features of this style of architecture are the red brick half roughcast rendered wall, semi-circular door and window openings with their 'sun-ray' decoration, and bull's-eye windows. The Chinese tiled roof is a local adaptation, internally there are two typical tiled fireplace surrounds of the period.

1.3 Historical Aspect

2 major historical aspects of the Victoria Peak Fire Station will be listed as study items for the project. The first is cultural aspect, as its past use as a school and the high educational achievements of its pupils who were the children of residents on the Peak. Second is the architectural / heritage aspect, as it is one of the few surviving examples of Arts and Crafts architecture in Hong Kong.

As VPFS represents the heritage value of Arts and Crafts architecture in the area, it is being selected for the production of HIM study.

1.4 Difficulties for the historic

The building was built before World War II, it may have been somehow damaged during the Japanese Occupation period. But the Japanese Occupation is also an important part of building and Hong Kong history, so not just the Arts and Craft architectural feature but also the damage during World War II are indispensable.

As building is occupied as a fire station right now, the internal scanning could not be taken as a vacated area, extra time and effort are required for the internal scanning.

What is HIM?

HIM is an extent of the swift-developed Building Information Modeling (BIM) nowadays. It is not just a digitalized building with physical, architectural, functional social and cultural characteristics, but can also with the implementation of new technologies, HIM provides a new way for working in collaboration. The asset data and three-dimensional model can be used for effective management and create more effective methods of maintaining and conserving the heritage buildings.

New technologies such as Laser scanning, unmanned aerial vehicle (UAV) based photogrammetry are used for the BIM process. Radio Frequency Identification (RFID), near field communication (NFC) tags, quick response (QR) code, augmented reality (AR) are being used for the user-friendly detection of heritage tourism and maintenance workflow at the heritage site.

Similar Overseas Examples

The application of BIM in historic buildings is not outlandish in the conservation arena. Many countries used the technologies like laser scanning, aerial and geo-referenced photogrammetry, and close range photogrammetry with geo-information for the BIM process of asset for heritage conservation.

Case study undergone by the Department of Structural, Geotechnical and Building Engineering (DISEG) of Polytechnic University of Turin in 2013 provides an investigation of application of laser scan surveying to the BIM process of the campus.

Link: http://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XL-5-W2/225/2013/isprsarchives-XL-5-W2-225-2013.pdf

Conference paper published in 2012 by Dublin Institute of Technology discussed the BIM process from laser scanning and photogrammetry and the linking of data for facility management. Case study was carried out at Henrietta Street in Dublin.

Link: http://www.academia.edu/2099497/Integration_of_HBIM_and_3D_GIS_for_Digital_Heritage_Modelling

Research including 19th century heritage buildings in the urban core of Toronto, Canada; a 600 hectare village in rural, South-eastern Ontario with modern heritage value conducted by Autodesk research team in Canada is an example of the implementation of laser scanning to BIM process for heritage and heritage documentation with time factor. It purposed to investigate the construction of BIM with the cooperation of quantitative asset data (performance data) and qualitative asset data (historic photos, oral histories, music).

Link: http://www.autodeskresearch.com/pdf/Fai.pdf

Most of researches carried out through are about the implementation of surveying methods (laser scanning and UAV photogrammetry) in BIM process on heritage and the setup of data base of asset for heritage conservation, but very little research has discussed the retrieval and the inputting of asset data and its further utilizations. In this research, the aspect of data retrieval and inputting methods like AR, RFID, NFC and QR code will be interpreted and proposed.

2. Report Scope

The fire station building is one of the few surviving examples of Arts and Craft architecture piece in Hong Kong, and it's closed to a number of historic buildings, such as Former Chatham English School in No.1 Chatham Path, Matilda Hospital in No. 41 Mount Kellett Road, the Peak Café in No. 121 Peak Road, the Peak Tramway Office in No.1 Lugard Road, the Peak Depot in No.102 Old Peak Road, Ho Tung Gardens in No.75 Peak Road the Peak Police Station in No.92 Peak Road. All of these buildings form a great historical area on the Peak and they represented the historic value of Hong Kong architecture.

New technology will be introduced into the historical building maintenance and history sharing. The historical information input, maintenance information input, asset management information and historic storytelling information will be included.

Photogrammetry and laser scan are the best solution for information collection. Since most of the historical building were built before World War II, some of the original building information were damaged or lost during the war. As the deviation of laser scan is less than 3mm, this is the best way to collect the existing / historical information compared to all other traditional ways.

BIM software (Revit) will be used to rebuild the model in virtual based on the point cloud collected by photogrammetry and laser scan, so that the information could be combined with drawings and stored in the model. And also these information could be store in cloud or other digital formation, which will be much easier to maintain. The choice of Revit is based on its popularity in the industry, user-friendliness and connectivity. It is, by far, the most widely adopted platform among government such as Housing, MTR, and other private development projects.

Further to the BIM technology adopted for building maintenance and building management, the other magnificent technology to be introduced is AR (Augmented Reality). This is a great way to combine reality and virtuality together, so that new values can be extracted from. Intelligent devices such as smart phone or tablets could use to scan the building or part of it, history of the building and stories happened to or in the building will pop-up during the scan. The heritage is no longer an old building stands by its own as the stories of building could bring people back to its greatest period. As its history is our history.

2.1 Key Issues

i) Some of the features need to be laser scanned and modelled for higher LOD (Level of Development), such as 3 fire places. Accuracy is essential.

ii) Combination of Photogrammetry and Laser scanning technology and techniques

iii) Automatic or semi-automatic transformation from Point Cloud file to BIM Model

iv) Publish of BIM information onto Cloud Based system

v) Apps need to be devised to receive web based information.

vi) The mapping of reality objects and the BIM objects is the key concern. Exact location of object disposition may experience minor displacement due to detection tolerance.

vii) The display of information is an appropriate format is another key issue. Even though the data/ information are hosted online, the different format of devices are of great variety and format. For this study, we may have to limit to one or maximum two devices for this study purpose.

viii) The selection of various detection technologies is also a key issue. Although the data stored in a proper way, the retrieval methods needed to be reasonable for the cost and the targeted users.

ix) Comparison of Cloud platforms used to store all data is another key concern. As the platforms have different ability to show the data. It is necessary to find proper platform for the prevailing of data to different users. Comparison of cloud platforms will be discussed in section 15.

2.2 Constraints

i) As the building is occupied now by the fire station, negotiation is required with fire station staff when laser scanning take place. Internal laser scanning shall take less than 2 full working days to minimize the impact for fire station.

ii) Mobile technology is the key to success of this project. Information, need to be store at Cloud and be accessed via internet. Government data, however, are not supposed to be hosted onto private cloud. Government owned private cloud with accessibility control may be an issue.

iii) Capacity of Mobile devices is limited still, the maximum amount of information, need to be tested, especially for large data format such as historical footage.

iv) Determination of location is the key issue. External location is straight forward with the adoption of GIS with mobile device. Internal location, however, relies on non-standard techniques such as iBeacon, Wi-Fi location or optical recognition mapping (QR Code). The accuracy for internal location in the current technology status is still yet to be improved. GIS does have its limitation. The accuracy of GIS is not enough compared with other positioning methods. In external location, object with large area coverage, such as building will be accurate but small object will be inaccurate and not enough to do the positioning. The signal of GIS cannot be received by any device indoor. GIS will not be a consideration for Indoor condition. For the purpose of HIM, it is recommended to apply iBeacon as the prevailing exercise as it has the least setup time and cost.

2.3 Special Requirement

i) Investigation of adoption of cloud technology from ASD (or from government) is essential for data transfer. For the course of this study within this contract time frame, different cloud system, even vendor cloud system, may need to be employed as a test for the implementation of the HIM Framework. In the long run, government (HIM) cloud need to be established for data storage.

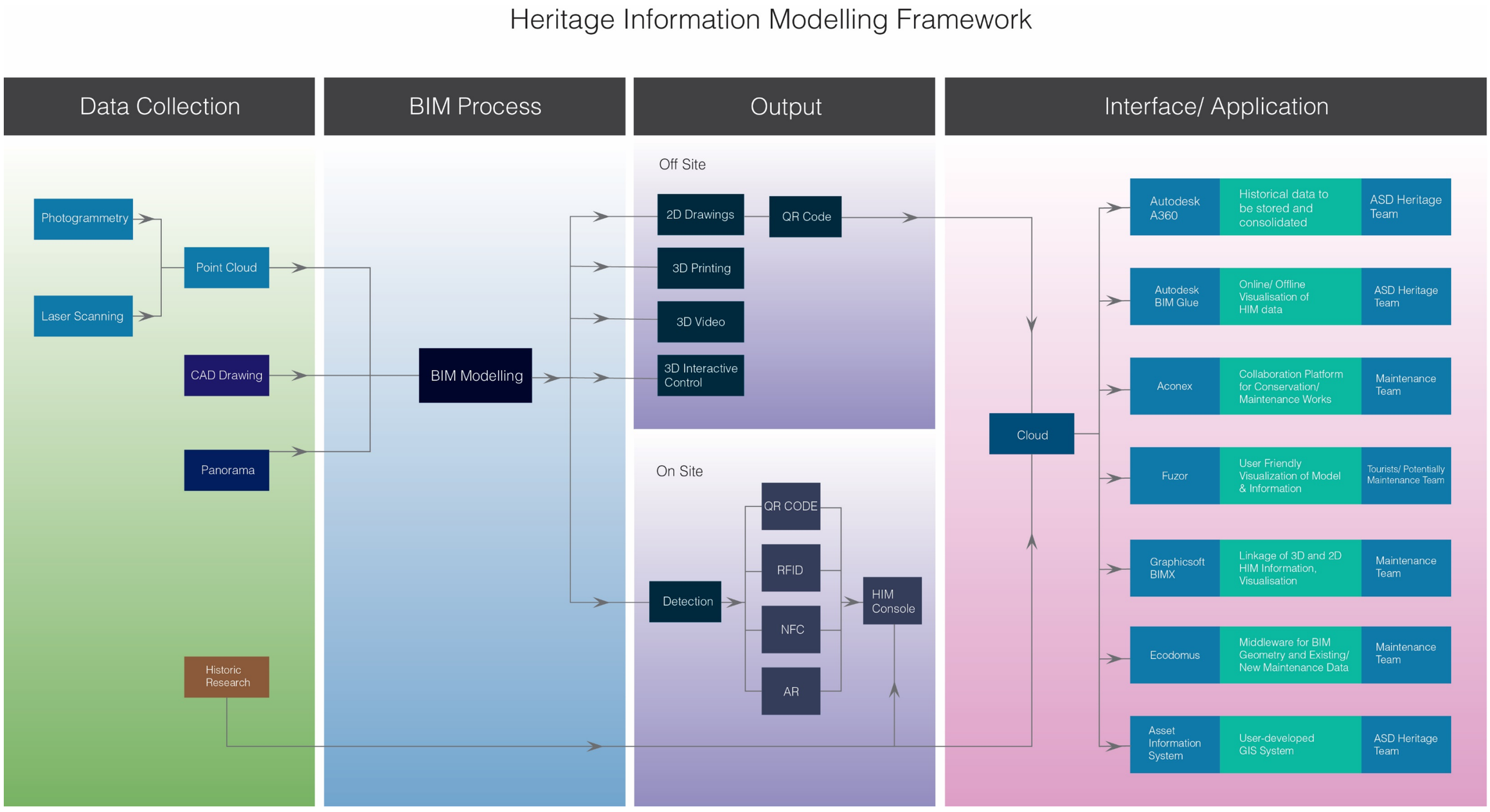
ii) Due to the testing of different platforms, special arrangements have been made to different vendor so that trial accounts can be established for demonstration purpose. These accounts may be closed after trial period of this study.

Site Visit Schedule carried out

Date	Time	Purpose
2014-12-23	10:00 – 14:00	UAV photo taking for Photogrammetry, Site visit for Historical research, NFC/RFID, AR
2014-12-29	09:30 – 17:30	Laser scanning
2015-01-15	09:30 – 17:30	Laser scanning and Site Visit for AR (Scanning objects)
2015-03-20	10:00 – 17:30	Site Visit for AR (Calibration)
2015-03-23	10:00 – 12:30	Site Visit for AR (Calibration)
2015-03-26	10:00 – 12:30	Site Visit for AR (Calibration)

3. HIM Framework

The HIM Framework devised is the path of how BIM is applied on a heritage project so that the maximum value can be obtained from the process. The HIM framework is outlined in the following diagram:



HIM consists of 4 progressive layers or process: Data Collection, Modeling and information Integration Process (BIM Process), Output to different functional usage and the Development of interface and platform process.

Data Collection refers to the collection of physical properties and condition, historic research, and O&M information or record about the heritage building. This includes the geometry, dimensions, materials, colours, and the like of the existing conditions. Currently, there are several ways of collecting data: photogrammetry, laser scanning, and panorama photography. In parallel, HM involves the historic research of the subject heritage building for background historical information. Other non-physical information such as building materials identification and functional use are collected in the normal means.

BIM process is building of geometries (components) and parameters (historical, architectural, group value, social value, local interest, authenticity, and rarity) that make up the heritage building, plus mapping, input and integration of relevant information such as heritage information (historic, location & setting, forms and design, use and function, timeline, social, scientific, artistic, analogy, contextual), physical properties and conditions and O&M information/record into the model so as to make it an Information Model rather than a 3D geometry model. The specialty about HIM is the incorporation of a TIMELINE into the BIM model, which is, BIM contains the historic information into the model.

If HIM is the consolidation of all heritage information into one Building Model, **Outputs** are the extraction of valuable information in different formats for specific use. This can be traditional 2D drawings or the many different new ways of utilizing BIM representations which will be discussed in this report. The Output Process refers to the provision, visualization and realization of the HIM for heritage management, facilities upkeep, heritage conservation, heritage education and training, user participation/engagement from the virtual to the reality and vice versa.

Lastly the Development of **Interface and Platform** process refers to the identification, review, selection and development/customization of the technical interfaces/platforms to collect, interlink, compare, visualize, analyze, share, present and navigate the heritage information available on the dimension and state of conservation of the historic building and where to add future information about the operation & maintenance or restoration/adaptive re-use activities. These is the display of relevant Information using different modes that includes the physical world, web pages and the mobile devices. They can also be categorized by different purposes.

13 elements were chosen to reflect the different aspects of the HIM framework which will be discussed in the Section 14.

Applications of HIM on heritage/ conservation purpose

This study puts Building Information Modelling into the heritage/ conservation context and study how BIM can bring benefits to all the parties and process involved. In HIM, there are 3 stakeholders involved:

1. Visitors/ General Public – those are layman who may be interested in an historic building for his/her interest, visitors/ tourist for self-education or visiting purpose.
2. Maintenance Team – those maintain and repair historical artefacts in normal wear and tear, or other incidence.

All different parties have different agenda and interest, this HIM Framework study intends to optimize the interest by utilizing the latest Building Information Modelling technology.

There are several considerations for the framework of HIM. Data collected will be stored in cloud or local server located at the place where owner designed. Data can be retrieved easily from the cloud by different platforms provided from the software company, such as Autodesk or Aconex.

In the current study, ground floor layout, roof and the site surrounding the heritage are converted to BIM models. The size of several files are few hundreds megabytes (MB) and the heritage information. The storage requirement are not too high but for the future use of HIM, larger building may needs the storage of the model and related heritage information in units of about Terabytes (TB). Different cost may be involved for the location of server storage. Point cloud data is for the formation of BIM and will only be used in the BIM process but further use of point cloud may consist in some middleware, like EcoDomus, which has the ability of showing point cloud.

The hardware required for the BIM process will be a problem for the data integration process since high specification is necessary for the importing of point cloud and the further action that using point cloud in the BIM process. For the current study, at least 16 GB ram are needed for smooth control of Revit. Latest version of display card drive is necessary. Latest version of Autodesk Revit (2015) is highly recommended for the BIM process because of the availability of plugins and the stability of software. Software requirement of different cloud platforms will be discussed later on in this report. Resolution requirement are relatively high in showing point cloud data. Graphic card with at least 1GB ram is used. For the Mesh model, Graphic card with at least 2GB ram is used but it is not necessary to use mesh model in the BIM process, cloud platforms, AM and FM. It may be used for presentation only.

Size of heritage in this study is relatively small. The size of point cloud data for use of prototype HIM of VPFS actually is not large and the details will be mentioned in the chapter of Laser scanning. Method of laser scanning does have its constraint, What can be seen, can be scanned, and vice versa, thus the upper part of

building cannot be scanned easily. For high-rise construction, the whole external walls of building cannot be scanned. Only interior rooms and the external walls of the ground floor can be scanned. CAD can only provide approximate dimensions and some existing information about the room use and details of specific structure, like frame structure of the roof. Photogrammetry can provide a good quality of point cloud of the external surface of the heritage without actual scale and dimensions.

Aerial photogrammetry and laser scanning are must in the data collection process. Close range photogrammetry and panorama can be replaced by taking site photos. Output will be printout and digital data. There are drawings, models, video, exe file. 2D Drawings can be pdf or dwf and both can be read by free viewers. 3D video can be in common format like, avi, mp4 window media player. Interactive control is exe file which can be opened directly without installation of other software. For common used, the file format can be selected when exporting.

There are some limitations in the current technologies used for detection. NFC is specified for the near detection distance with lower cost compared with RFID. RFID can serve most requirement but the cost is high. AR can have better presentation ability but the less information can be retrieved. They will be discussed in the chapters of detection.

Different software of cloud platforms has their pros and cons and limitations. They will be discussed in the chapters about cloud.

Comparison of photogrammetry and laser scanning

Photogrammetry can provide a point cloud of upper external surface of high-rise building but laser scanning cannot. Photogrammetry can be used more easily with low cost compared with laser scanning.

Photogrammetry cannot give accurate scale, dimension and geo-information if you do not import them into.

Laser scanning can provide accurate scale, dimension and geo-information. Laser scanning can only provide the point cloud information of interior and partial external surface.

CAD drawings will be first import to Autodesk Revit for the initiation of modeling but the information is insufficient, the dimension is approximate, the co-ordinate are not correct. Information of laser scanning and photogrammetry must be provided afterwards. The information got from photogrammetry and laser scanning is point cloud data. It can import to Autodesk Revit. Modeler can then follow to the point cloud to revise the model which is strict to the reality (Actual dimensions and geometry). Panorama will be reference for the modeler about the colour, pattern, and materials of the elements of heritage.

Useful point cloud database can set up at the cloud or server. All useful point cloud can import to all Revit files and they are directories inside Revit files which means all point cloud files are linked to the files. It is similar to the external reference function of AutoCAD.

Photogrammetry and laser scanning cannot be ignored for HIM. They are vital data collection method to provide relevant and correct information for the asset management and facility management. If they are missing, only approximate information can be provided and it can only be a type of presentation for heritage conservation by giving the appearance of heritage.

Relation of site survey, laser scanning, CAD drawings

Site survey will be done when laser scanning. The data from laser scanning will be geo-referenced. Coordinate and scale must be absolutely correct. Coordinate and scale of CAD drawings can be specified from the information of point cloud from laser scanning just like the point cloud created from photogrammetry. One or two control points will be defined in the point cloud. Usually, point which can be easily recognized will be selected. But, CAD drawings is not necessary but it can provide the information of hidden services if the structural and building services drawings are provided in HIM. If there is point cloud data from laser scanning, it will be extremely reliable than CAD drawings. Laser scanning will be the source of dimension and scale of HIM.

Deal with hidden services and things cannot be seen

Laser scanning and photogrammetry for hidden services and things cannot be seen can be avoided. The cost and manpower of doing so must be large and not efficient to HIM. The procedures are also complicated to implement. Hidden services and things not able to be seen of heritage are the difficulty in HIM since photogrammetry and laser scanning cannot be easily done in heritage. The structure must be kept in original so approximate information from CAD drawings will be useful but only when those drawings exist. If there is no CAD drawings provided, it is inevitable to predict those lacking information from existing services that are able to be seen. Traditional surveying methodology will be the last resort for the hidden services and things cannot be seen.

4. Aerial Photogrammetry

Photogrammetry is the science of making measurements from photographs, especially for recovering the exact positions of surface points. The objective of using photogrammetry in VPFS is to obtain aerial information which is not easily accessible from street level, recompose using algorithms and form reliable 3D data.

An Unmanned Aerial Vehicle (UAV) was released to take aerial photo of VPFS and its surrounding. In this project, Align M480 and Sony A7R camera were used. Information such as roof structure, site typology, contour planting conditions, nearby massing, road structure etc. can be obtained.

UAV photographed VPFS at 360 Degree in both high and low angles in order to obtain a holistic view of the roof top, tree top, roads, terrain and its surroundings.

A high resolution camera was used to obtain high quality photographs for point cloud generation.

The software developed by Autodesk called Recap 360 will be used in this research. Data integrity with Revit is good since both of them are developed from Autodesk. Point cloud created from Recap is in .rcs format which can be directly import to Revit for modeling with accuracy. Recap 360 is a cloud service. Their servers are located in United States. That means the calculation process of creating point cloud from photos will be taken at the servers in US. It can save the resource of computer for calculation.

There is a limitation of Recap 360. It can only create point cloud or mesh model without geo-information. The scale is also not correct. Input of geo-information and the actual dimensions is inevitable. Also, only 250 photos can be uploaded to the cloud service so the quality of point cloud and mesh model is limited. Time may also be spent on queueing, since the software is quite common in the world.

Pix4d is another software for the convert from 2D photos to 3D model or point clouds. But, the photos needed to be geo-referenced and process needed to be operated in computer not cloud service.

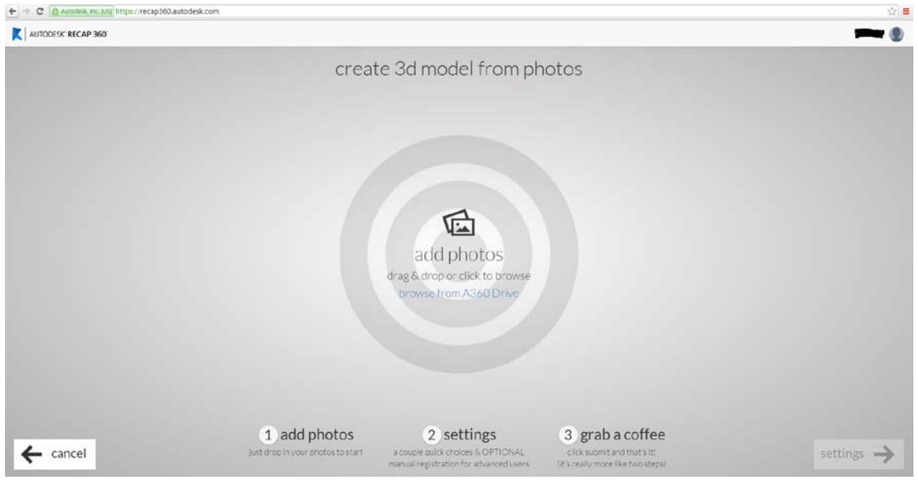
Photographs were upload onto Autodesk Recap 360 platform and returned with .rcp file format, which may be subsequently changed to other point cloud format. The Point Cloud file was then used to recreate the 3D BIM models. Mesh model can also be generated from recap 360. After users sign in their service, they can upload the UAV photos taken from any other types of cameras to recap360. The calculation will occur at the server of Autodesk. Then users in Autodesk Subscription Version can download the outcome as point cloud format, rcs and mesh model format, fbx, rcm, obj. while selecting the button of Ultra quality mesh to be created. Point cloud can be opened by recap desktop version. Mesh model can be viewed by Maya, InfraWorks, and 3ds Max in fbx, obj format. Mesh model in rcm format can be viewed by autodesk momento beta. The 3D mesh model is only for visualization and presentation. It cannot be further calibrated to facilitate building of BIM since no geo-information and dimension can be added on the model.

The time required for the formation of point cloud and other format of mesh model is related to the speed of network, the number of users of Recap 360 and the number of photos used. In this study, 250 photos are used for formation of point cloud. A whole day was needed for the Recap 360 cloud service to send the result back and downloading to the local computer.

The point cloud data, generated from aerial photogrametry, since they are generated purely from photographs, has two draw backs – lack of true co-ordinates and the lack of scale. These information have to be supplemented by laser scanning and site survey. The actual scale and coordinates can be found in the point cloud of laser scanning. Both of them can be input when the point cloud inserted into revit. By using the command specifiy the coordinate and input the scale into dimension parameters.

Align M480 Quadcopter	Equipment Information
APS-M Multicopter Control Unit	• Support quad (4), hex (6), and octo (8) rotors • Flight modes include attitude, GPS speed, GPS angular, intelligent, and manual • GoHome failsafe, low voltage failsafe (through LED indicator and auto GoHome), OSD signal output, gimbal control, fix-point survey functions • Compatible with PC and Bluetooth interface, could be easily adjust flight parameter and update firmware at any time
Battery	• Align 6S, 22.2V, 5200 mAh • Use for battery output under 15000mAh capacity
Flight Time	• 20 mins
Flying Weight (without battery)	• 2700g

Sony A7R	Equipment Information
Maximum ISO	25600
Image Resolution	7360 x 4912 (36.2 MP, 3:2)
Movie Resolution	1920 x 1080 (60p(28Mbps)/60i(24/17Mbps)/24p(24/17Mbps))
Image File Format	JPEG
Movie File Format	AVCHD 2.0 / MP4; Audio: Dolby Digital (AC-3) / MPEG-4 AAC-LC, stereo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Just drop in your photos to start
2 settings
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3 grab a coffee
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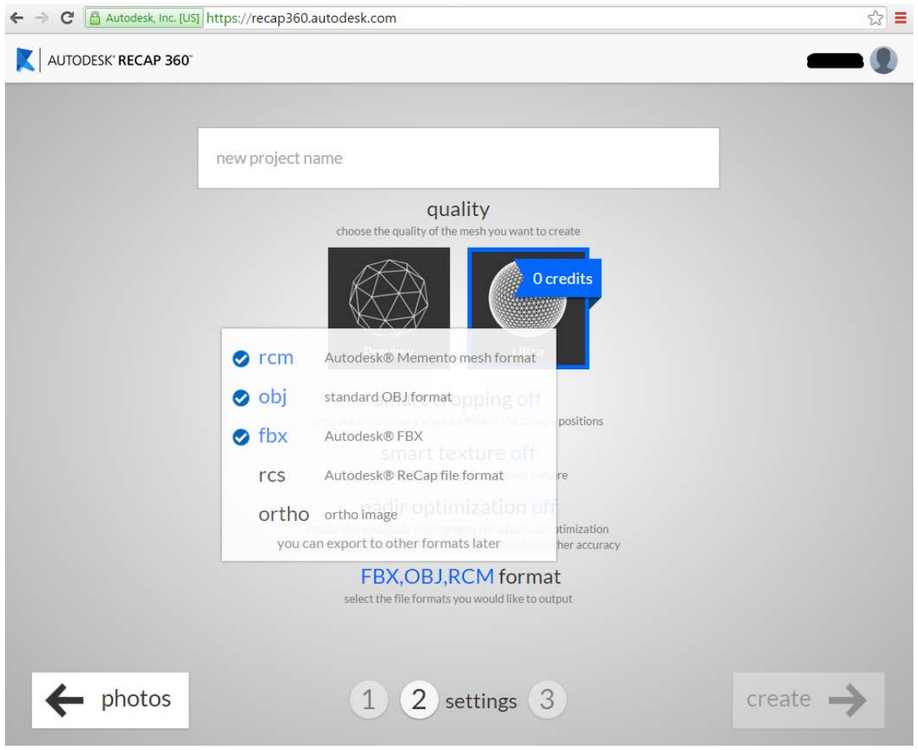
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0 credits
rcm Autodesk® Memento mesh format
obj standard OBJ format
fbx Autodesk® FBX
rcs Autodesk® ReCap file format
ortho ortho image
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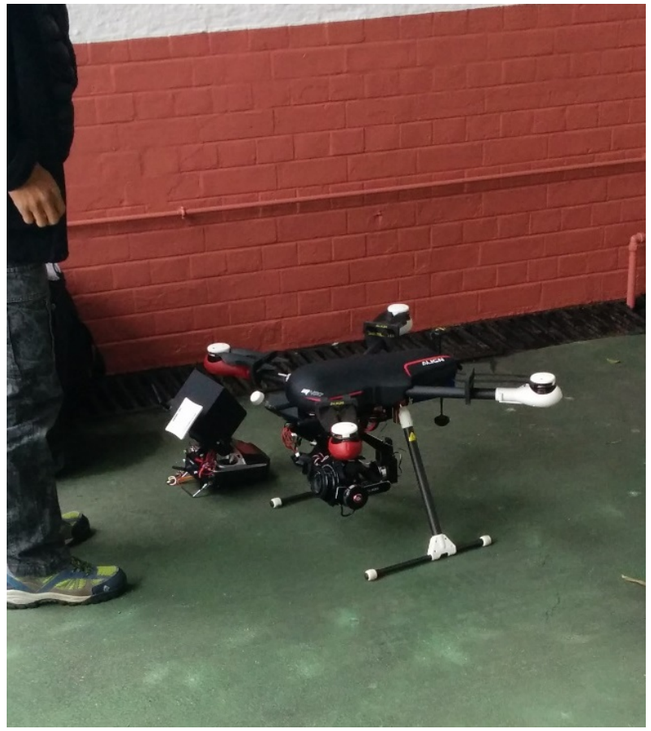
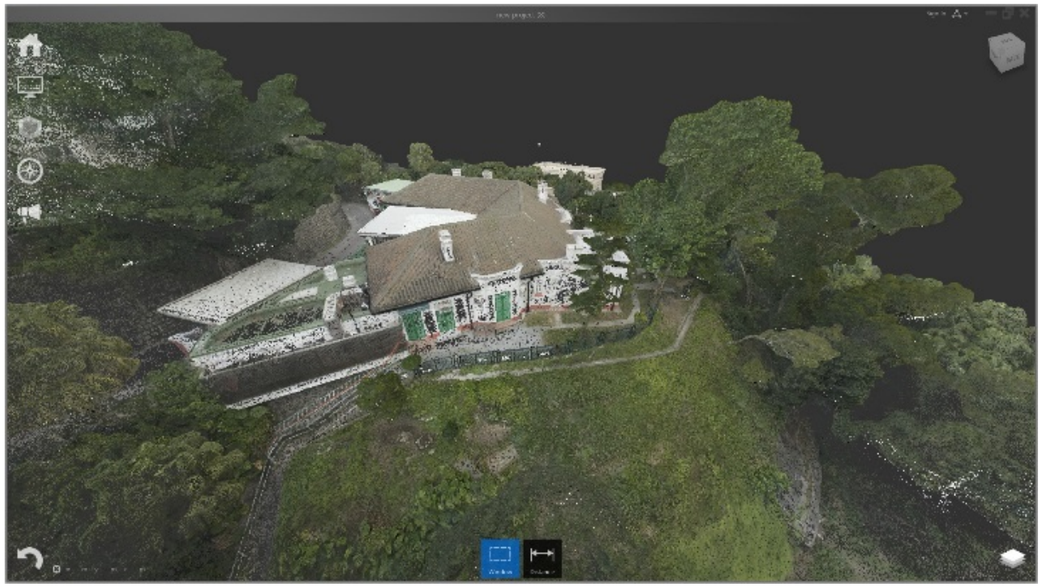
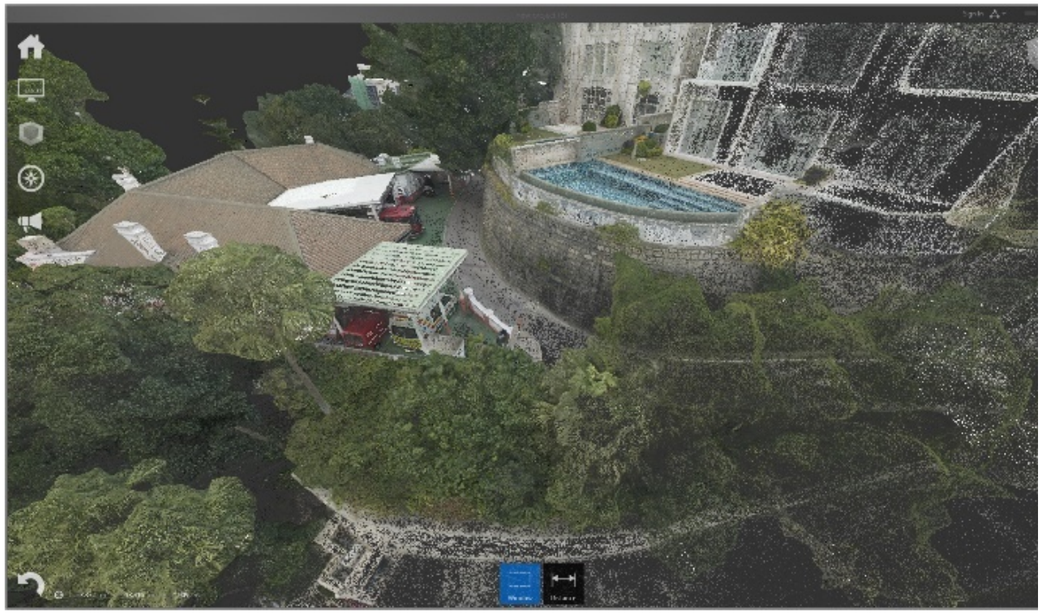
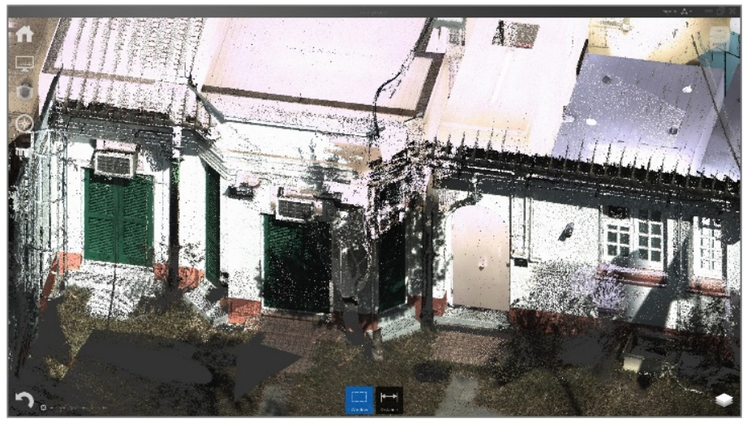






Heritage
Information
Modelling
VICTORIA PEAK FIRE STATION

Architectural Services Department
The Government of the Hong Kong Special Administrative Region



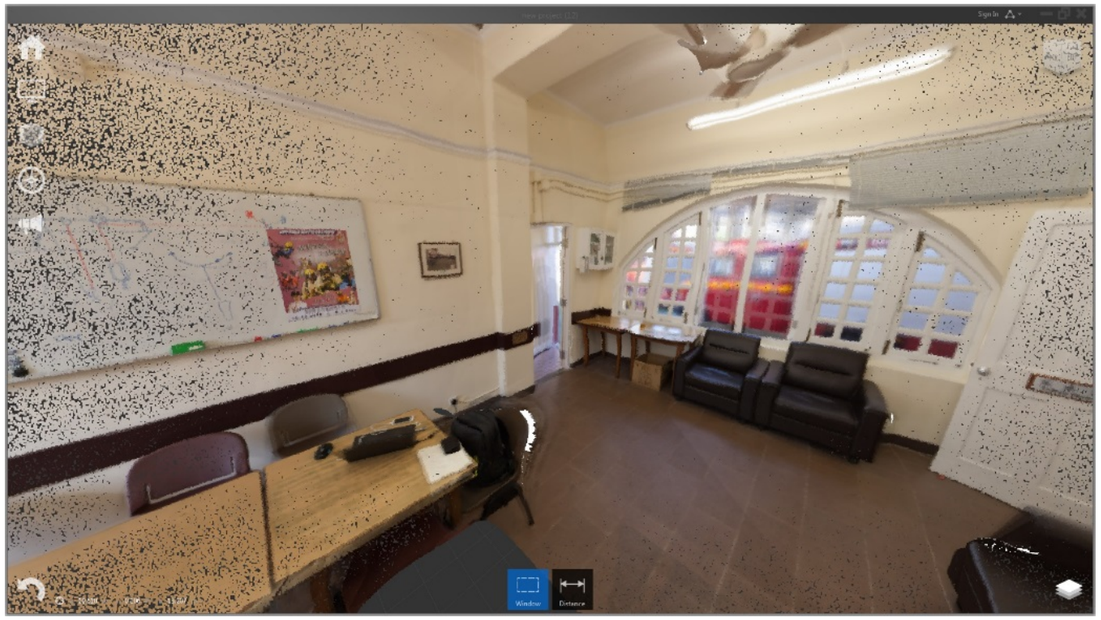
5. Close Range Photogrammetry

Close Range Photogrammetry is a branch of photogrammetry in which more point cloud data were generated at a closer range than the aerial photogrammetry but shooting with hand held cameras. It does yield a higher resolution.

Interior pictures were taken at VPFS o record the details. Through the conversion, the pictures are turned into point cloud field for BIM modelling references. First, upload your photos to web recap 360, and select the quality of mesh to be created. Then point cloud could be generated. (Same process described at Section 4, Aerial Photogrammetry.)

Despite its higher clarity, it is not comparable with point clouds generated from laser scanning process. The point cloud from close range photogrammetry also suffers same problem with the aerial. The dimensions of them are not accurate. The scale is not correct. They are also not geo-referenced. The outcome will be in point cloud format, rcs and mesh model format, fbx, rcm, obj. Point cloud can be opened by recap desktop version.

Another major issue with close up photogrammetry is the lack of actual scaling. It is to rely on laser scanning or actual site dimension to recalibrate the appropriate scale.



6. Laser Scanning

Laser scanning has been used for collecting accurate dimensions of the existing environment. It has long been used in Civil Engineering. Not until recently it is being used in building and construction industry. Compared to traditional site surveying, it is quick, efficient, accurate and precise.

Case Study of VPFS

In VPFS, the exterior and all interior spaces have been laser scanned for two days. The resulting point cloud file has been adjusted to the true co-ordinate and above sea level. Also, it provides accurate base for point cloud files generated from photogrammetry which does not bear any scale.

There are two kinds of registration methods for laser scanning. One is the common points method and its counterpart is cloud matching. Common point was used when the scans are successional which means they must have at least one common point. Could matching will be used when the scans are not continuous. One common place connected both of the scans should be scanned for the positioning of the scans. For the internal scanning, one common area outside the building between two scans is involved. The common point method was used for the other scans. Leica C5/C10 would be suitable for laser scanning in this project.

	Interior	Exterior	Total
Scan (times)	33	23	56
Point (points)	703693837	328898733	1032592570

Properties	Whole Building
Volume (m^3)	1416.59832
Average density	10mm spacing (underestimated, the volume is including the empty space within the building)

File Formats and Sizes

File Format	Size
RCS	10.7 GB
PTS	54 GB
Binary file	14.2 GB

There will be two set of raw data, binary files which cannot be read by any reader software and pts files which is a kind of formating of point clouds. The pts files can then be converted into different point cloud format for fitting different viewer software. Pts will be large in file size compared with rcs format. RCS files can transmit easily by using portable data storage device like DVDs, USB. PTS must be in the tranference way of USB with large storage or external harddisk.

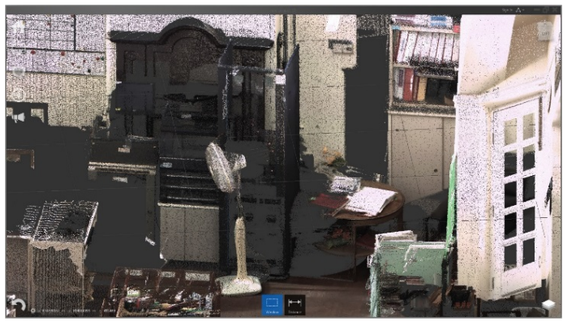
Leica - Cyclone

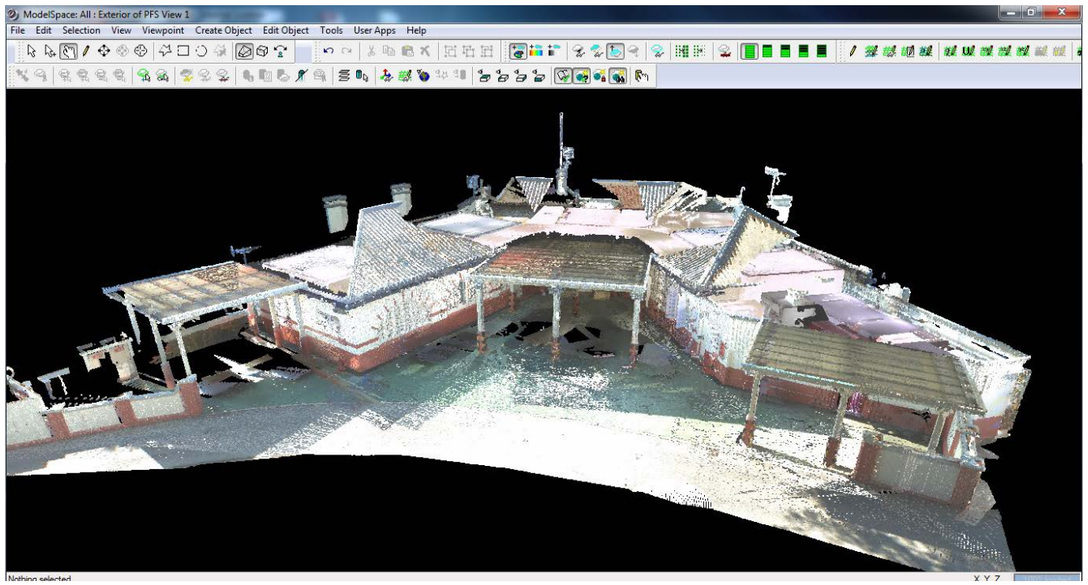
Leica has a specified software called cyclone. It can read the point cloud files and provide higher visual qualities of point cloud than that of recap. The measurement of distance of points and making floor plan and section are basic function of it. On the other hands, it can also calculated the total area of space scanned and time the height to give the volume scanned. The software is not only a viewer but can handle the point cloud to generate geometry from points specified. The process of interchanging .pts and .rcs formatts can be performed inside the programme. It supports E57 Scan Format (.e57), Faro Laser Scan (.fls), Optech IIris Binary Exchange (.ixf), Text – PTX Format (.ptx) and HDS4500 – HDS7000 Scan Faromat (.zfs).

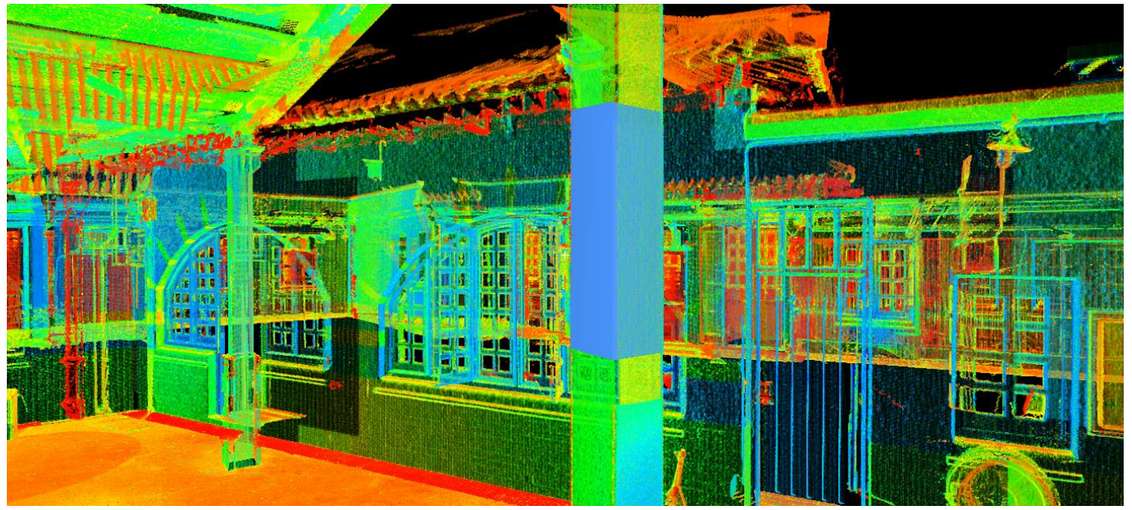
Limitation

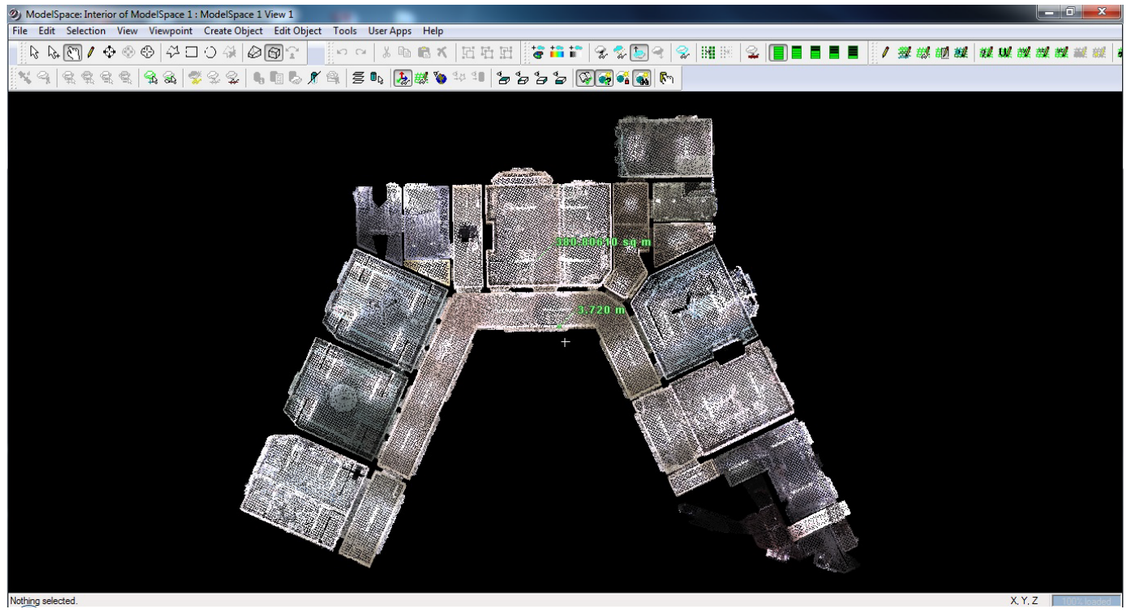
Since it is difficult to use laser scan for the scanning of the roof or any other objects at high level, photogrammetry can help to complete this part. Both of their outcomes can be insert to revit and for building up of BIM with high accuracy. This combination method is a suitable way to get comprehensive point cloud of whole building and terrain, as lots of historical buildings are huge or shaded by plantings or others. The point cloud can be inserted to revit for the creation of 3D model with quantitative (dimension, geometry, color) and qualitative (history of objects) information.

Leica C5/C10	Equipment Information
User Interface	Onboard control, notebook, tablet PC or remote controller
Data storage	Integrated solid-state drive (SSD), external PC or external USB device
Camera	Auto-adjusting, integrated high-resolution video camera
Point Spacing	Fully selectable horizontal and vertical; <1mm minimum spacing, through full range; single point dwell capacity
Scan Rate	25,000 pts/ sec, up to 50,000 pts/ sec
Range	35m – 300 m




ModelSpace: All : Exterior of PFS View 1
File Edit Selection View Viewpoint Create Object Edit Object Tools User Apps Help
Nothing selected
X, Y, Z



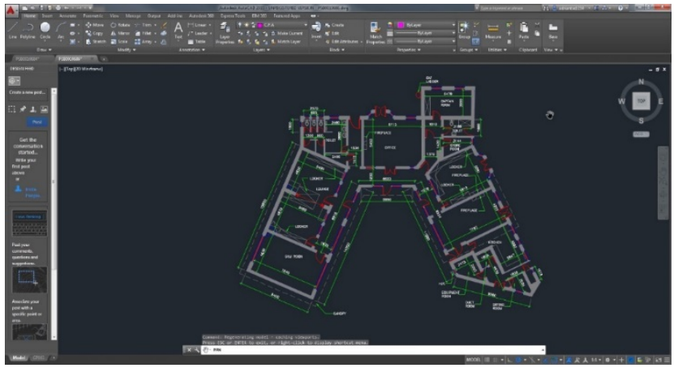

ModelSpace: Interior of ModelSpace 1 : ModelSpace 1 View 1
File Edit Selection View Viewpoint Create Object Edit Object Tools User Apps Help
Nothing selected.
X, Y, Z

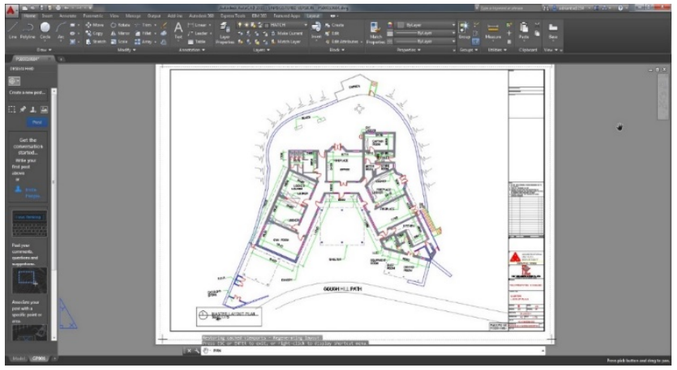
7. CAD Drawings

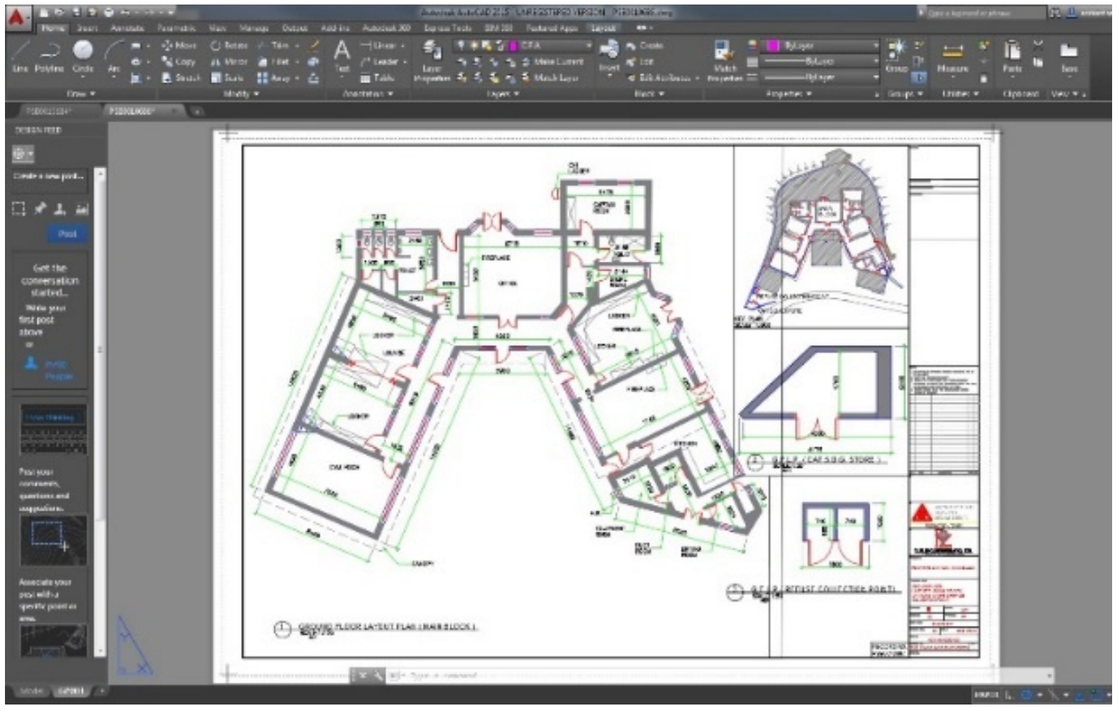
There may be cases where heritage projects do have 2D CAD drawings which were drafted previously. The existence of CAD drawings sometimes forms the base for BIM process but is not essential.

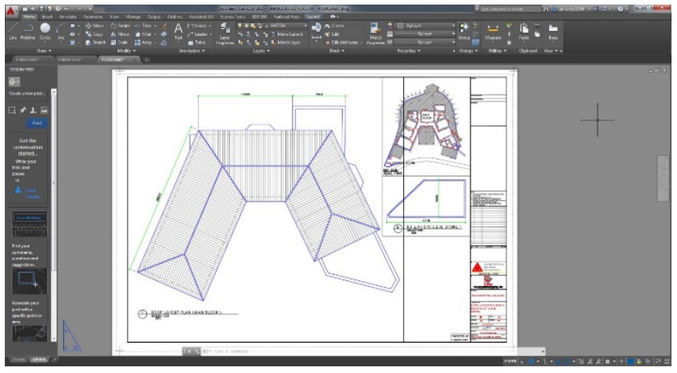
IN VPFS, only site plan and dimensioned floor plans are found available. No other drawings such as sections, floor heights etc. are available. The floor plans were imported into BIM platform and form the base of 3D model, however, the height and configurations must come from other sources such as photogrammetry and laser scanning.

One point to note is the accuracy of CAD drawings are only approximated representation of the heritage building, it is due to the fact that CAD drawings tends to simplify the layouts, for example, walls of a room are drawn parallel in CAD but in fact they are which can be detected from laser scanning process. CAD drawings can give some information of the room usage and initiate the project before completion of laser scanning but it is not essential for later on setup of model since the scale and dimensions finally will be relied on laser scanning. If there is no CAD drawings, the 3D model can be directly built according to the point clouds from laser scanning.









8. Panorama

Other than traditional photo-recording, the panorama recording is a special recording technique using a 360 degree panorama camera to record the space at full range. The result is a distort jpeg which is no different to any photo format. However, by using a special viewer to view this image, a rotatable full panorama can be recovered. It is used for recording the existing conditions of the heritage.

The advantage of full panorama photo recording is a quick response to the immediate surroundings, in particular the continuity of space and services inside a space, as comparison, traditional site photos gives only fragments of space. Limitation is that No information of actual dimension and scale can be found in panorama.

Panorama give the BIM model building a solid base to ensure the continuity of building and services elements within a space. A cheap and quick method for quality checking. Site photos will be used for some detail construction of modeling like the old hanging lamp and fireplace.

9. BIM Process and Check List for HIM

BIM Process involves the building up of BIM elements from point cloud files, CAD information and the supplement of panorama and site photos. The common point of all data collection methods is the reference of existing geometry information. As illustrated in the HIM framework, all data collected will be integrated manually in revit for BIM process. Point clouds from both photogrammetry and laser scanning and CAD drawings can be imported into revit. Revit can read dwg, pts, rcs format. The coordinate system will set to follow the result of laser scanning. Panorama and site photos are for the reference of color and any other detail shapes like the pattern on fireplace. The process involved as a check list for HIM:

1. GIS data including Co-ordinations and Points	Determine the exact locations, real Hong Kong Co-ordinates and above sea level. For setup of coordinate system of the project file.
2. 3D Spatial Data (3D-BIT00) Maps from Lands Department	3D site map was purchased from Lands Department to form the base of the 3D site. The formation of topography of targeted building.
3. Tree Survey Plan	Despite the effort, no tree survey plan was found from the surrounding vicinity. The size of the trees are estimated from photogrammetry instead.
4. Breaking up of Files	BIM files are broken up by means of disciplines for easy operation, in this case, Architecture (including structure), MEP and Land File. (To be updated by users). Autodesk recommended that a single Revit file (of any discipline) shall not be more than 200Mb.
5. Timeline (phase setting)	Based on the heritage research, BIM can divided into several main phases according to the milestone changes in History.
6. CAD reference	Since some previous CAD drawings were found, they form the base for BIM modelling before the data from photogrammetry arrives.
7. Point Cloud from Aerial Photogrammetry	Provide data for roof levels, configuration which are inaccessible from ground level.
8. Point Cloud from Close Up Photogrammetry	Provide details from detailed photographs
9. Point Cloud from Laser Scanning	Provide data for interior rooms, external walls of ground level, which includes the geometry (true dimensions) and geographic (location on the earth) information.
10. Reference from Panorama	Give overall record of the existing conditions and forms the reference for the BIM model making. The format of data will be input manually.
11. Materials and colour	Visual record material and colours and to be set inside the BIM Models. The format of data will be input manually.
12. Product Catalogue	Helpful when product literatures or catalogue are available so that colours, dimensions, and other functions can be incorporated into the BIM model.
13. O&M information/record	Extremely helpful for BIM Process as it can provide important information of any change in structure, materials, colours in the heritage.
14. Aerial photos of district in past years	Useful for BIM process since these information give any significant change in the appearance of heritage. Help the setup of topography of different phases Giving the definition of different phases of heritage.
15. District maps of heritage in past years	Provide information of change in site surrounding the heritage.
16. Any records of renovation inside(past CAD, Documents to mark up all changes)	Help the BIM process of HIM. Some equipment changed, for example, doors, windows.
17. Defining CDEs from heritage report	To define the CDEs in the heritage from the help of the heritage report. To build the CDEs with high LOD.

BIM components will be built in the model with the integration of the collected data according to the checklist, for example, the fireplace. This is the modeling part (M) of the HIM. Then, the historical information (I) will be stored in cloud server. To be specific, the cloud used in this project is box. Parameters (I) collected from the data collection stage which means the elements in checklist is set up within the component. Eventually, the component and the information in cloud are linked by means of component ID or URL.

10. Phasing

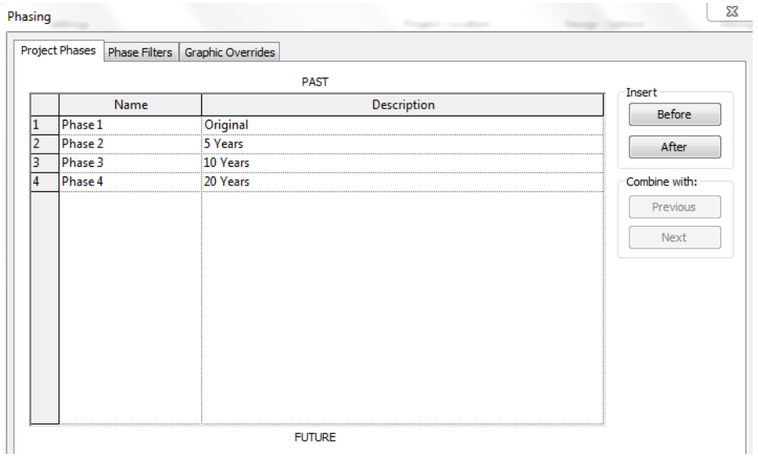
The most significant application of BIM in HIM is the application of Phasing.

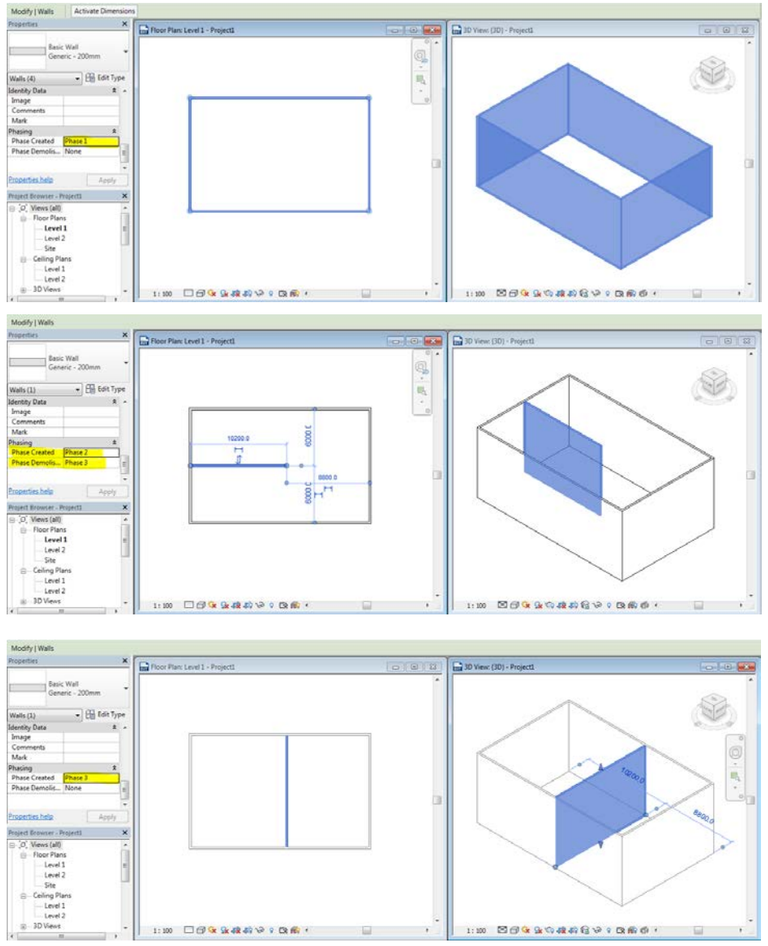
In heritage context building, components were built in different stages, for example walls, were built in the original design, throughout the history, some walls may be demolished, some remain, whereas some other new walls may be built to suit other functions. This is a dynamic process which embraces the historic evolution into the building components.

Phasing is an important part of BIM process to make HIM possible. Any building component, a wall, a door, a window etc, are associated with two phase parameters – which phase it is created, and which phase it is demolished.

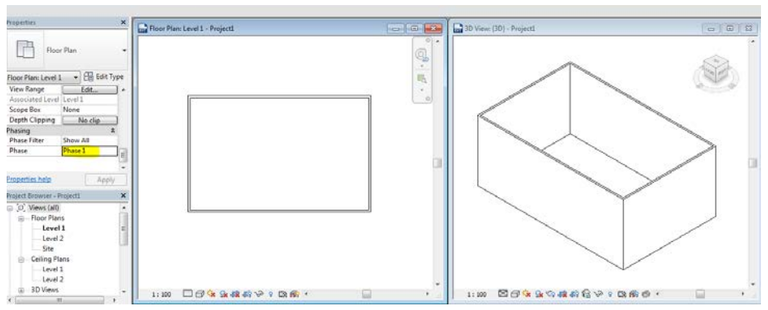
Now that the whole HIM project is subdivided into certain Phases – the phases of significance to highlight or illustrate the important historical changes. Take the following example:

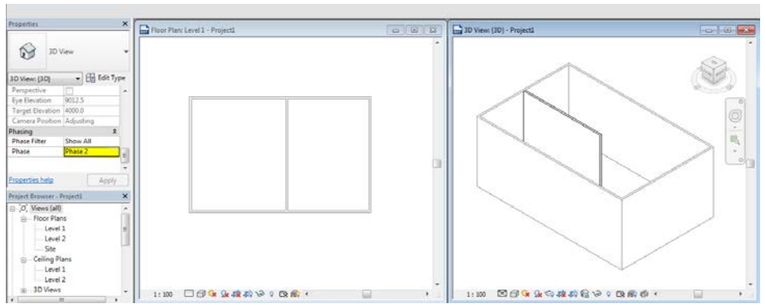
A heritage project is classified with 4 important phases:

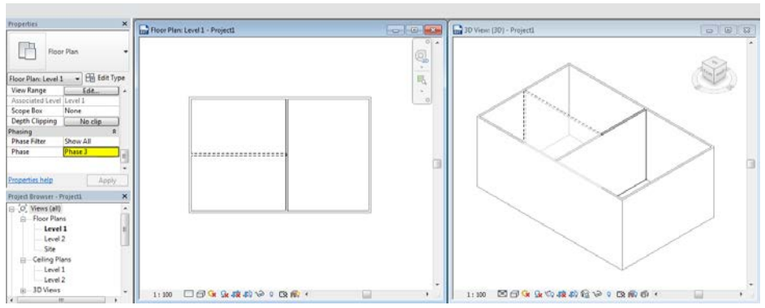


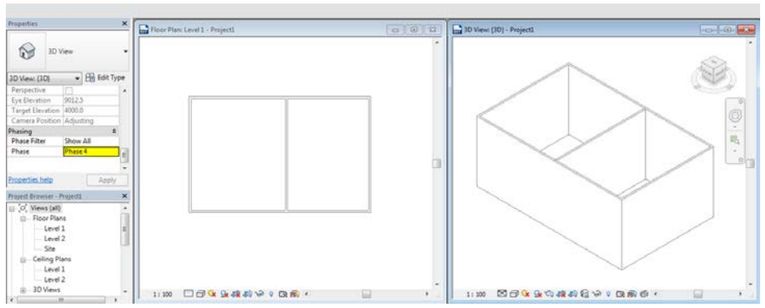


By using Phase Filter, different phases can be displayed:









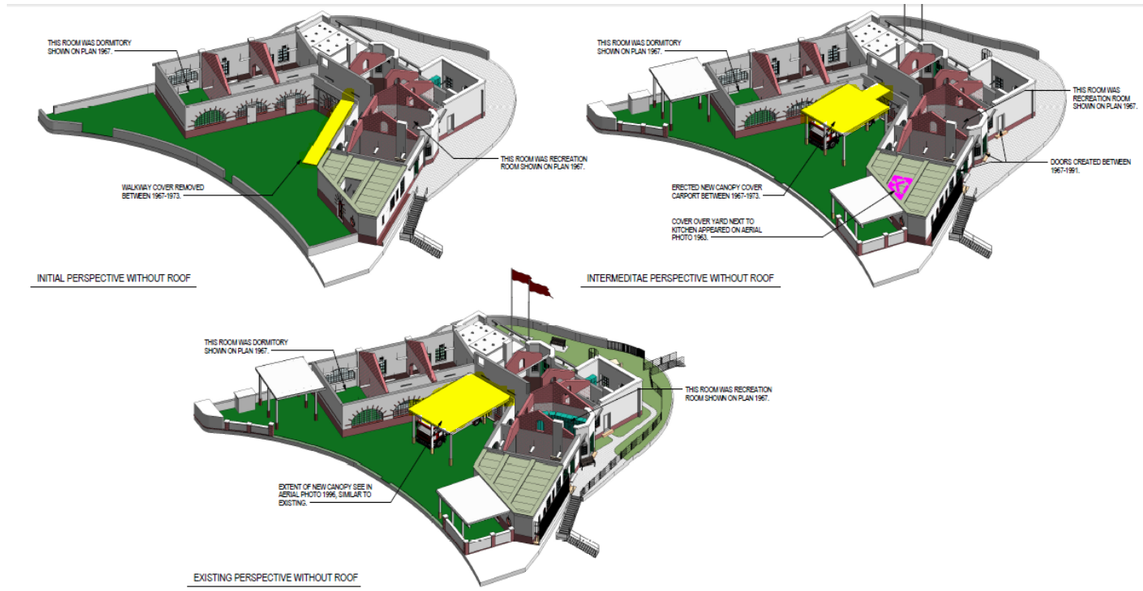
In VPFS, this phasing technique was used to define the following phases:

Initial Stage – Original School configuration

Intermediate Stag**e** -1967 when the School was converted to a Fire Station

Existing Stage – the current status as it stands

The carport for the fire engine for example, there is no carport in the front yard in the school (initial). It was erected during the 1967 conversion (Intermediate) with a “notched” configuration. It was later then modified to a rectangular configuration and become the current status (Existing).



We can see that the external walls built in Phase 1 will existing through all phases. The elements in subsequent phases can be seen as:

Phase 1 = Phase 1 (Initial)

Phase 2 = Phase 1 + Phase 2

Phase 3 = Phase 1 + Phase 2 + Phase 3

Phase 4 = Phase 1 + Phase 2 + Phase 3 + Phase 4

Thus, by defining elements in appropriate phases, they can be shown to display the right time line in the BIM model. BIM can then become a very power tool to store all the historic changes in the HIM framework, and then by defining appropriate phase filter, we can see the gradual change of heritage conservation. This avoids building different models in different phases and ensures the continuity of historic interpretation.

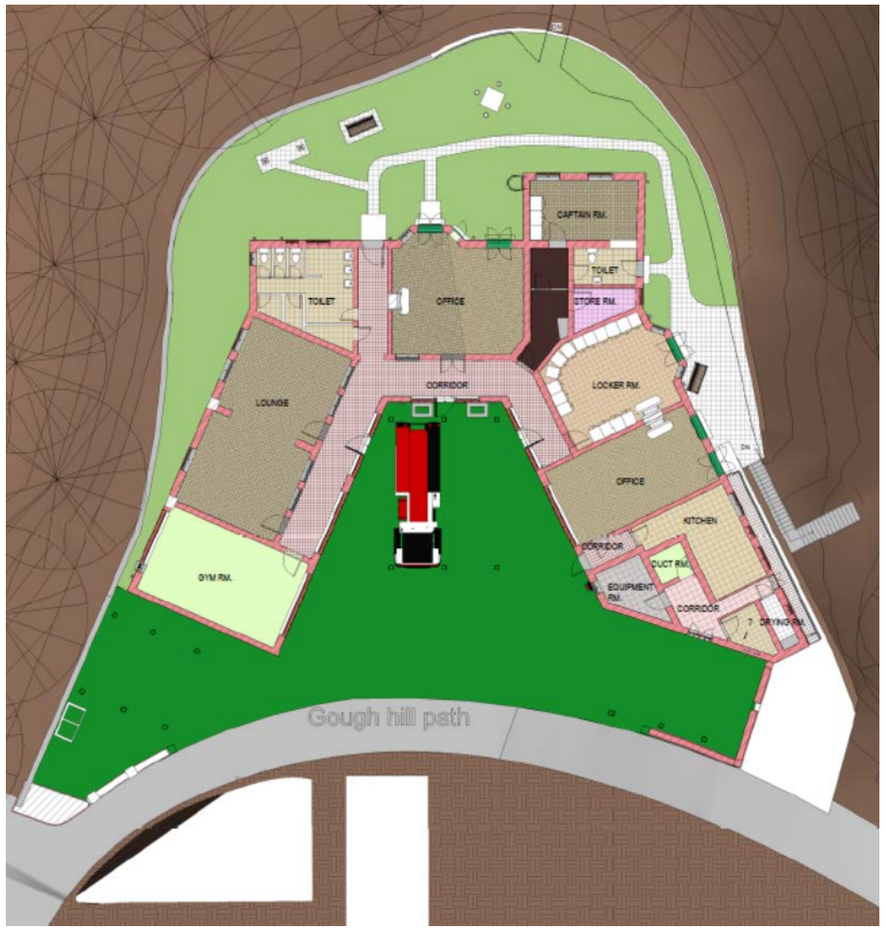
11. Output (Off-site)

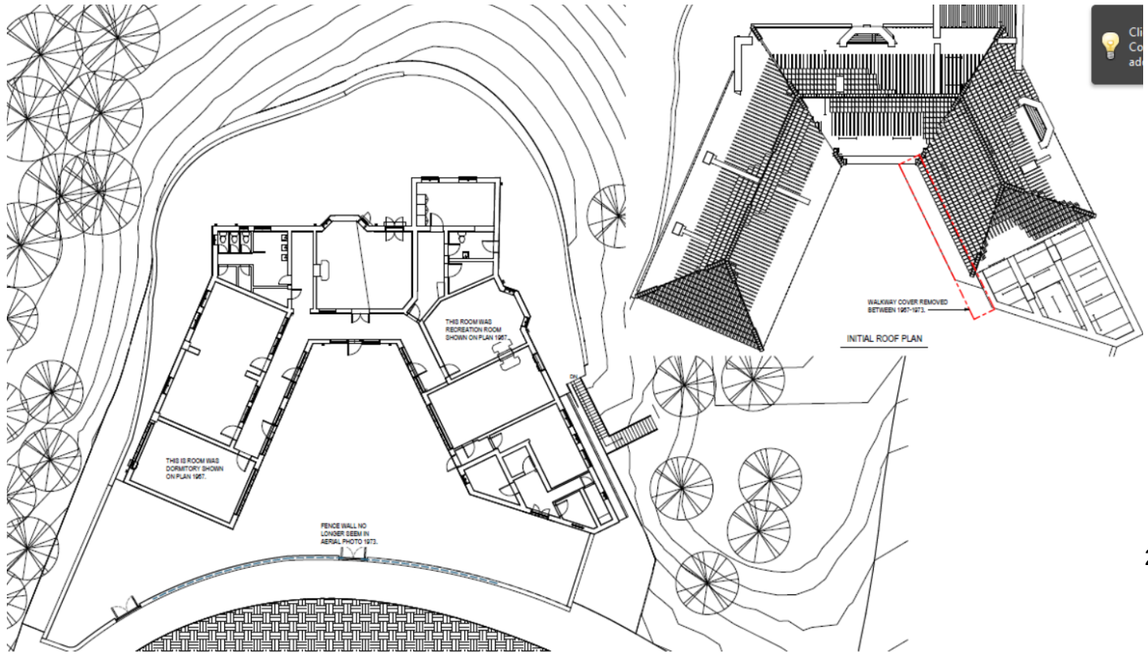
11.1 D01 2D Drawings

One major advantage of using BIM is the production of traditional drawings.

With BIM models, we can produce architectural, structural and building services drawings. Traditional Plans, elevations and Sections can be generated with ease, showing all different aspects of the BIM model.

The 2D drawings can be created by putting views on the sheet in Revit. Then, these sheets can be published in dwf or pdf for this study.





11.2 D03 Renderings

Since BIM is an object based environment, every object appears in its 3D representations, with the precise location and elevations, the heritage building can be appeared in 3D format with the sun angle and shadows calculated precisely according to the different locations and time.

Also because the object based can be assigned with respective materials, thus a traditional computer generated perspectives and renderings can be represented without much difficulty. It is important for HIM to keep the different phases of a heritage building in a rendering quality with precise texture, material, colour, light and shade quality.

The rendering process can be done in Autodesk Revit. Actually, it is one basic function of Revit. The quality of Revit's rendering is good enough to presentation. To have a rendering, first important thing to do is to create a 3D view wanted to be shown in the building model. Then, the command can be done by clicking the panel button called "Render". Rendering dialog will be opened, the quality which include resolution, DPI) and effect (Lighting, Background, Exposure, Sun and shadow, Material's texture, Plants, Entourage) can be adjusted by setting in dialog. The memory should be high enough for the computation of rendering. For the time used in this study on rendering, at least one full day was spent.

There is another button called "Render in cloud". It is a cloud service provided by Autodesk. Similar to Autodesk Recap 360, the rendering process will be operated at the server of Autodesk. Reduce the computational resources in a pinpoint on this service.

There are links for reference.

Workflow of Rendering:

http://help.autodesk.com/view/RVT/2015/ENU/?guid=GUID-69A3785E-5C96-4222-A09D-305243B46B9B

Workflow of Rendering Settings:

http://help.autodesk.com/view/RVT/2015/ENU/?guid=GUID-35F117CC-8ABA-4E61-AADD-B96C2A5E760F

Rendering in Cloud:

http://help.autodesk.com/view/RVT/2015/ENU/?guid=GUID-02127227-2726-4CDA-B25B-7AE3CABBC151

If the rendering quality was required of a high level of photorealistic and resolution, 3D view of model can be exported from Revit to another Autodesk software called 3Ds Max. Fbx format will be involved. Extra resources must be used for rendering in 3Ds Max.

11.3 D04 3D Drawings

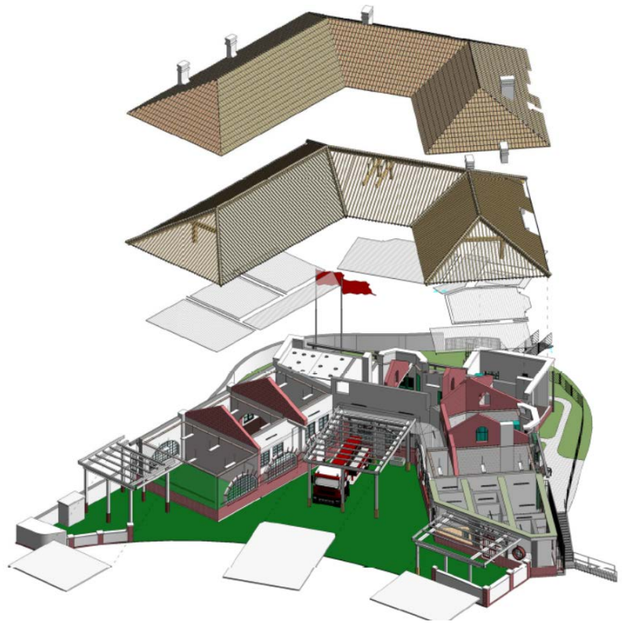
Traditional presentation of drawings is in 2D format, such as plans, elevations and sections, together with blow up technical details. 3D presentation, limits to very small number and for illustration purpose only. The reason is due to the fact that drawing up 3D drawings are extremely time consuming.

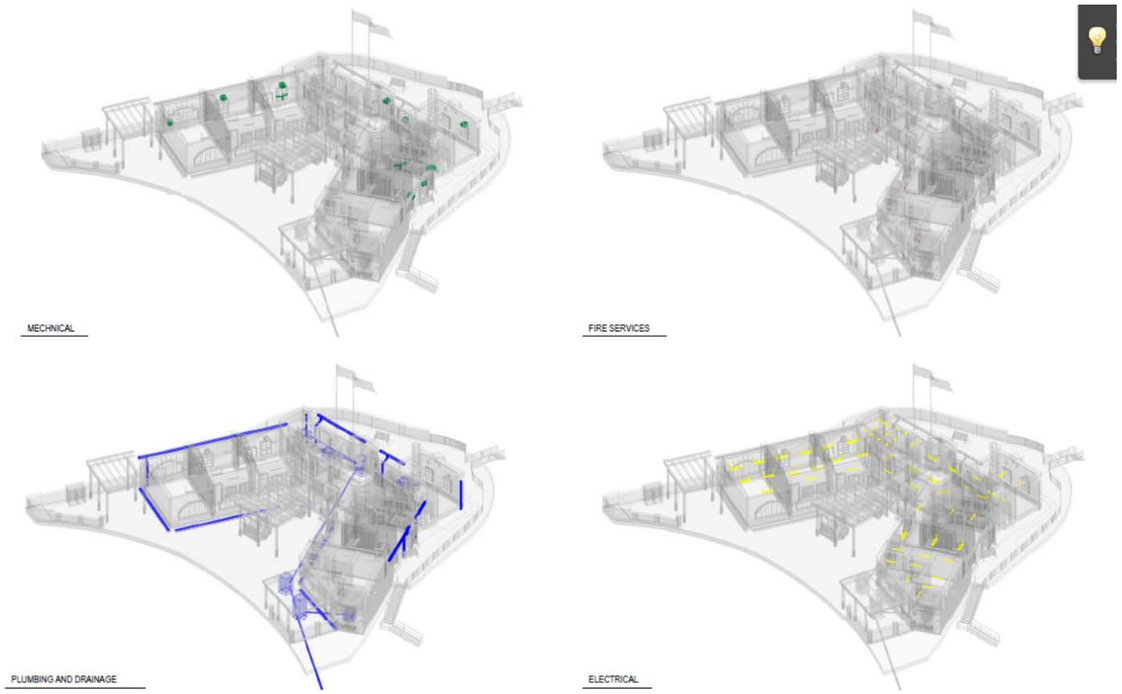
With BIM, the model is already in 3D, thus issuing 3D drawings is not of much extra work. Thus, it can be a common deliverable with 3D illustrations showing the different part of a project, from the overall building outlook to smallest component part.

3D presentation, together with latest techniques such as hiding elements, making elements transparent or temporary exploding different components to derive better clarity, revealing a new way of communication, delivering far better information than traditional 2D representation.

In the context of heritage conservation, different components throughout different stages can be easily shown in 3D presentations.

The example of can be found in the Deliverables with file name called HIM_VPFS_Drawings.pdf





11.4 D02 QR Code on Drawings

QR Code provides a link. In this HIM, a major invention is the use of QR codes in drawings.

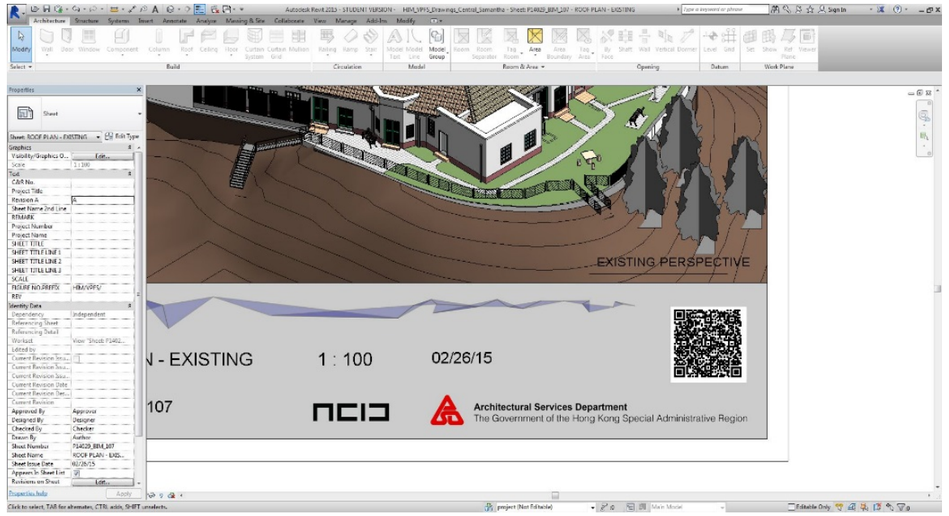
Since BIM models can issue drawings while at the same time stays as a 3D information model, both 2D and 3D representations bear the same information. Thus by incorporating a unique QR Code at each individual drawings brings the 2D and 3D representations together. By delivering traditional 2D drawings, we do not only deliver information on the paper, but all the information that can re live read from the BIM model.

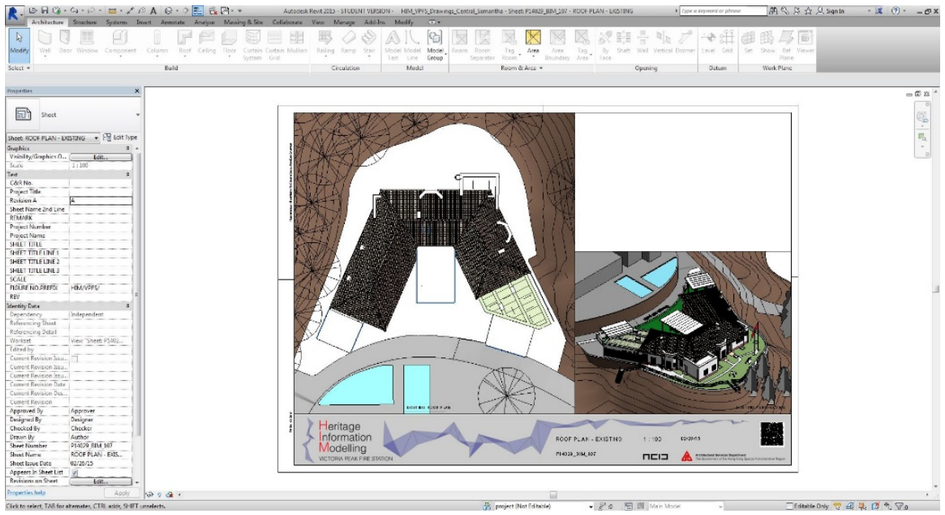
Free plugin called “QR code generator” from web can help for the production of the QR code. One thing which is important is url from cloud platform with dwf viewers. Then, URL will be entered into the plugin, a QR code produced.

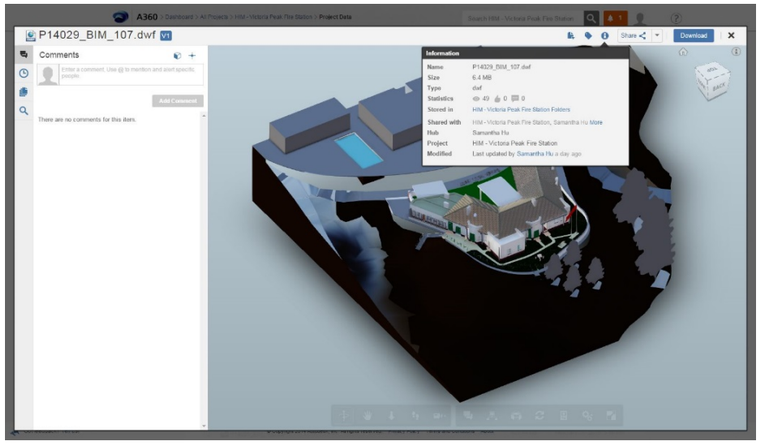
The 3D model published from Revit will be in dwf for uploading to Autodesk 360 and time for exporting dwf depends on the amount of views needed to be exported. If the views and dwf files are ready, one day was used for generating all the 2D drawings including the time of printing on this research.

User may sometimes experience some difficulties in scanning the QR codes from the mobile devices due to the differences in the mobile scanning apps. It is therefore recommended users to install different scanning apps for successful results.

One point worth noticed is that for this study, the cloud platform that host the HIM data resides with Autodesk 360, which is a public cloud, For long term application, private cloud which is setup and maintained by ASD shall be adopted for security reason.





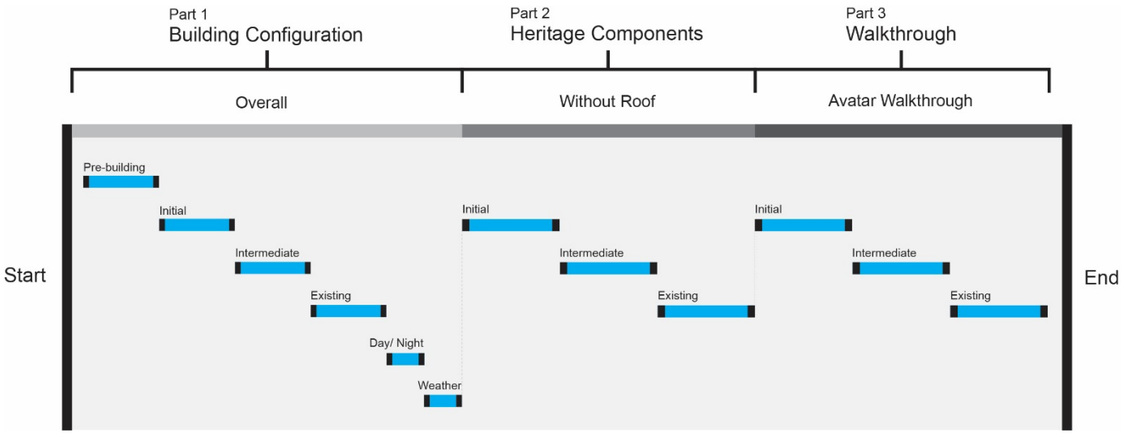


11.5 D05 3D Video

Animated video can easily be generated through platform like Fuzor.

Animated video is used to illustrate the different aspects of HIM such as the timeline changes, the contextual or social changes around the heritage building. Fuzor can synchronize with Revit or operate independently. There is one button to open the dialog for exporting the video for building and walk-through video (using avatar as the angle of view) shown in the pictures below.

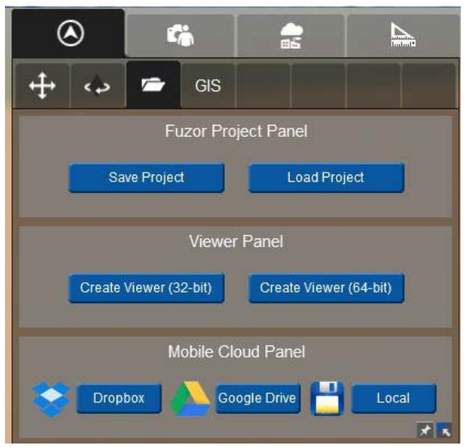
Different aspects such can materials, sun and shadow effect, historic significance etc can be delivered to viewers. Not only existing phase of building can be shown in the video, past phases can also be used for generating video. It is particularly effective and useful for visitors for conservation purposes by visually showing the past status of heritage.

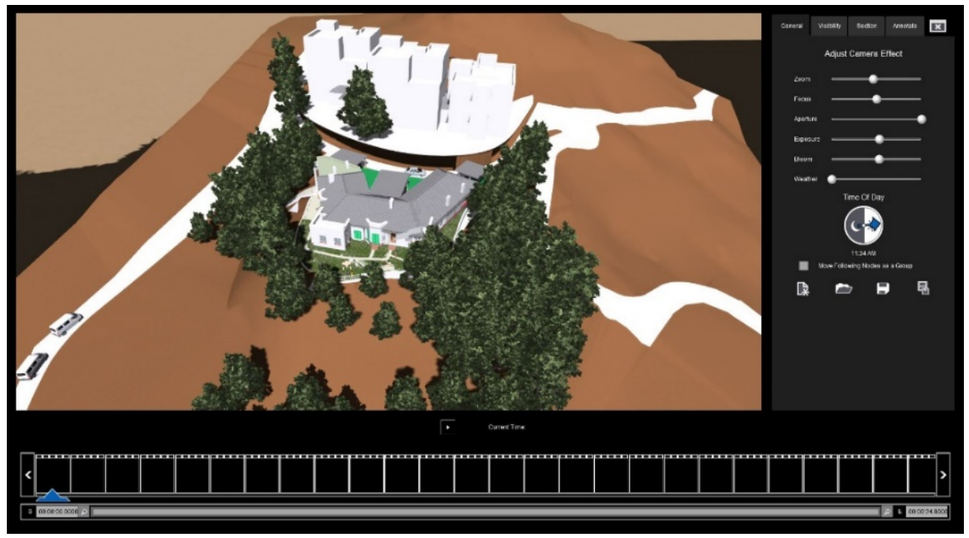


Examples can be found on the submission of Fuzor Output. In the part one for Building Configuration, phasing, day and Night and Weather. Part two will show the Heritage components according to phases. The final part of the video is Walkthrough. Avatar will be the view angle for viewers.


General
Visibility
Section
Annotate
Adjust Camera Effect
Zoom
Focus
Aperture
Exposure
Bloom
Weather
Time Of Day
Move Following Nodes as a Group
Current Time:


Element Properties
0.475 m
1.300 m
2.240 m


GIS
Fuzor Project Panel
Save Project
Load Project
Viewer Panel
Create Viewer (32-bit)
Create Viewer (64-bit)
Mobile Cloud Panel
Dropbox
Google Drive
Local


General
Visibility
Section
Annotate
Adjust Camera Effect
Zoom
Focus
Aperture
Exposure
Bloom
Weather
Time Of Day
Move Following Nodes as a Group
Current Time

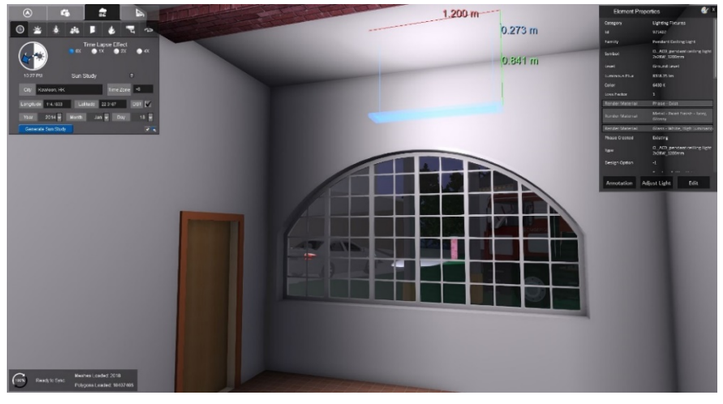
11.6 D06 3D Interactive Control

While the production of 3D video is uni-directional, i.e. viewers can only observe what is being projected, 3D Interactive Control refer to an active control of the submergence of viewer as the first or third person in to the 3D space, and navigate to wherever at will. It is also produced from Fuzor. The Color and rendering quality is limited. The video may not be realistic even compared with the rendering quality of Revit, not to mention 3Ds Max. The controlling method is similar to RPG game. By using the computer mouse, users can control the view angle.

3D interactive control and 3D video do have high potential on the real life application. Although they are not realistic enough, it is effective to create them from Fuzor based on Revit. Last but not least, the

Spatial quality, material, texture and lighting condition etc can be simulated so as to provide the viewer the virtual reality experience. The following screen captures were generated by Fuzor.

Examples can be found on the submission of Fuzor Output.



11.7 D06 3D Printing

3D printing provides fast and effective 3d printed product when professional grade 3D printing systems and production materials were used. In HIM, the process of 3D printing cost around one to two days. It greatly maximizes the design time by shortening model production time.

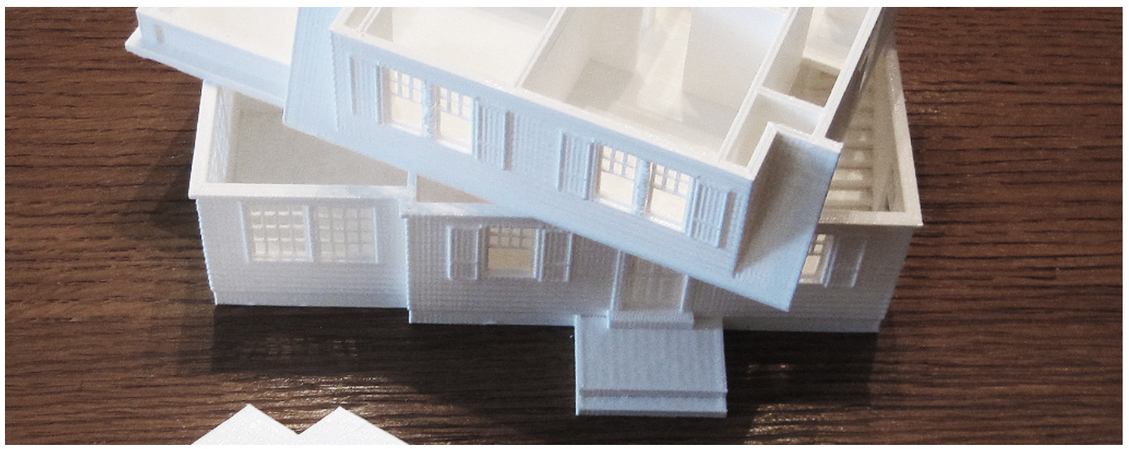
Different materials such as Nylon Plastic, Powder based composite and PC Polycarbonate can be applied due to different conditions needed. For HIM, Colored Nylon Plastic is suggested because it is strong, flexible and smooth compared to others. Instead, complex surfaces and geometries can easily be created which minimizes the blunder of handmade model. It is durable enough to display for a long period of time. Once physical model was printed, it provides a real time spatial experience for visitors and audiences.

For 3D model file method, .wrl, .ply, .obj and .fbx are acceptable while .gif, .jpg and .png and preferable for texture file formats to be submitted.

However, there are some limitations for 3D printing. For example, the balance and weight of model has to be carefully distributed, for those parts which are too fragile are not recommended to support the self-weight of the model. Also, be aware of outstretched elements, such as wires or appendages on figurines and/or parts of the products during design and create of models.

In HIM, 3D softcopy models were already built up in the BIM platform, e.g. Autodesk Revit, the BIM model can be exported out to the 3D printing format and directly fit into the printing machine for output.

Application of 3D printing may vary from small scale souvenirs for visitors or 3D replication of historical artefacts. Following the rapid development of printing materials, the printing trend is envisioned to produce full scale durable replicas of some damaged parts in historical buildings.



12. Detection

12.1 08 QR Code

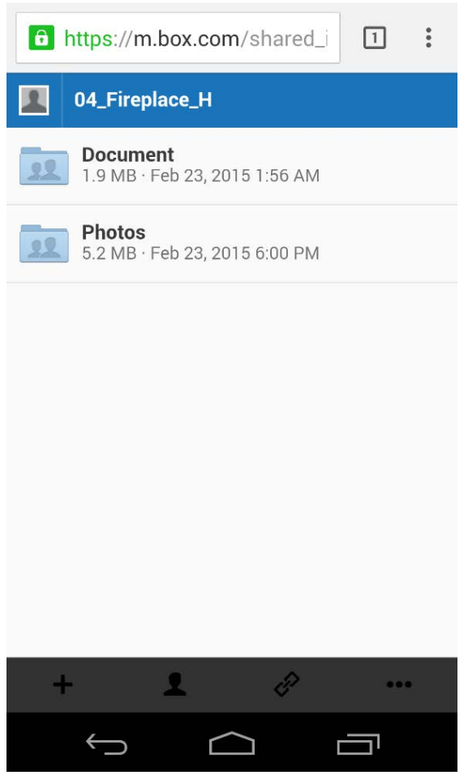
QR code innovated from Japan is a technology for data storage by special 2D barcode which can be scan by any cameras of smart phone. It is an application of basic image-based identification.

The related information can put into cloud or civic server. They can be in different format, such as photos, videos, soundtrack, word files, pdf files. Then, the URL can be generated from cloud services and create a QR code from the URL.

This URL can be generated from simple cloud service which document viewers or cloud platform like A360. The file can be dwf format which is the 2d or 3d

Those QR code can stick on the objects. Visitor can view the related documents of object by using mobile device which installed apps for QR code scanning to scan the QR code. The related information can be viewed by using the browser provided from the cloud. This can adapt to different format of files according to the ability of the cloud. As the attached QR code, the digital information can directly link to the real world to provide live information of the object for the visitor to access.

The advantage of QR code is that the speed of modification of content needed to display is fast. The only thing needs to do is when there is any modification, make sure the QR code is the most updated version. Also, compared with other ICT, it is the cheapest one to be used. No extra apps or device needs to facilitate the detection of QR code since those QR code scanner are already exist in the market and can be easily downloaded from app store.



RFID enables a one-way wireless communication, typically between an unpowered RFID tag and a powered RFID reader. RFID tags can be scanned at distances of up to 100 meters without a direct line of sight to the reader and as such RFID is used globally for asset tracking in warehousing, airport baggage handling, livestock identification and much more. RFID operates at a range of radio frequencies each with their own set standards and protocols.

However, RFID involves a separate device (reader) to receive information/ data which cannot be utilized by common devices such as smartphones. From the HIM point of view, it is suggested to used NFC (Near Field Communication) to serve the purpose.

NFC operates at 13.56 MHz and is an extension of High Frequency (HF) RFID standards. NFC therefore shares many physical properties with RFID such as two-way communication and the ability to communicate without a direct line of sight. There are however three key differences.

1. NFC is capable of two-way communication and can therefore be used for more complex interactions such as card emulation like Octopus Payment.

2. NFC is limited to communication at close proximity, typically 5cm or less.

3. Only a single NFC tag can be scanned at one time.

RFID & NFC technologies comparison table		
	UHF RFID	**NFC**
Frequency	800/960Mhz	13.56Mhz
Standards	EPC Gen2	ISO14443A
Communication	1 way	2 way
Reading Rang	2m ~ 10m	5cm
Scan Tags Simultaneously	Yes	No

12.2.1 Methodology

12.2.1.1 Software Framework

The first step was to integrate BIM database and BIM by means of the application programming interface (API) provided by Autoedesk Revit. Therefore, a Revit plug-in software module was developed in Visual C# to connect with the database where in the cloud platform. This application communicates between the BIM Server (database), BIM model, and desktop / mobile users (figure 1).

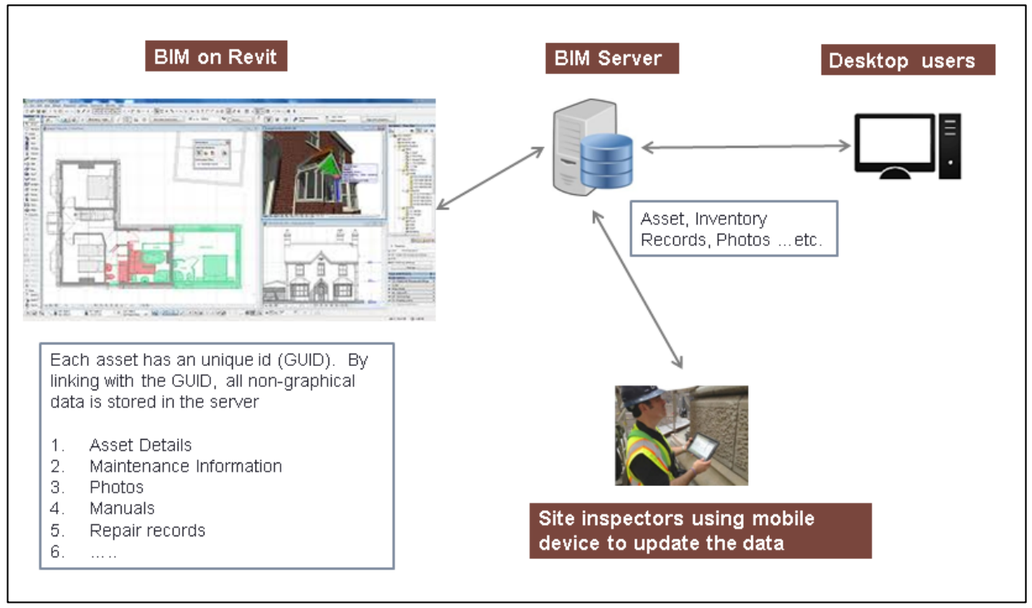


Figure 1

Autodesk Revit comes with complete API for software development purpose. In the Revit API, you can create a GUID directly, and then associate a unique integer value to the new GUID.

A software plug-in was developed to search an object in the BIM using the GUID and then display the corresponding object information based on the pre-defined data attributes (*historical information, pictures, repair records …. etc.*). This software plug-in communicates between the BIM Server (database), BIM model and mobile/desktop users.

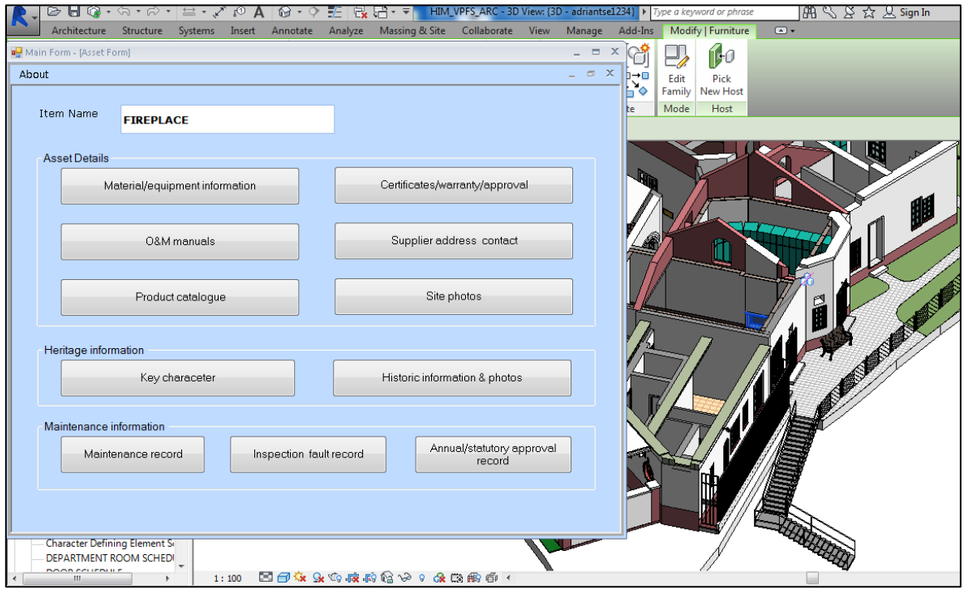


Figure 1: Revit Software Plug-in

The software plug-in also runs the algorithms and displays the user interface and real-time visualization in Revit software (figure 2). In addition to storing all the geometric information (the standard 3D model), a BIM model also has the capability of storing the data attributes for each of its elements, such as part number, material type, historical documents, and pictures. For demonstration purpose, the data information is stored on a cloud database.

Eighteen objects (*roof-timber structure, arch windows, ceiling light …etc.*) are selected in the BIM to demonstrate the application. An additional historical document and pictures are associated with the BIM. By selecting an object in the BIM, its details information will be displayed in the Revit plug-in module (figure 2).

The Autodesk Revit software plug-in is delivered in a zip file and an addin file. Unzip “Etag_Data.zip” to “*C:\ProgramData\AutoDesk\Revit*” directory and copy “ASD_Plugin.addin” file to “*C:\ProgramData\AutoDesk\Revit\Addins\2015*”. By general practice, the “*C:\ProgramData*” directory is hidden. It can be shown by enabling the “*Show hidden files and folders*” attribute in the “*Folder Options*”.

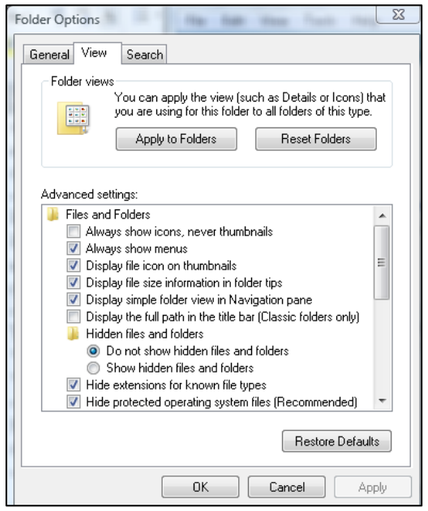


Figure 2: Folder Options in Windows Explorer

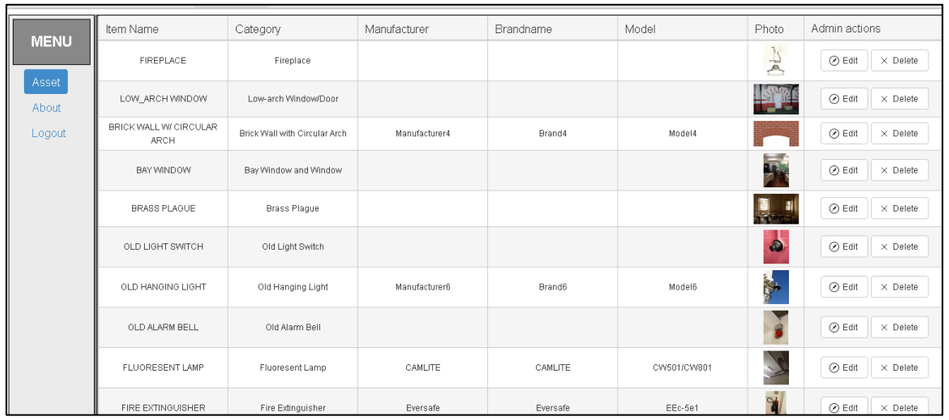


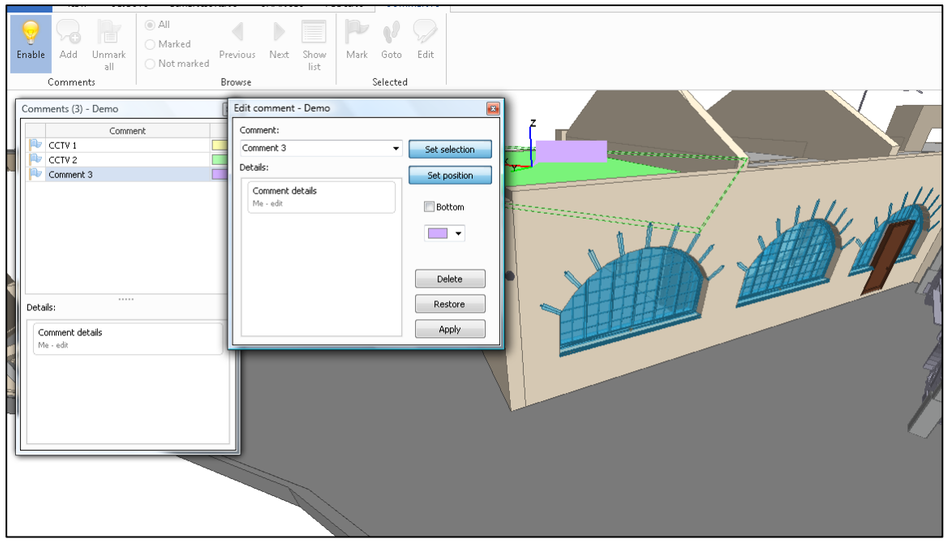
Figure 3: Web Console

Upon the objects are uploaded to the cloud database, the object information (photo, user manuals …etc.) can be viewed / manipulated in the web console (http://archsd-him.etag-hk.com/login). All data amendment can be seen in the Revit plug-in if any data is modified in the web console.

Recommendation

In the long term, a **lightweight and cost effective BIM viewer** is proposed so that the field service people can view the 3D model and retrieve its data on-site. For example, **BIM Vision** is one of the BIM viewers in the market which allows the software plug-in development. BIM Vision is a IFC model viewer. It allows viewing the models coming from CAD systems like Revit, Archicad, Advance, DDS CAD, Tekla, Nemetschek VectorWorks, Bentley, and others without necessity of having commercial licenses of these systems or having each of particular vendor's viewer. BIM Vision visualizes the BIM models created in IFC format 2×3. It has many built in features and is the first viewer with plugin interface. Most importantly, the software requires 2GB ram only. Therefore, it can be installed in most of the PC.

The fire station model is exported from Revit to IFC format and then imported to BIM Vision. All data attributes are recognized by viewer without any data lost. Here is the screen capture of the model displayed in BIM Vision software. A software plug-in was developed so that field service people can put the comment of an object and then updated in the BIM.



For the purpose of HIM study, a BIM Vision is being used for the demonstration purpose.

Deliverables

1. Autodesk Revit 2015 plug-in module
2. BIM Web Console
3. BIM Server Database on Cloud platform
4. BIM Server API for data retrieval application on mobile device

12.3 D10 Augmented Reality

12.3.1 Abstract

We describe a complete methodology for real-time integrated mixed reality systems that feature realistic complete simulations of animated BIM who augment real environments. Although initially targeted at Cultural Heritage Sites, the paradigm is by no means limited to such subjects. The abandonment of traditional concepts of static cultural artefacts or rigid geometrical and textual augmentations with interactive, augmented historical character-based event representations in a mobile platform, is the main contribution of the described work as well as the proposed extensions to AR Enabling technologies: an AR character simulation kernel framework with character to object interaction, a marker-less camera tracker specialised for non-invasive geometrical registration on heritage sites and an mixed reality illumination model for an alternative modal reality. We demonstrate a real-time case study on the actual site of ancient Pompeii.

Augmented Reality

Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data.

Methodology

Tracking

Mobile augmented reality systems use one or more of the following tracking technologies: digital cameras and/or other optical sensors, accelerometers, GPS, gyroscopes, solid state compasses, RFID and wireless sensors. These technologies offer varying levels of accuracy and precision.

Display

Various technologies are used in Augmented Reality rendering including optical projection systems, monitors, hand held devices, and display systems worn on one's person.
In this case we selected iPad and Android Tablet as the development platform due to popularity and usability of mobile smart devices.

Solution

Our solution effectively presents a BIM model overlaid on camera view in real time. Imagine a complete project team in a design review meeting zooming in on the 3D BIM model, each team member is able to highlight different aspects of the project, explore the model to expose details and discuss options, browse historical information for building management from a BIM model. By applying Augment Reality technologies, our visualising BIM solution can improve efficiency and quality.

Development Tools

1. Autodesk Revit
   BIM development tool
2. Autodesk 3ds max
   Triangulation, lighting and texturing
3. Unity3D
   Real Time 3D Rendering
4. Qualcomm Vuforia
   Augmented Reality Engine and Camera-based Tracking System
5. Xcode and Eclipse
   iOS and Android Development kit

Mobile Technology Overview

Four key factors highlight the main reasons for this rapid adoption by mobile users:

1. Democratisation of smartphones: The high penetration of these mini computers coupled with the unlimited data flat rates associated with them have led to a market explosion for applications and Internet access from mobile phones, leading to the proliferation of on-the- go services.

2. Maturity of the market: Users no longer demand mere mobile applications, they want to live experiences that are easy to use and that add value.

3. A boom in location-based services: The
   success of location solutions in recent years acts as an enabler for the takeoff of AR solutions.

4. Consolidation of Apps Stores: In a very short period of time, Apps Stores have managed to position themselves as the user's favourite distribution channel of mobile applications and have created a reliable ecosystem for the development of new services.

Today, the use of AR technology has spread mainly through the two mobile platforms already mentioned, Android and iPhone, and al- though with current penetration levels they are not dominant in the worldwide market (yet), at the level of mobile service usage and revenue generated by their contents, they are.

As with all new technologies when they first appear, the market is currently very fragmented. Smaller vendors, in some cases recent startups, provide AR applications. AR tools and facilities are not standardized so availability varies among mobile platforms. This means that the organizations that want to exploit this

technology will need to choose between one or more platforms to deploy their new AR services.

At the moment, there are different kinds of AR services on the market that allow interaction with the outside world. These fall into two broad categories depending on the technology required to identify objects: Location and Recognition.

Location

If an individual knows their exact position and what their mobile camera is focused on, they can represent information about any object in their field of vision in 3D.

This exploits the capabilities of the numerous navigation sensors incorporated in the latest smartphone generation to help contextualize surrounding information:

1. A GPS to accurately locate the user's position using satellite triangulation.
2. A digital compass, also called a solid-state compass, to measure the relative position to the Earth's magnetic North Pole.
3. An accelerometer to detect changes in orientation and speed, and the variation of inertial motion, including falling and vibration shocks.
4. A gyroscope to support the accuracy of the accelerometer and correct variations in the conservation of angular momentum.

All these features, which were unthinkable in a mobile phone just a few years ago, are now the basis for the development of all kinds of AR services that impose virtual information on real space.

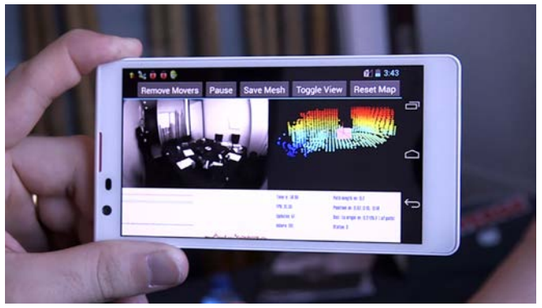
Recognition

The second method is more complex. It is based on the way that the phone is able to recognize the shapes and sounds that surround it by identifying digital patterns. Unlike the previous approach, this method can also work in indoor spaces because it does not depend on the user's GPS positioning. How does it work?

Using Markers:
Small images that allow the mobile device to recognize or translate content must be given. For example, when 2D barcodes, now ubiquitous in the market, are read by a terminal they are capable of generating an action: play a multimedia video, send an SMS, connect to a mobile web device, etc. LLA Markers from Junaio Company, can generate 3D content in real time from latitude, longitude and height as transmitted to the terminal that is then superimposed on the screen.

Marker-less indirect recognition:
With object recognition, point could database is being created as tracking target. The smartphone compare the detail and featured point of the captured image in real time and mapping the information model on top of the screen.
A similar system, processing the data in the cloud and delivering a result, is used by the Google AR product known as Google goggles. Among its features is the ability to provide information about any monument, translate texts, read labels on wine bottles, download information from a picture in a museum, etc.
The other method is using 3D structure camera such as Kinect, Google Project Tango, Microsoft Hololens or other dual lens camera system. These device can capture not only the visual image, but also the depth of the world which can be helped to perform markerless augmented reality.

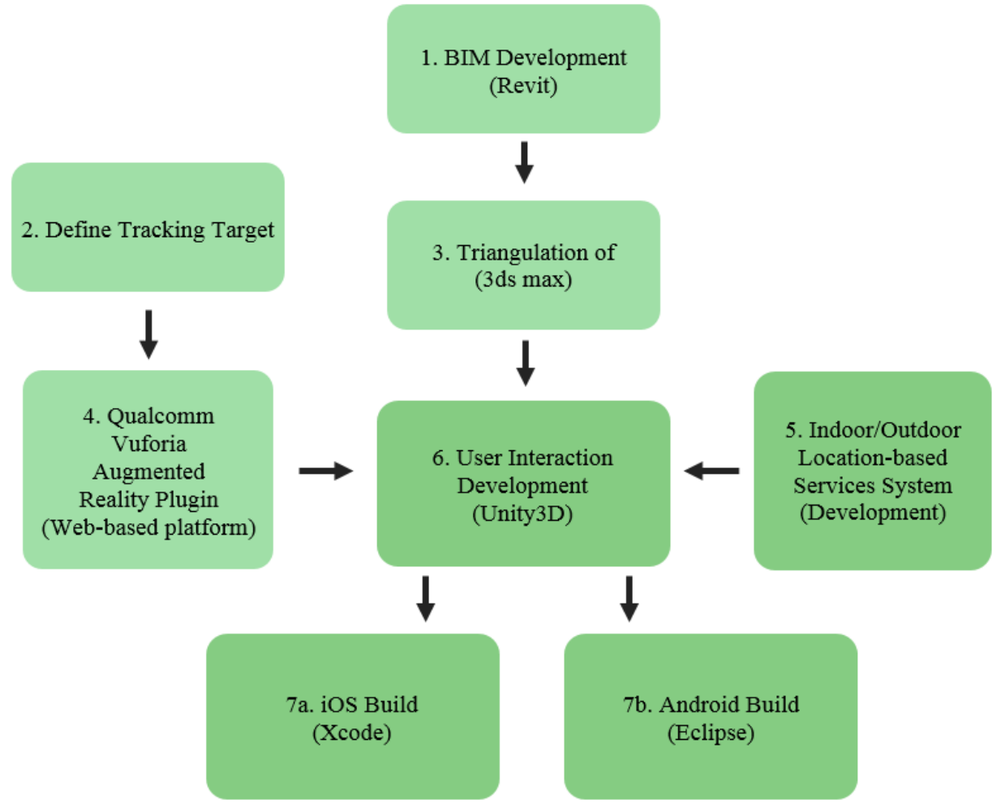
Microsoft Kinect ONE



Google Project Tango

Microsoft Hololens

Development Cycle



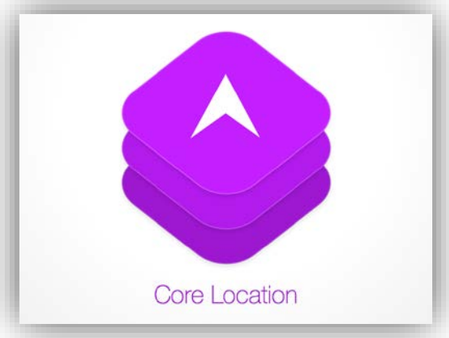
Tools Definition

1. Autodesk Revit
   http://www.autodesk.com/products/revit-family/overview
2. Target Manager
   https://developer.vuforia.com/target-manager
3. Autodesk 3ds max
   http://www.autodesk.com/products/3ds-max/overview
4. Qualcomm Vuforia
   https://www.qualcomm.com/products/vuforia
5. Core-location framework
   https://developer.apple.com/library/ios/documentation/CoreLocation/Reference/CoreLocation_Framework/
6. Unity3D
   http://unity3d.com
7. Xcode & Eclipse Development Guide
   https://developer.vuforia.com/library/getting-started

Selection of Tracking Technologies for HIM

1. Tracking methods used for BIM mapping:
   a. Outdoor position using Core-location framework
      i) Geographic information system (GIS) based Augmented Reality for heritage sites.
      ii) Official development framework
      iii) Support iOS and Android platform with official OS updates

   b. Indoor position using Core-location framework
      i) Bluetooth 4.0 low energy with Triangulation for positioning
      ii) Trends for indoor positioning purpose
      iii) Fully supported iOS and Android



c. Image-based Tracking using Vuforia Augmented Reality Engine

i) The Vuforia platform uses superior, stable and technically efficient computer vision-based image recognition and offers the widest set of features and capabilities, giving developers the freedom to extend their visions without technical limitations. With support for iOS, Android, and Unity 3D, the Vuforia platform allows you to write a single native app that can reach the most users across the widest range of smartphones and tablets.
ii) Extended image-based Tracking (Compass, Gyroscope and Accelerometer)
iii) Object recognition Tracking
iv) Fully support iOS and Android

2. Visualisation:
   a. Triangulation using 3ds max
      i) GPU in Mobile supports triangulated or Quadrangulated polygon meshes. Nurbs, Nurms, Subdiv surfaces must be converted to polygons.
   b. Unity3D for mobile app development
      i) With an emphasis on portability, the engine support OpenGL ES on Android and iOS
      ii) Real Time Image-based lighting
      iii) Support Vuforia Augmented Reality Plugin

3. Hardware:
   A. iBeacon Transmitter
   Our beacons are best in class iBeacon certified beacons, that are also available in volume and can be rebranded to match Authority identity.
      i) Compatible with all BLE Ready enabled smartphones
      ii) Battery and USB options available
      iii) Fully configurable over-the-airSecure firmware to ensure tamper-free operation and denial of service protection
      iv) Multiple certifications (CE, FCC, IC etc.)
      v) Long range models available with 200m+(up to 450m) of range
      vi) Works with all Bluetooth Low Energy (Bluetooth Smart Ready) enabled smartphones (Apple iPhone 4S/5/5S/5C, Android 4.3+)

WiFi and iBeacons support and requirements

The following table shows the compatibility of different operating systems with WiFi and iBeacons.As a rule of thumbs, we suggest to perform the initial site survey with an Android smartphone for WiFi collection, and with iOS 7+ for iBeacons.

Platform	Wifi 2.4 GHz	Wifi 2.4 + 5Ghz Band	iBeacons
Android - OS >= 3	**Supported - fast scan rate**	**Supported - slow scan rate**	**Supported on Android 4.3+ - Medium scan rate**
iOS 6.x	**Supported - fast scan rate**	**N/A**	**N/A**
iOS 7.x	**Supported - slow scan rate**	**Supported - slow scan rate**	**Supported - medium scan rate**
iOS 8.x	**N/A**	**N/A**	**Supported - medium scan rate**

Accuracy factors

Number of obstacles

It works better inside building with a lots of walls. Since the attenuation of the radio signals is stronger, it is easier to pinpoint the position of a WiFi device. In open space environments the WiFi signal attenuation is weaker, so everything being equal, the accuracy will be lower.

Materials of obstacles

Although the system works well in closed environments with a large number of solid walls, it must be said that different types of materials can affect in different ways the accuracy.
In fact, if the walls are too thick and the absorption of the walls is too high the entire communication of the nodes in the mesh network may be compromised.

Human

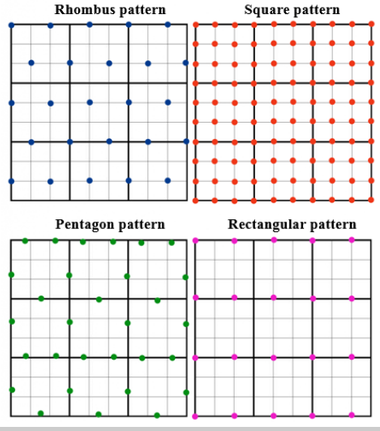
One source of interference is the human body that, with its high percentage of water, attenuates the RF signal.

Number of Beacon

Increasing the nodes density (and especially increasing the number of gateways) will almost always increase the system accuracy.

However from the accuracy point of view, it is possible to calculate the minimum number of nodes needed to achieve a desired accuracy. Keep in mind that nodes must be placed uniformly in a grid pattern (not strictly a square pattern):

The accuracy of the system is affected by the spacing between nodes inside this grid:
• accuracy of 2-3 meters, you have to place your nodes about 10-15 meters from each other
• accuracy of 3-5 meters, you have to place your nodes about 15-20 meters from each other



Accuracy factors (continue)

To estimate the approximate number of nodes required to cover a given surface with a SQUARE pattern we use these formulas:

NODES_PER_SIDE =

(SQRT(AREA) / NODES_SPACING) +1

NUMBER_OF_NODES =

NODES_PER_SIDE * NODES_PER_SIDE

Spacing and position

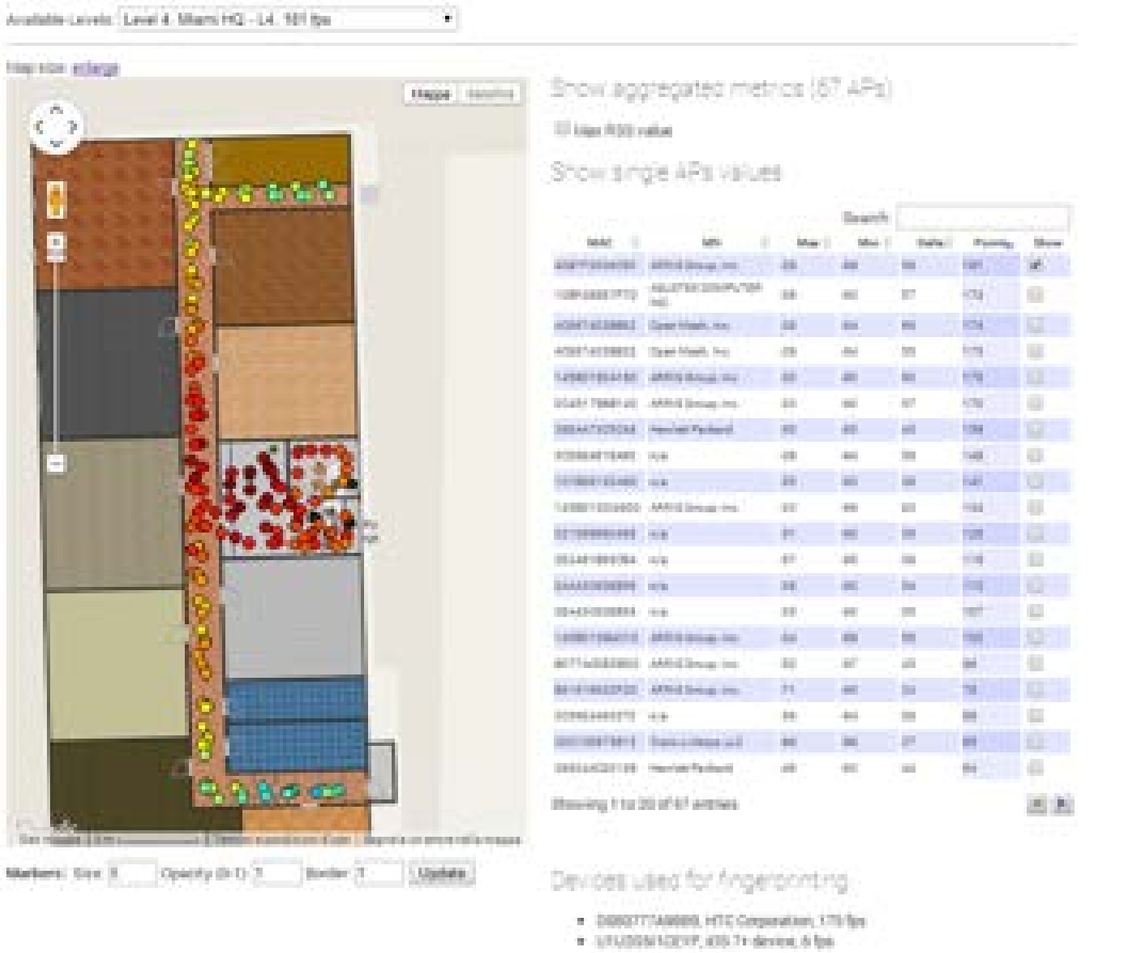
Even if, very often, you will not be able to change the disposition of the access points already installed/available in the site, you need to be aware that the best results are obtained when the access points are installed uniformly (ideally in a in a grid pattern) all around your site.

The nodes should be installed (in order of preference):
- on the ground
- inside a false-ceiling
- on the ceiling
- on the upper or lower part of the walls.

Fingerprinting Technique

The fingerprinting technique is widely used where line-of-sight signal propagation is not typical. The low cost of the user hardware and the promising performance are its main advantages. Wi-Fi location fingerprinting consists of two phases: the off-line data training phase and the on-line positioning phase.
The aim of the training phase is to build a fingerprint database. To generate the database in a conventional way, some reference points (RP) in the area of interest are selected. Locating a MS at one RP location, the RSSs of all the APs are measured. From such measurements the characteristic feature of that RP is determined, which is then recorded in the database. This process is repeated at another RP, and so on until all RPs are visited. In the positioning phase, the MS measures the RSS at a place where it requires its position. The measurements (including RSSs and MAC addresses of the APs) are compared with the data in the database using a matching algorithm. Typically, the signal distance is computed.

The smallest signal distance indicates the best match and the likeliest location of the MS can be determined.



For each one of the unique access points detected during the training phase, it is possible to get:
MAC: the MAC address of the access point.
Mfr: the manufacturer of the access point.
Max (dBm): the maximum Received Signal Strenght (RSS) for the access point.
Min (dBm): the minimum Received Signal Strenght (RSS) for the access point.
Delta (dBm): the difference between Max and Min RSS values. Delta values bigger than 40 dBm can be considered very good, because this means that the specific access point has been seen multiple times during the training phase.

Points: the number of times the access point has been detected during the training phase. Number of Points over 40 can be considered very good, because this means that the specific access point has been seen multiple times during the training phase.

Show: this is a check box used to show all the positions (reached during the training) in which the access point has been detected. It is like an heat map and this means that Red dots represents positions in which the access point has been seen with a very high RSS. Blue dots represents positions in which the access point has been seen with a very low RSS.

Implementation:

A. Part 1: Displaying the site change
Objective:
Display the building changes (exterior).

I. Methodology:
Outdoor positioning using Geographic information system.
Display unit: macro (building)

This project is focused on developing a design methodology and software tools for heritage augmented reality applications. The aim is to explore the use of virtual heritage reconstructions to recreate the experience of historical events using both augmented reality and mobile geo location (GPS) technology. This new system which would run on a smartphone or pad device will increase the appreciation and understanding of the cultural heritage of a specific location as well as greatly increase the accessibility and relevance of museum collections.

Capturing the site GIS data for best viewing area.
Latitude : 22.265333
Longitude : 114.152385

Google Map API is used for mapping between 3D scene and reality. There is approximate identity between the user's visual perception of the real physical environment and the user's visual perspective into a 3D graphics environment as it is represented on the screen. The relative congruity between the real and the virtual perspectives is obtained by letting the camera position and movement in the 3D environment be conditioned by the positioning and orientation hardware. As the user moves in real space the perspective inside the 3D graphic environment changes accordingly.

App applies HDR image-based lighting. By importing, converting, and managing panorama backgrounds, the bring high quality natural lighting to the 3D rendered environment.

II. Screen capture

III. Limitation
- Accuracy of the tracking depends on GPS
Signal
- Working in outdoor environment only

IV. Future possibilities of prototyping
I. Simulate and map non-existing groups of buildings / environment for users' vision (outdoor)
II. Sample:
Situated simulation for Rome Forum

III. Building Maintenance Applications using Augmented Reality 3D Tracker

B. Part 2: Roof with architectural style - World's first application combining BIM and BLE indoor positioning

Objective:
Display the unseen partition (interior).

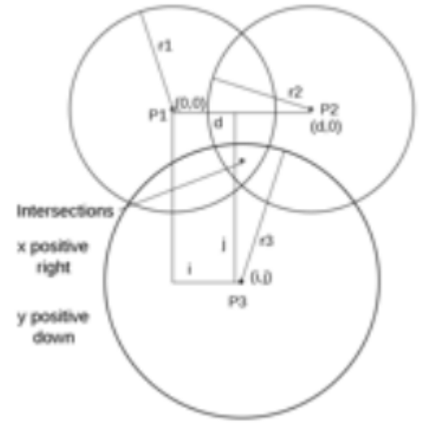
The aim of this project is to explore the potential for creative technologies to increase our understanding of life in VPFS. It includes research into the 3D reconstruction of VPFS within a gaming environment. With the latest indoor positioning technologies, the BIM model is mapped to the camera view of smart devices and overlay information on top of the computer vision.

We recently completed a trail of the iBeacon positioning system at VPFS, utilizing Bluetooth 4.0 low energy proximity sensing to identify the movement of people and machines to improve safety on site. Bluetooth 4.0 is a very low power, low-cost transmitter embedded in most modern smartphones, including iPhone above iOS 8 and recent Android phones.The system installed at VPFS, involved setting up a local positioning network that triangulates between operatives' Bluetooth phones, and Bluetooth transmitters positioned on plant and machinery, and a network of beacons set up across the site.
The aim of the trial was to understand the capabilities of using local positioning networks to demonstrate the site with Augmented Reality Technology.

I. Methodology:
Indoor positioning using Bluetooth Low Energy triangulation.

Display unit: macro (room)

Hardware requirements:
1. iBeacon sensing infrastructure
2. Ranging the signal strength and record all the sampling data, the data should include: map coordinate, position signals and their RSSI. (picking three closest iBeacon signals for positioning with three points positioning algorithm)



3. Mapping the calculation to the actual environment iBeacon details:
1. Range: within 20m
2. Frequency: 10Hz

II. Screen capture:

III. Limitation
Setup and calibration to increase accuracy of detection, only supported with smart device with Bluetooth 4.0.

The height of the user in 3D rendered scene is fixed (Eye level) due to the infrastructure design.

IV. Future possibilities of prototyping
(i) Illustrate the whole interior of the building with different layers, such as construction, indication, useful information for specific group of users.
(ii) Install indoor positioning system to different room (or building).
(iii) Integrate interactions for visitors.

(iv) build 2015 hololens demo architecture firm for overlaid BIM visualization

III. Limitation
Flatten object with limited perspective changes and non-reflective surface

I. Future possibilities of prototyping
(i) Capture different part to gather a library of targets
Use this feature to facilitate creating more robust applications, because any augmentations attached to these Targets will persist. In practice this means that after you point your device away from the initial Target, any augmentations maintain their positions with respect to the real world and are consistent with the initial reference frame defined by the target. The more detailed and feature-rich the environment, the better Extended Tracking works.

C. Part 3: Fireplace - extended image based tracking

Objective:
Display the internal construction with animation.
I. Methodology:
Extended image-based tracking
(Extended tracking during tracking image target is out of the camera capturing area)
Extended Tracking utilizes features of the environment to improve tracking performance and sustain tracking even when the target is no longer in view.

Display unit: micro (wall, partition)

Screen cap shows, the augmentations of buildings on top of fireplace are displayed on the screen of the device. This encourages the user to pan to these items by moving the angle of the camera to point upwards, thereby making the fireplace
Target disappear from view. In previous versions of augmented reality application, this led to all augmentations disappearing, because the Target reference frame is lost.

With the Extended Tracking feature, the buildings remain visible even when the fireplace Target is not in the camera view.

Note that after the Fireplace Target goes out of view it is not required for further display of the augmentations if this feature is enabled. That means that the augmentations persist without the target, and this capability supports more robust and continuous AR experiences.

II. Screen capture:

D. Part 4: Old light switch using 3D object recognition

Objective:
Display the object with animation / instruction.
I. Methodology:
Object recognition and mapping
Object Recognition, one of our most requested features, enables apps to recognize and track a wide range of objects. This new capability is ideally suited to bring objects to life.

Display unit: micro (single object)

1. 3D object scanning
The Object Scanner is an Android app that makes it easy to create object targets. As you scan an object, the app provides real-time visual feedback on the target quality, coverage, and tracking performance, allowing you to test and adjust the target even before starting app development.

II. Screen capture:

III. Limitation
Require 3D object scanning with nonreflective surface
IV. Future possibilities of prototyping
Capture different part to gather a library of target objects

Summary

The above listed features are designed to solve time consuming problems that hindered architects productivity. These solutions include support for large Autodesk Revit projects, removal of a constant export/ import process into supporting software, and an easy method to present clients an interactive 3D environment in Augment Reality experience.

Augmented reality (AR) is an emerging technology that could have a significant impact on the AEC industry in the coming years. Augmented reality is the enhancement of real world environments by overlaying virtual data, images, etc. onto a physical space.

1. Improved visualization using Augmented Reality and BIM
2. Improved productivity due to easy retrieval of information
3. Increased coordination of construction documents
4. Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering
5. Increased speed of delivery
6. Reduced costs

A console is to integrate the different technologies to form an integrated layout for the HIM process. A necessary integration for all technologies is the interface of HIM to all the public.

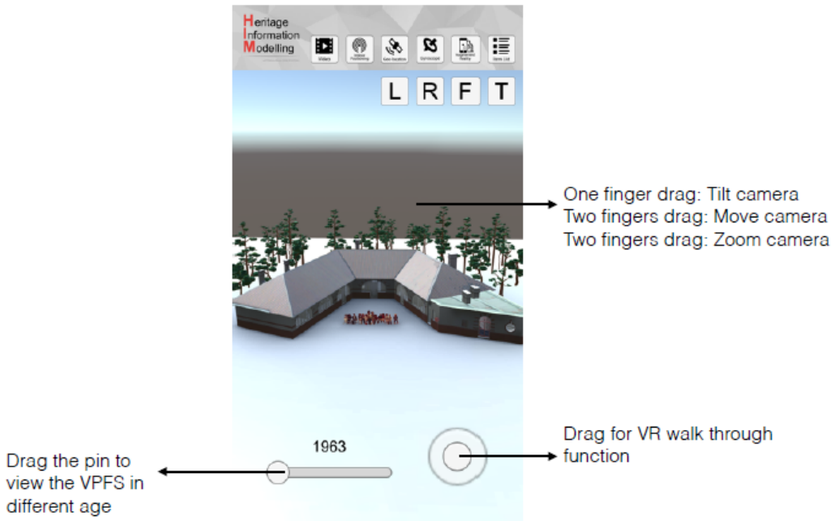
Users can push six buttons possessing on the console. Each button represents different technology used for the project. For example, when users want to use AR, than clicking on the AR button, the app for AR can be called out and users can experience the technology immediately. Visitors and maintenance staff can both be facilitated by this console for experiencing all technology provided.

Next consultancy can be given about the true integration of the technologies. The current consolidated platforms can only provide the access points of different applications. Further development can be achieved by programming a new application for detecting the tags of related technologies like NFC or AR automatically.

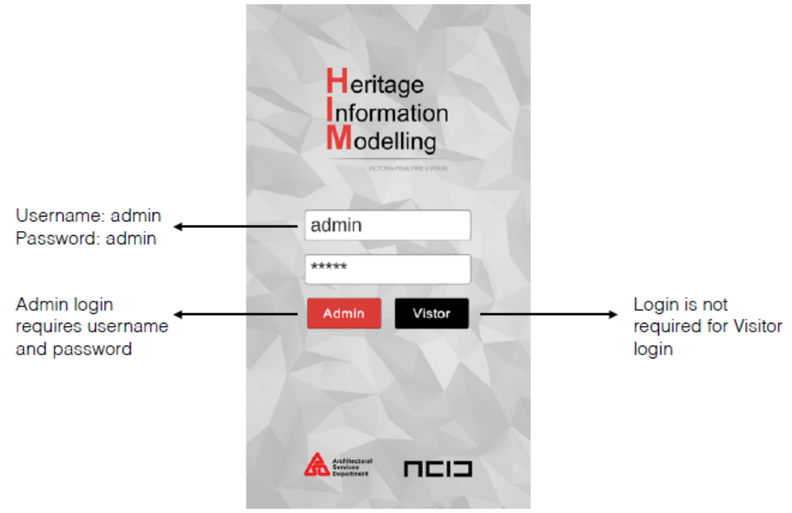
Deliverable

System requirements:
Android 4.3+ with BLE 4.0 or above

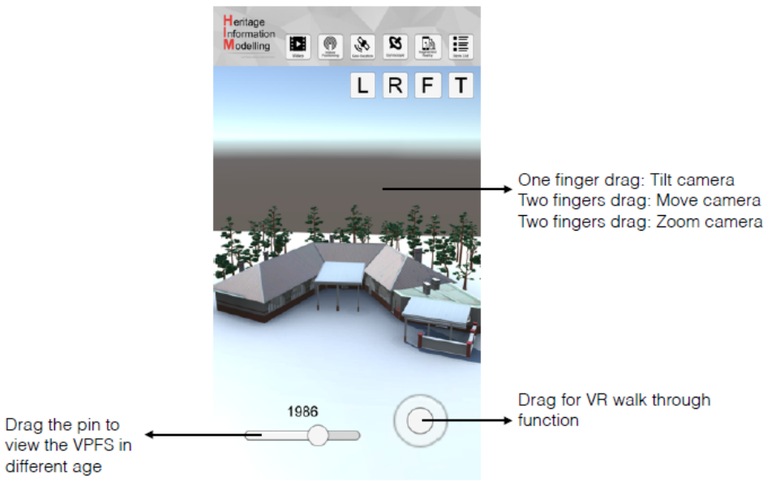
Main features:
1. Geo-location HIM mapping
2. iBeacon indoor HIM mapping
3. Augmented Reality (image-based tracking)
4. Virtual Reality (Gyroscope, digital compass and sensors)
5. Cloud Asset Information



3D View Page (1963)

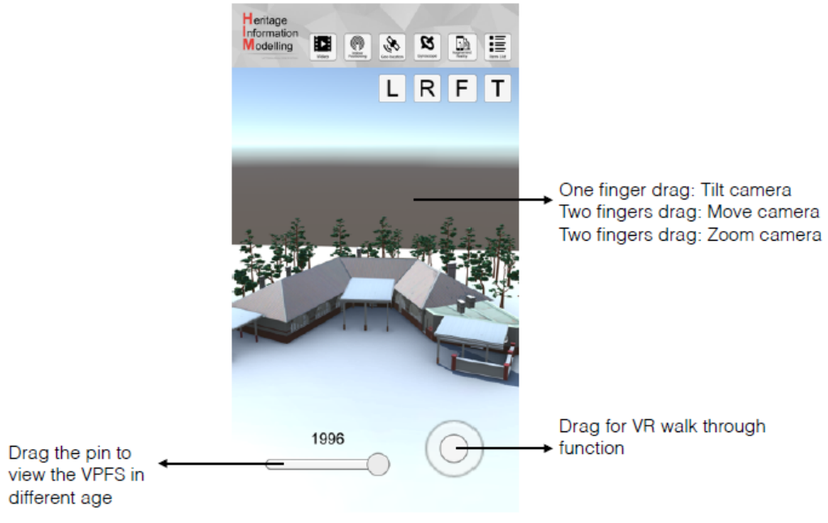


Login Page

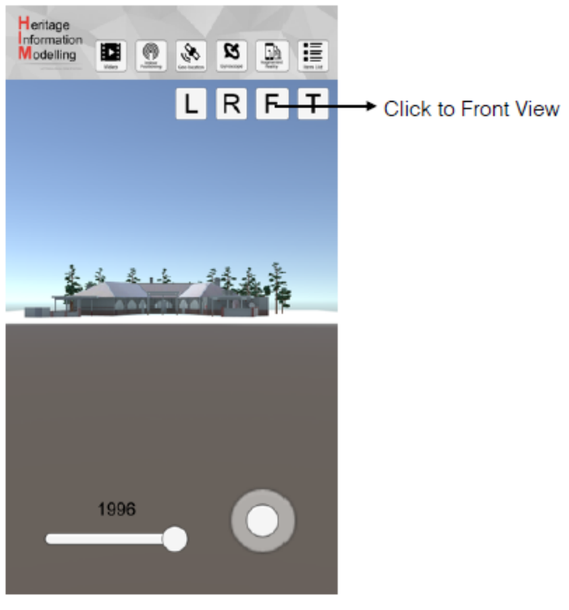


3D View Page (1986)

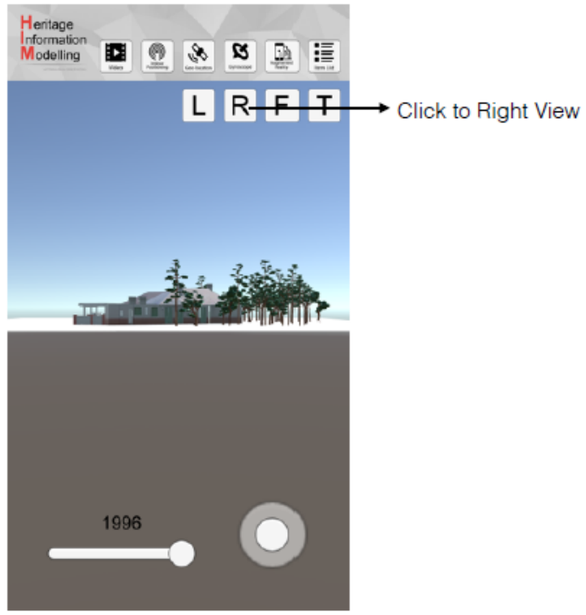
3D View Page (Left)



3D View Page (1996)



3D View Page (Front)



Click to Right View

3D View Page (Right)

Click to Top View

3D View Page (Top)

Camera mapping with the iBeacon signal

Indoor positioning mode
Current camera located by indoor positing system (iBeacon)

Drag the pin to view the VPFS in different age

VR walk through function locked, indoor positioning override the camera movement control

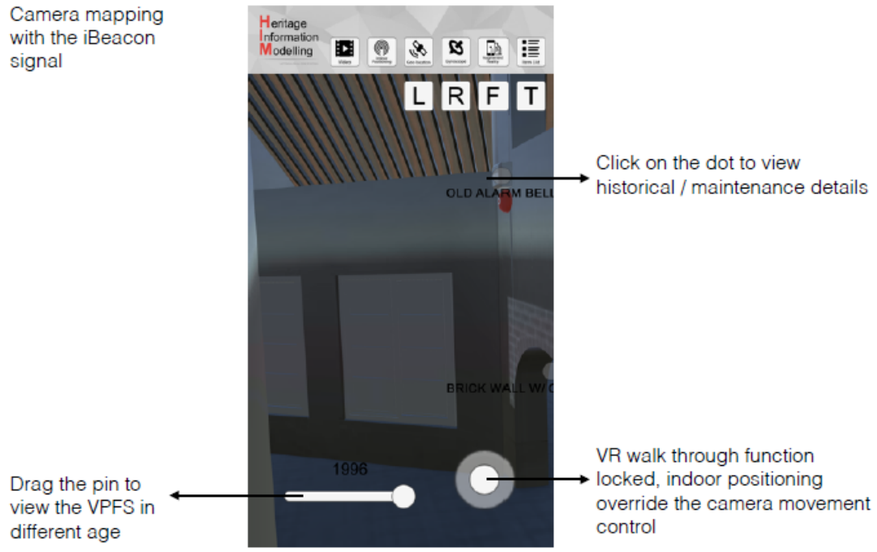
3D View Page (Indoor positioning mode)

Historical item list

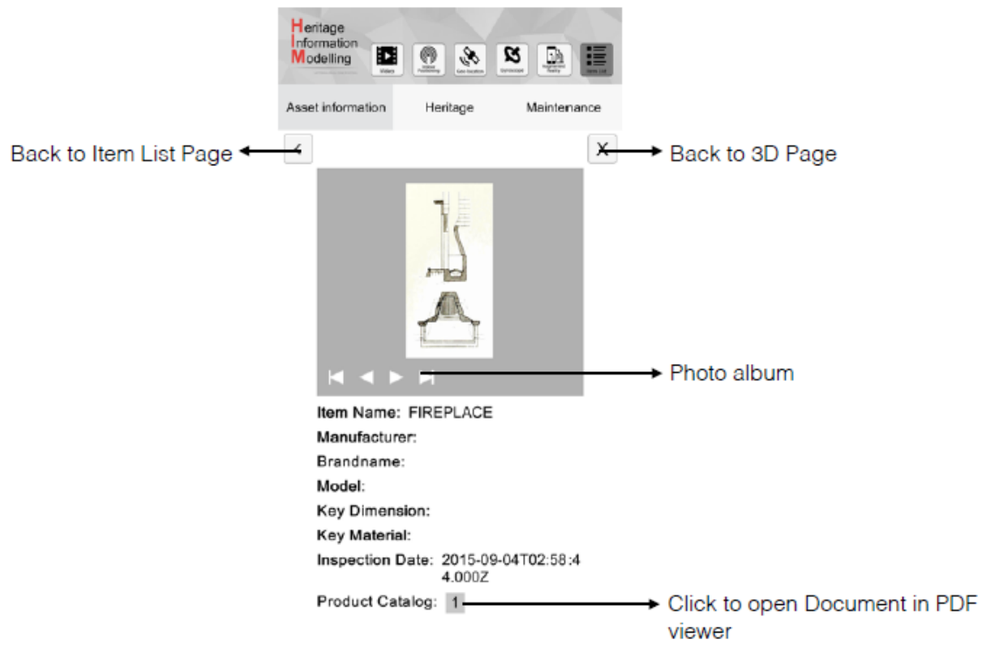
FIREPLACE
LOW_ARCH WINDOW
BRICK WALL W/ CIRCULAR ARCH
BAY WINDOW
BRASS PLAGUE
OLD HANGING LIGHT
OLD ALARM BELL
FLUORESENT LAMP
FIRE EXTINGUISHER
ROOF AND CHINESE TILES
SITE CHANGE

Click to view item detail (multimedia)

Historical Item List Page



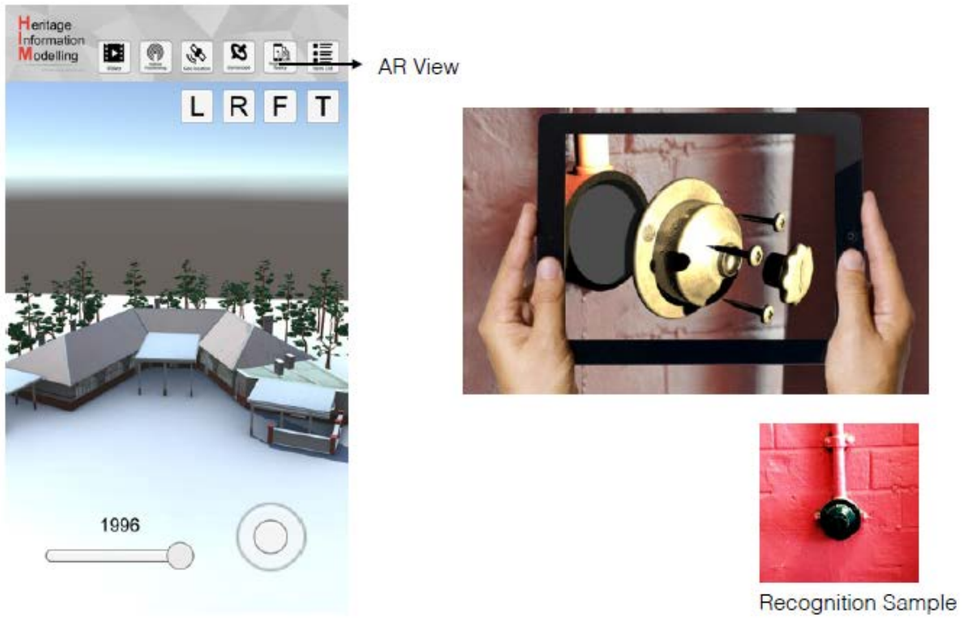
3D View Page (Indoor positioning mode)



Assest Information Page (Admin login ONLY)

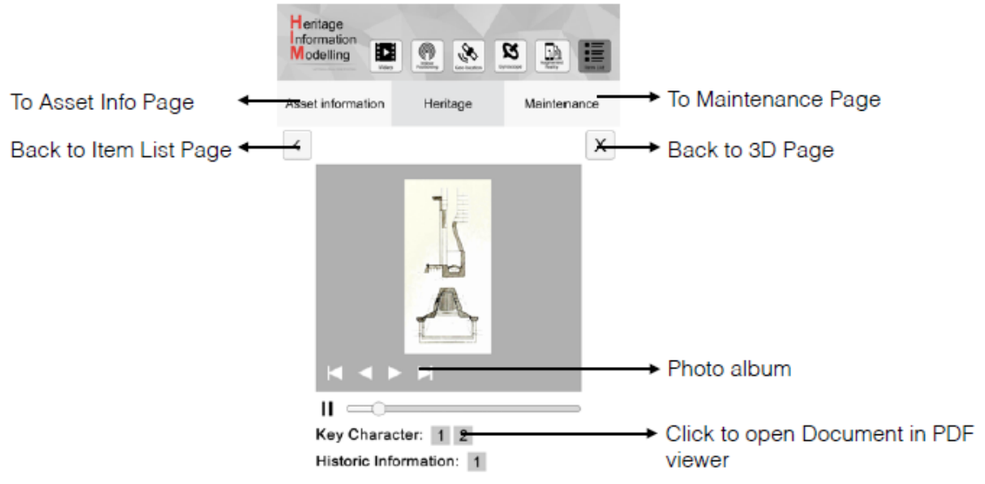
Video Player Page

PDF / Document Page

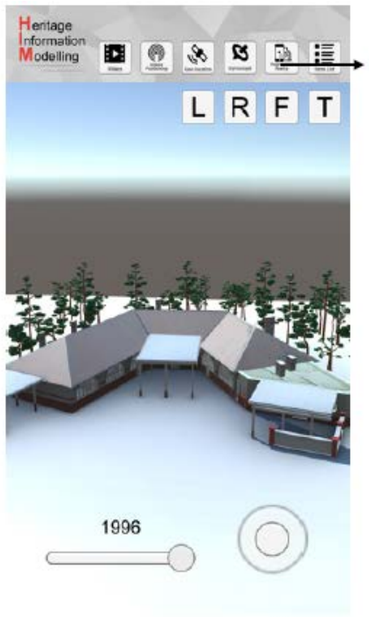


Recognition Sample

Old Light Switch Page



Heritage Information Page (Admin and Visitor)



AR View

Recognition Sample

Fireplace Page

Low Arch Window

Old Alarm Bell

QR Code

13. Cloud

There are two issues on the Cloud:

What is the capacity?

Where is the cloud stored?

After the BIM process, tremendous amount of data will be produced. A platform which can store all the data and provide methods such as viewer or middleware to retrieve and input the data is vital. The cloud can be located in civil server at asset or on server at the service provider. The objectives of the following paragraph is to discuss the applicability of different cloud platform and compare their ability so as to orientate to different users such as the maintenance staff and visitors.

The quality of texture and rendering of model for different platform can be shown in this study. For the purpose of presentation, the quality is acceptable. Of course, the quality can be improved but enormous work must be involved. Since it is not the scope on this study, this topic must be carried out by another consultancy.

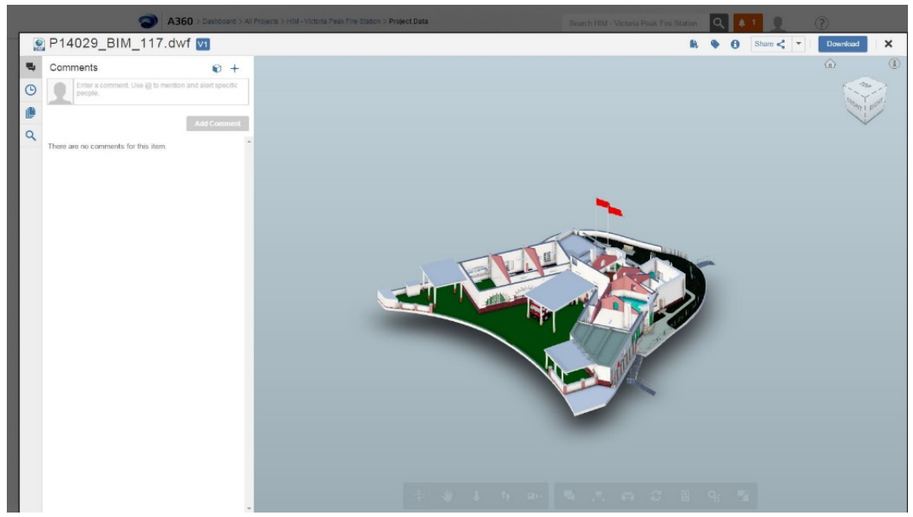
13.1 Autodesk 360 / Design Review

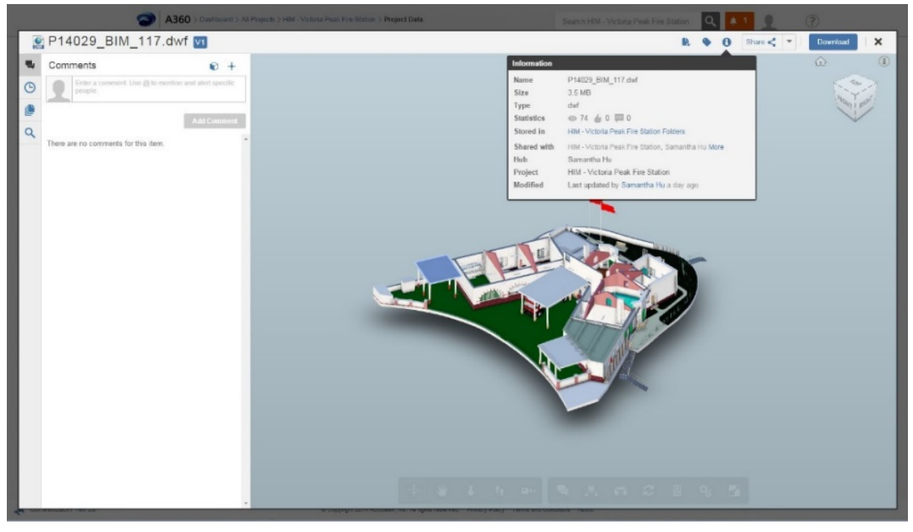
Design review is a software from Autodesk which could view the DWF format file. The DWF file is a 3D base file with all information that Revit model carries. Which means all the information of the model is accessible, but the model it is not editable. Mark ups could be made in the DWF files and all mark ups could be insert into Revit file to allocate the problem. Design review only have desktop version, but you could view the DWF file in webpage through Autodesk 360. Several views of the models can combined into one dwf files and you can compared the difference of model in each phase and the views that are related.

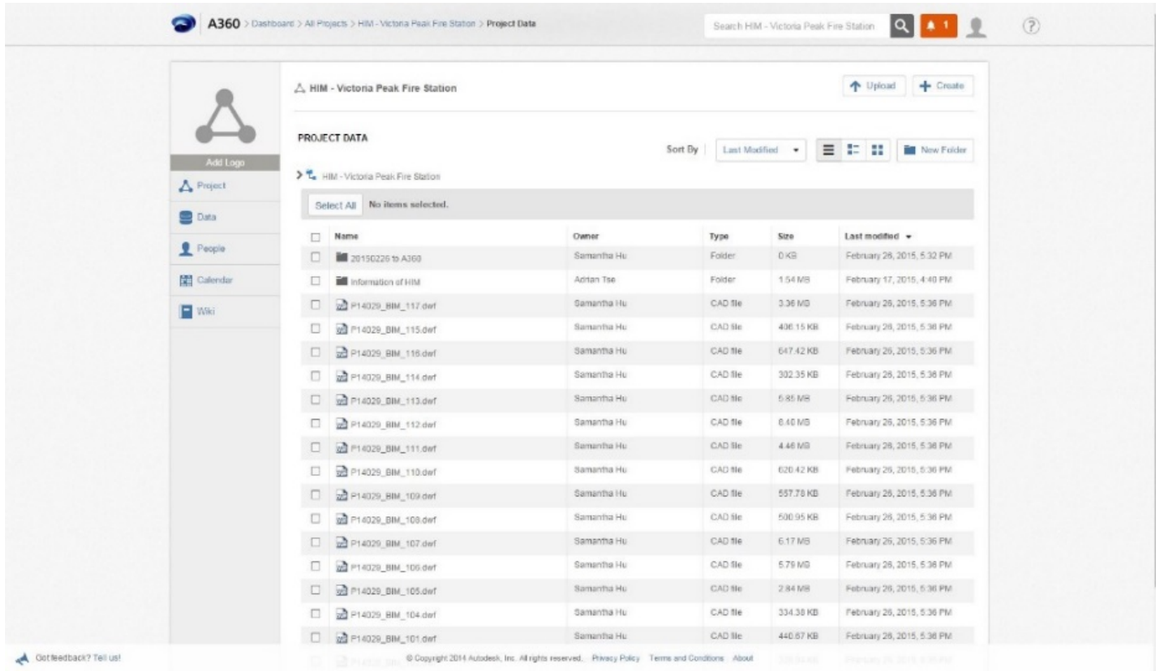
Autodesk 360 is one of the cloud data storage platform within Autodesk family, DWF files could be view in the Autodesk 360 webpage (no software installation is required). Mark ups could be made in Autodesk 360 and you could also view and mark up on the model use your mobile devices. But notification could not be sent in Autodesk 360, other people will only notice your comments when they view the model / mark ups themselves.

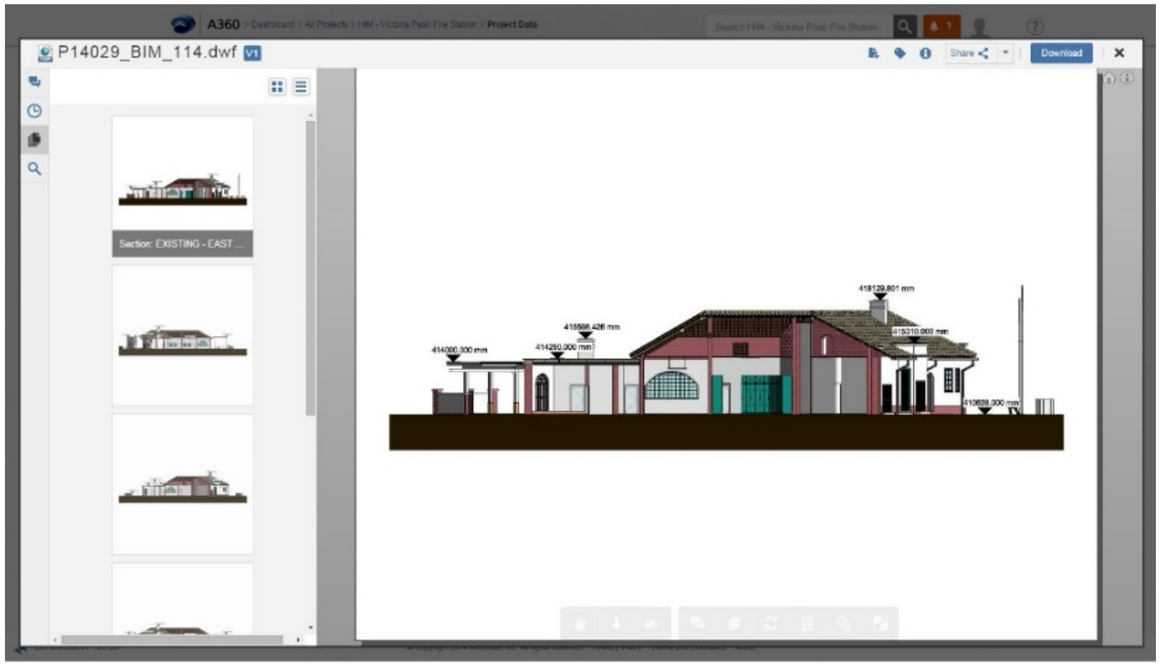
All drawings for VPFS were exported into DWF (2D/3D) and uploaded to Autodesk 360. Everyone could access the model by scan the QR code on the drawings.

Both Design Review and Autodesk 360 are free and unlimited capacity is provided.









Heritage Information Modelling
VICTORIA PEAK FIRE STATION

Architectural Services Department
The Government of the Hong Kong Special Administrative Region

13.2 D13 Autodesk Glue

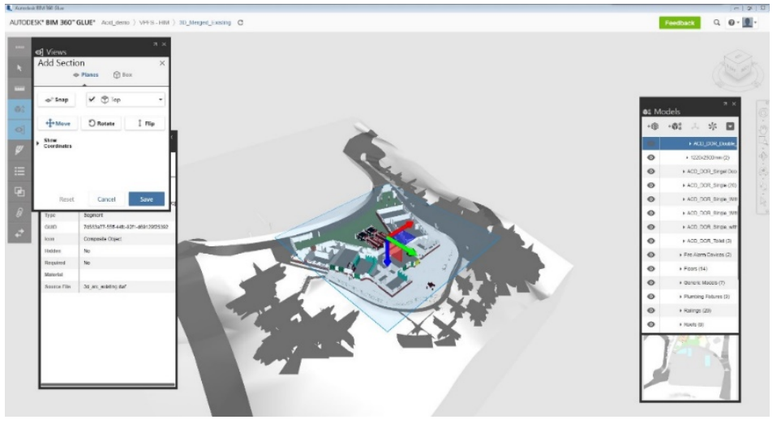
Glue is a DWF storage platform. 3 phases of VPFS models were exported and uploaded to Glue for design / model checking. Client and all consultant could make their comments within the Glue platform and each comments could be notified by email to make sure everyone is aware of the comments. Merge models can be form on glue from different files.

Clash detection and mark ups could be made in Glue, but none of the clash result and mark ups could be import into Revit file. When mark ups were made in Glue, notification could be sent out to relevant parties so they notice the comments immediately. Models could only be access from Glue desktop version and app version. No 2D drawings could be view in Glue.

Glue is a useful tool for design checking. All models could be downloaded to the apps, even if there is no internet access (e.g. on site), client / consultant could still make their comments on the download model and send out the notification when internet is available.

The model could only be access by invitation. The invitation system still needed to be debugged. Since the status of members and the authorities are confused. The numbers of members with enough rights are limited.

Glue is charged as per project base or per account base, unlimited capacity is provided.



13.3 D15 Fuzor

Fuzor is fundamentally a visualization tool helps to solve some common BIM issues and simplify the process thereby allows different stakeholders to communicate collaboratively. It uses the BIM data from Autodesk Revit to create visualizations and simulations as well as validates the intended design and provides instant visual feedback. The collected BIM data can be analyzed and generates different reports to validate for engineers, or illustrate design purpose. The point that needs to emphasize is the planting inside Fuzor is very high quality in visualization compared with all platforms used.

Pros and Cons

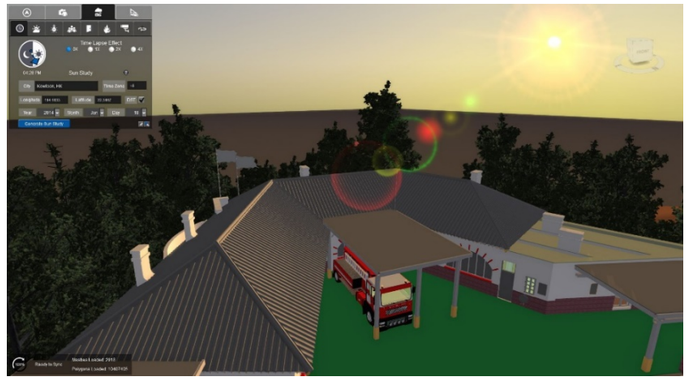
Its strong points lie in the bi-directional live link between Revit and Fuzor allows continuously work on Revit and visualize the effects of their design instantaneously. Irrational Errors can be discovered easier when using fuzor for checking and corrected immediately. The output such as 3D animation and interactive control can quickly response to the

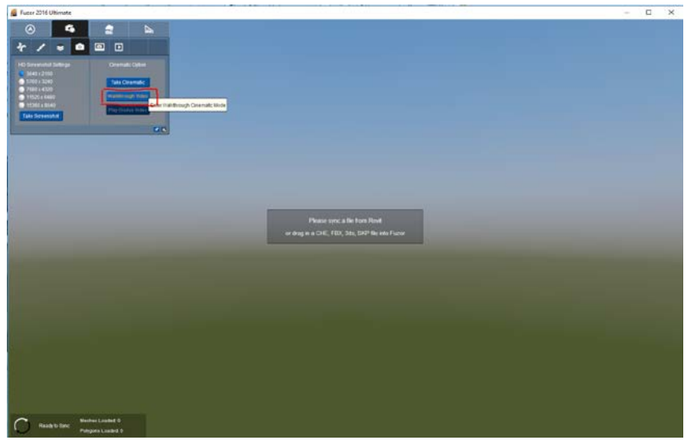
Fuzor produces game quality video and Fuzor does not require remapping of textures and setting lighting effect. Users can save the cinematic path and load the path to the updated model in the later stage of the project, by pressing the walkthrough video button in cinematic option. It saves a lot of time for video production. Also the generated EXE file can let users interactively experience the space without the installation of extra programme. The sun path, weather, view range, etc. can be analyzed by using Fuzor.

Fuzor also has mobile apps for iphone, ipad and android devices.

The disadvantage of Fuzor is that high specification of display card is needed to operate the exe file on desktop. The platform still has some problem on phasing which is big difficulty in HIM. The effect on adding people and cars still need to be improved. The races are limited and the flow of cars are not reasonable. Also, problem of phasing in linked files needed to be solved as the requirement for HIM. Fuzor can only sense the phases of live file that the file opened with Fuzor in Bi-direction Link. To the linked files, their phases will display in the same time which means overlapping of object occur.

Too much information is displayed for the interactive and automatic panel. As the targeted users is visitors, heritage information is the most important. Information for maintenance such as dimension and materials is relatively reluctant.





13.4 D16 Aconex

Aconex is an Australia based project collaboration platform which recently incorporated BIM capability. VPFS was exported into IFC model and then imported into Aconex system (IFC is the only BIM format that Aconex could accept at the moment). Aconex is good at construction coordination, it's not only a platform for BIM coordination. It could have all the drawings (in CAD or PDF format) and correspondence stored in cloud, no one could remove any of the record, which is essential to construction.

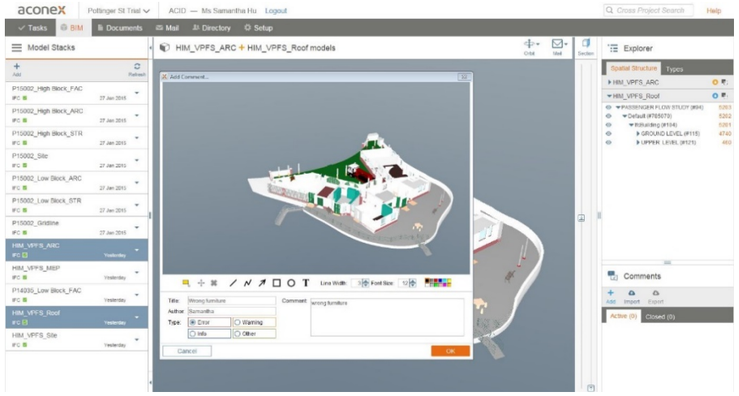
Aconex as an advanced building management platform, has a powerful communication system stronger than mails or message communication. The messages can be categorized and sorting when one wants to check for the record. Access is through dedicated login and password by a System Administrator as per organization.

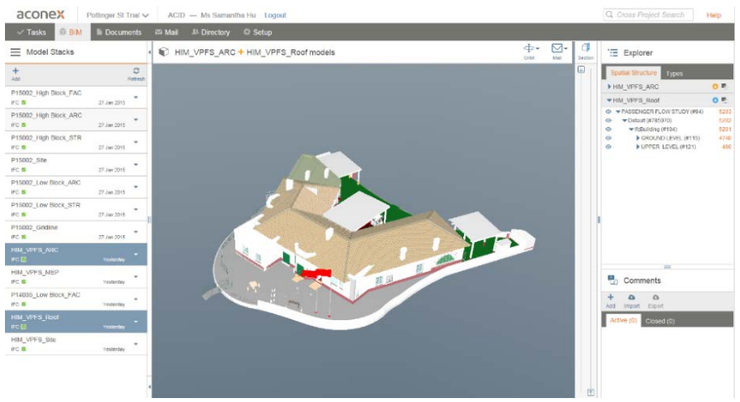
Comments could be made in Aconex BIM model with notification send out to relevant parties, and also could attached to RFI (Request for information) or DQ (Design Query). And comments could be view with different version of model, other platform could only view comments with current version of model.

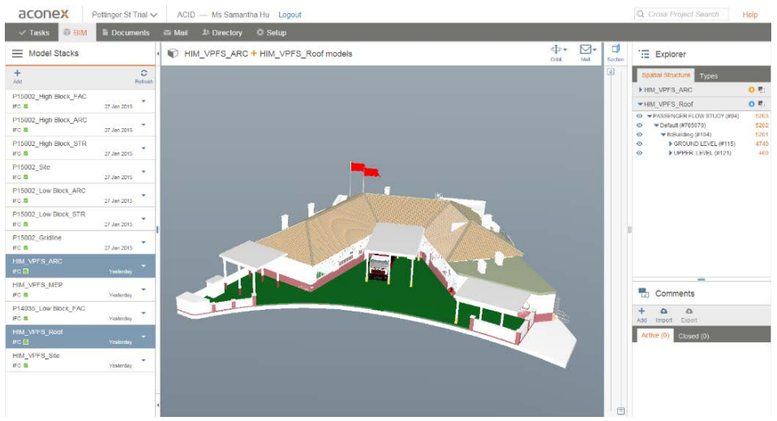
Aconex link BIM and construction together, not limited to the design stage, it also has the Aconex app version. However, BIM is not yet in mobile apps yet, it will launch soon in autumn 2015.

It is a powerful platform of building management no matter the project for existing building or work in progress construction. The key point of it is communication of project. Thus, the collaboration during the construction and maintenance of project will be more efficient compared with other platforms. Nevertheless, fair performance on retrieving data to public is weak point of Aconex.

Aconex is charged per project base, unlimited capacity is also provided.



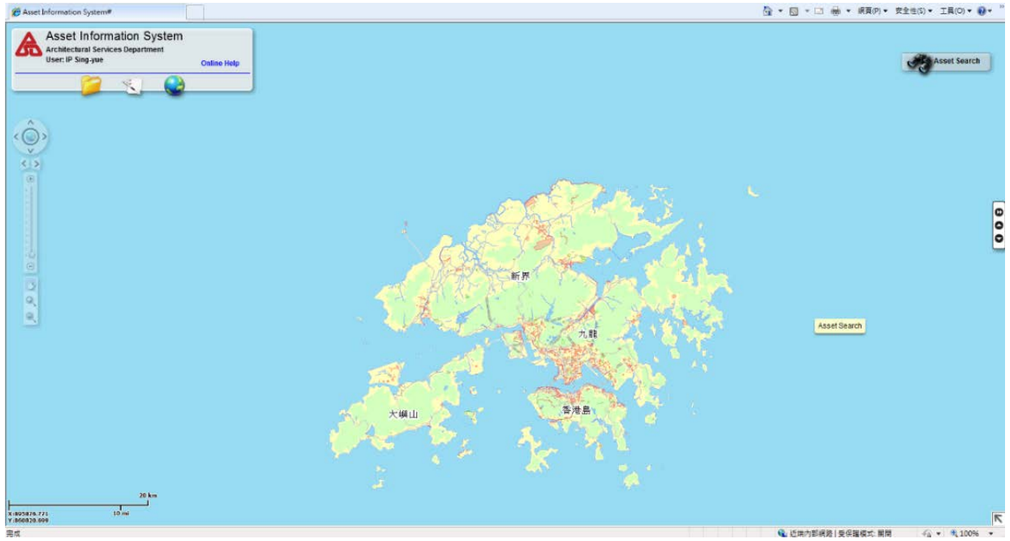




13.5 D17 AIS integration

13.5.1 *Current* AIS *(Assets Information System) interface*

The system is a combination of a viewer and database of record in ASD. It is GIS based database software to facilitate the maintenance work of PSM. It can call out the related information with the location of targeted building. The information can be dug out by clicking the 3D button representing the targeted building on the map and the photo of the targeted building. The related files in format of excel, word, pdf, dwg can be viewed by the url from database. The database is a textual based.



13.5.2 How BIM can help on AIS interface?

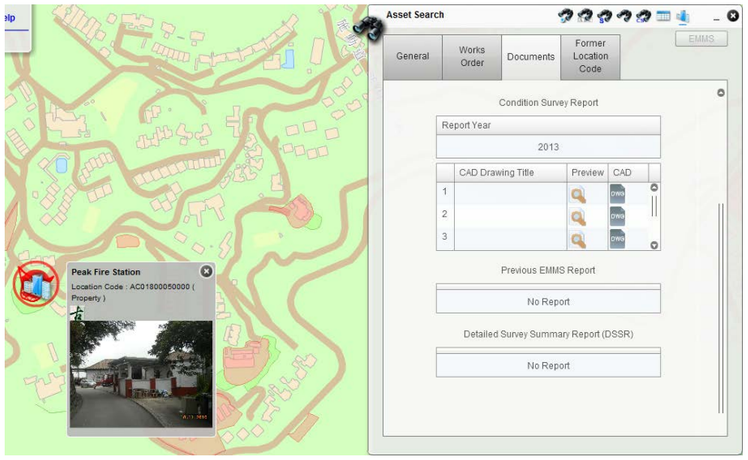
BIM can link to the viewer of AIS by giving the url of the BIM model on cloud. When user open the viewer, they can click on the url on the 3D button on HK map of viewer and view the BIM model. Also, the BIM model can link to the database though a middleware. Middleware can facilitate the BIM model not just viewing the related documents of the targeted object but adding attributes to the database to update the database. The middleware can also link to the viewer of AIS by adding the url and view the model with related documents from AIS through the middleware.

13.5.2.1 Increase the efficiency of viewing related information

BIM with middleware can facilitate to the system to give the related information or attached document directly to the targeted object not the entire building. It can find the related information prompter and more accurate than just using textual search methods since the information is related to real location.

13.5.2.2 More information can be given

- Precise quantities of repairing materials and better estimation of cost



The BIM model integrated different precise information. They are all information based on the true building. The dimension for the building are the same with that of BIM model. With using the middleware, all dimensions of objects in BIM model which is exactly equal to the real dimensions can be measured and the estimated quantities of materials with the unit rate can be counted and the budget can be calculated before going on site.

- Better preview of the situation of the site

BIM can give an accurate location of defects and the status of surrounding environment which is very helpful to have a better planning before the repair works.

- Suggestion of repairing methods

BIM model with middleware can give the related documents according to specific object with the correct location. The attached documents can be a manual, catalogue from manufacturer, warranty, repairing record in order of date. When the object is identified the repair methods can be found out by the related information attached to the target.

- Immediate Updating the status of objects on site

AIS is a system to view the inspection record and survey report of the building by search the location of it on map. If there are any updating of database, the system called Action in textual base will be used. Middleware can add attribute on site promptly update the status of object or work orders.

AIS is a GIS system derived by ASD for heritage purpose. Integration of HIM and AIS requires significant amount of effort for data mapping and matching. It is recommended to introduce a separate consultancy if integration is required.

13.6 D18 Ecodomus

Ecodomus is an US based platform which act as a middleware for BIM and Facility Management (FM). BIM model is converted into DWF and loaded into Ecodomus.

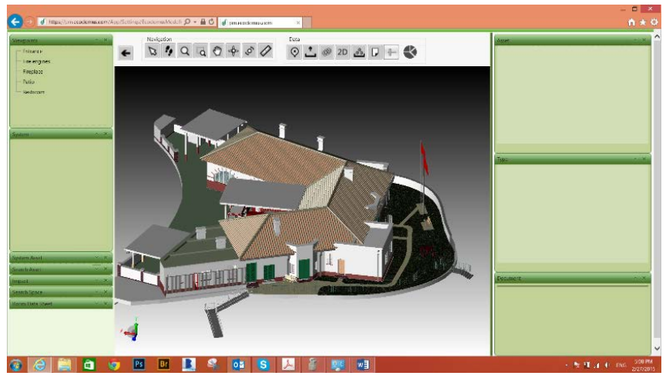
Pros and Cons

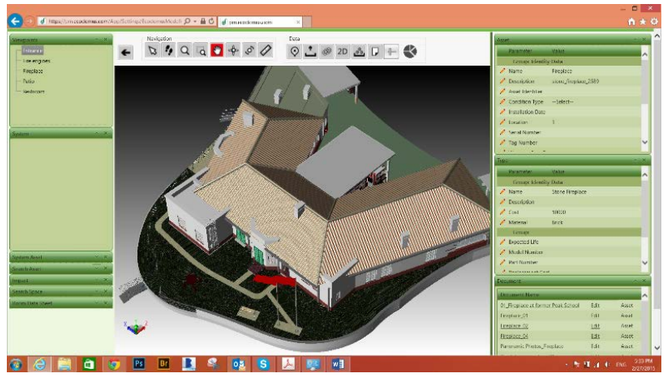
Information in different formats of files can store in the cloud or civic server. The model can be minimize to light weight format and will be viewed by web browser installed the plugin of viewer. After clicking on the targeted object on model, there will be several buttons for the access of the related information. Not only viewing of the model and related information. Ecodomus can used to update the information by adding some attributes. It is very useful for facility management. Mobile version is also provided. Users can update the status on site directly. Ecodomus gives another way for users to create up-to-date relationship for the information of reality with the BIM model. Partial point cloud can be also uploaded to the cloud on Ecodomus' sever or civic server. This point cloud which can do the function as BIM model can attach documents and input attributes in it. That means the step of modeling can be skip in some circumstance.

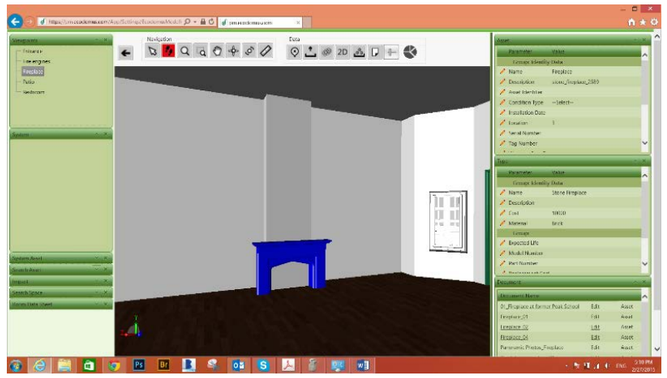
But, Time will be spent on the process of uploading and updating model and there are many attributes and properties which are not user-friendly for some new users of maintenance staff. The web browser must be internet explorer which will be close its service soon.

It gives new direction for FM facilitated with BIM. Staff can control it on work station or on site by using mobile device. They can have more comprehensive control on the information of properties which can make more accurate budgeting and well-planning of schedule. However, only Android mobile can access Ecodomus mobile page.

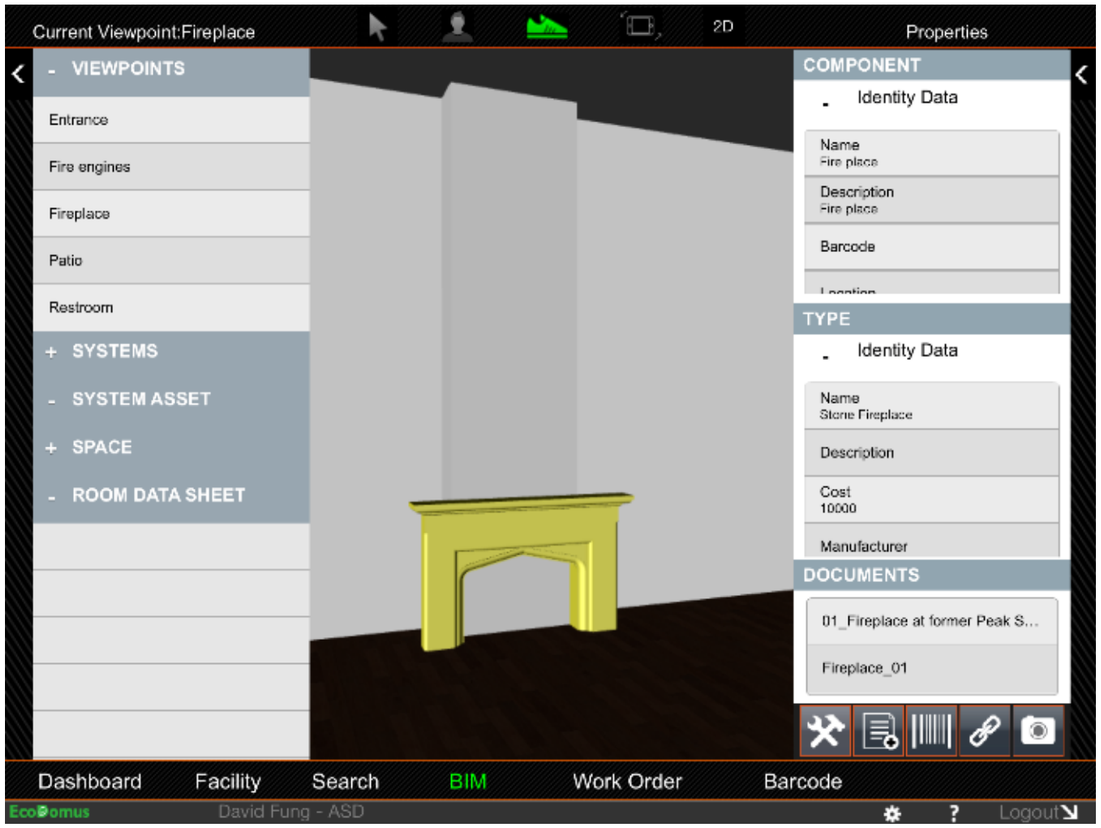
Web Browser page.

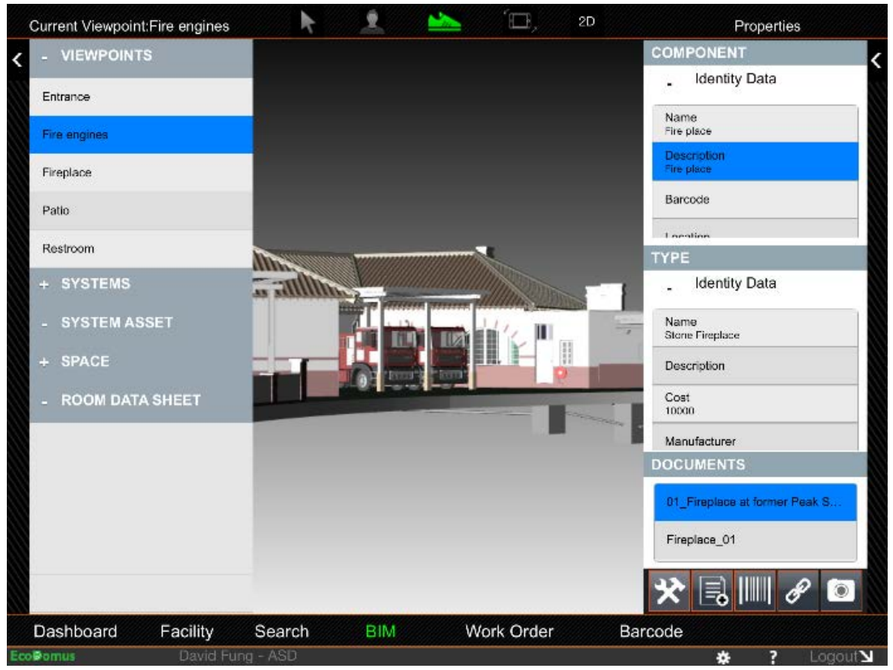


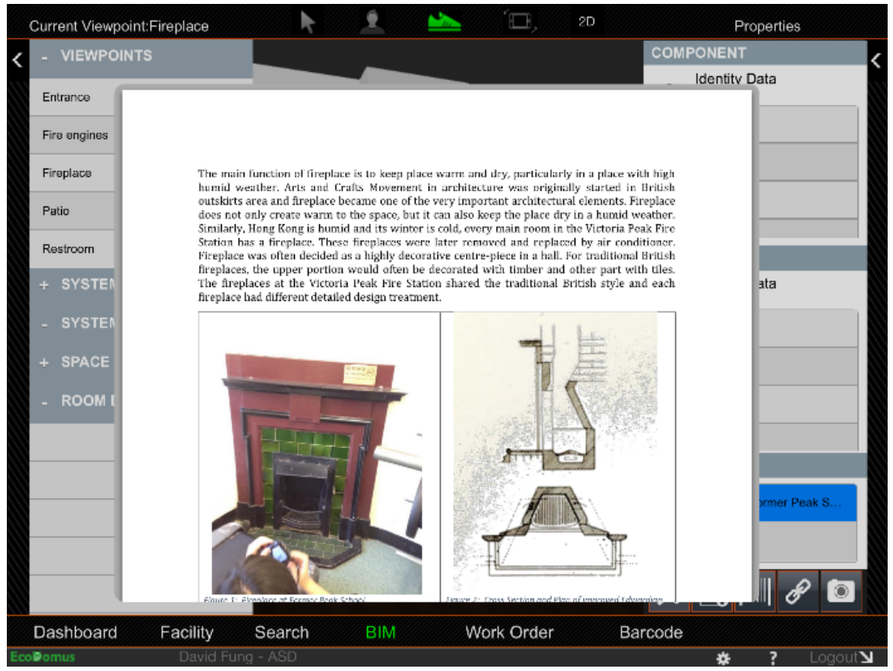




Mobile Pages.







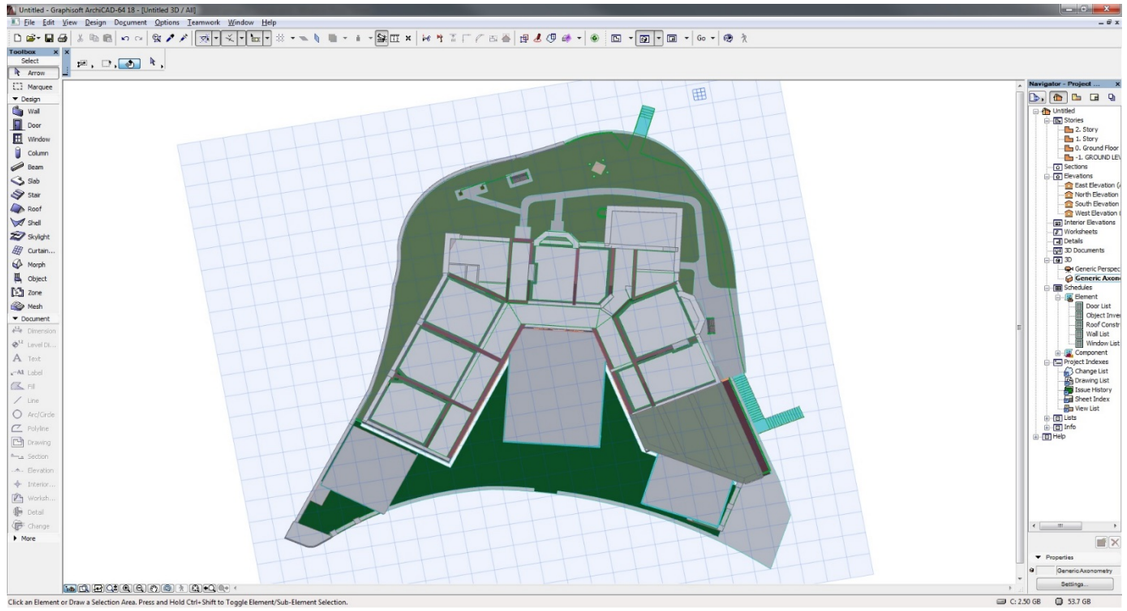
13.7 D19 BIMx

A Cloud service facilitates BIM from ArchiCad. It is provided by Graphicsoft. Archicad is another kind of software for BIM, just like revit but with different format of model. BIMx can store the BIM model and the users can view their model on desktop computer. BIMx can provide a good combination of 2D drawings and 3D BIM model. Users can view the model and 2D drawings on site by using mobile device. Less papers will be used for the deliverables. The model files from revit must be transferred to ArchiCad in IFC format. But, there will be some drawback. The sheets in revit file may not be transferred to ArchiCad with the model.

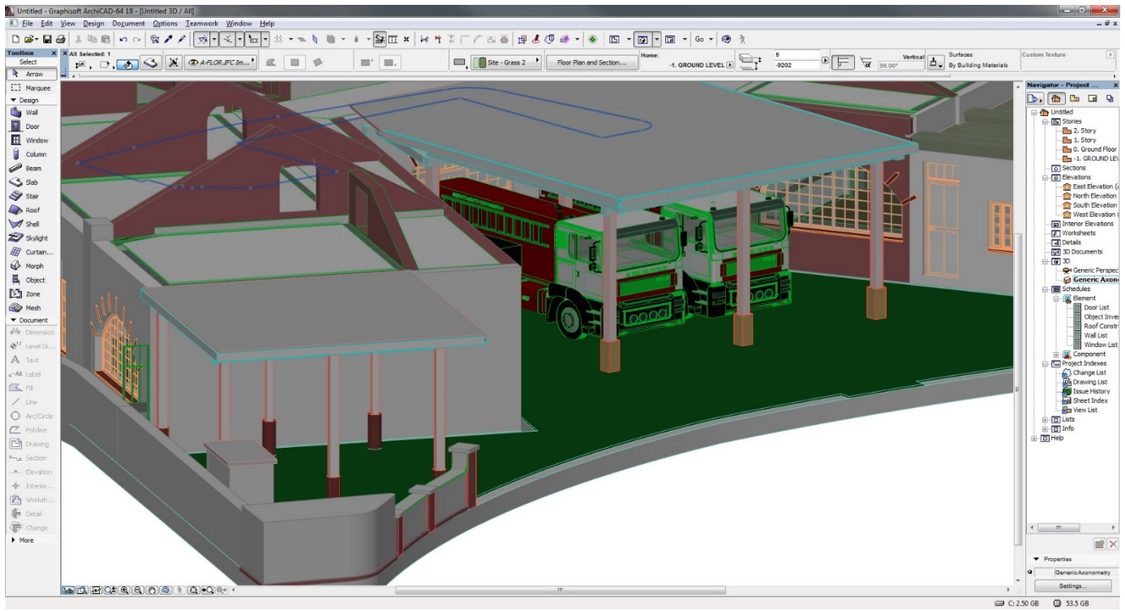
Pros and Cons

The advantage of BIMx is that it can call out the 2D drawings with mobile device on site and these 2D drawings are all linked to the BIM model. That means these drawings for communication on site are now as one 2D aspect of BIM.

Unfortunately, the market shares of ArchiCAD compared with revit will be a problem since the compatibility of it and revit are not comprehensive. If users want to use BIMx as a cloud platform with revit to build model, there are actually several steps must be done. It is time-consuming from revit to BIMx. Users must export drawing from revit in dwg format and 3D model in ifc format or create drawings in ArchiCAD then export to BIMx.



IFC files in ArchiCAD



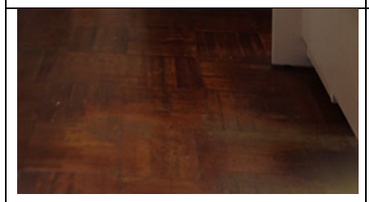
Heritage Information Modelling
VICTORIA PEAK FIRE STATION

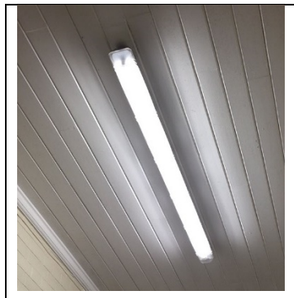
Architectural Services Department
The Government of the Hong Kong Special Administrative Region

14. List of Items for Demonstration

ITEMS		STORIES	FORMART /TECHNOLOGY TO PRESENT
4. 4 	Site change (Diversion of Gough Hill Path) . .	The Gough Hill Path in front of the building had been changed when an English children School was built. There is not much evidence to show the change but a picture was found from the Government Record Services showed the diversion of Gough Hill road. There was a permission from government to change the path for providing the site to build the school. It is the improvement of policy for children lived at the Peak.	By using phasing in BIM, it can show what has been changed. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when you scan. 2D information can be linked to 3D. The model will be stored in cloud server.
	History of English children school and Peak Fire station	It included the objective to build the school at the Peak. Room usage changed when changed to fire station.	Demonstrate in the BIM model. By using phasing in BIM, it can show what has been changed. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when you scan. 2D information can be linked to 3D. The model will be stored in cloud server.
	Change of exterior of building	The building exterior had changed over a period of time. Some outdoor components, such as the covered car parks outside gymroom and fire engines, were changed. These changes can be seen in the aerial photos.	By using phasing in BIM, it can show what has been changed. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when you scan. 2D information can be linked to 3D. GIS will be used for the positioning of exterior changes. Three phases will be shown in the app of AR.

	Fireplace	It is a Character Defining Element style in the building. Those fireplaces were not operated anymore. It is one of the very important architectural elements of Arts and Crafts Movement. It was decided as a highly decorative centre-piece in a hall. For traditional British fireplaces, the upper portion would often be decorated with timber and other part with tiles. The fireplaces at the Victoria Peak Fire Station shared the traditional British style and each fireplace had different detailed design treatment.	Animation / AR - The fireplace operating situation and configuration can be demonstrated in the form of AR. It can show the ability of 2D mapping in AR.
	Old light switch	It is a very old switch in the building. The production for this type of switch was ceased. It cannot be bought in the market again.	Animation / AR Demonstrate the ability of AR by using animation to explode the configuration of the switch. It can also show the ability of 3D mapping in AR.
	Roof with architectural style	The Peak Fire Station is one of the buildings in Hong Kong with architectural style inspired by “Arts and Crafts movement”. The roof is one of the outstanding components of the building to show this special architectural style in Hong Kong.	Demonstrate in the BIM model. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when you scan. 2D information can be linked to 3D. The model will be stored in cloud server. AR and iBeacon - The timber truss and roof configuration can be built in the BIM model and use AR to map it to the ceiling. Users can see the structure of roof truss when look up to the ceiling. It can show how BIM facilitates maintenance work of hidden or unreachable structure or system. The application of “iBeacon” to locate the model will be explored.

	Window and door Style	Window and door are Character Defining Element in the building. It is one of the main features of the Arts and Crafts Movement in architecture is avoiding decorative features on the facade and therefore the expression of the doors and windows become important to the facade design.	Demonstrate in the BIM model. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when using mobile device. The model will be stored in cloud server.
	Teakwood flooring	Teak timbers takes 70 years to process as construction material. Most Chinese would prefer timber such as Phoebe, mahogany and ebony. However, Europeans would consider teak as the best timber.	Demonstrate in the BIM model. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when using mobile device. The model will be stored in cloud server.
	Window with a door in the center	The lower portions on each end of the large arch were often small windows in conjunction with the door in the middle. The wooden window frames were subdivided into smaller glazing pieces. The upper glazing portions pieces were trim to respect the overall geometry of the large arch. This showcased the arch technology with bricks at that period of time. The rounded brick windowsill is treasurable authentic artifact.	BIM Models will be built. Items will be tagged with RFID/NFC for linking to maintenance and inspection record.
	Drainage	To facilitate the monitoring and maintenance of the plumbing / drainage system.	BIM Models on plumbing / drainage systems will be built. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when you scan. 2D information can be linked to 3D. The model will be stored in cloud server.

	Ceiling Light	A kind of untouchable indoor equipment of the building, it can illustrate the ability of RFID.	RFID - By detecting the element in a specified space, it can draw relevant information such as work order numbers, suppliers, warranty, time record, swift with geolocation referenced on site. Drawings will also be attached for the deliverables. QR code will be printed on the drawings. It can link to cloud storage and review the 3D models when you scan. 2D information can be linked to 3D. The model will be stored in cloud server.
	Fire Extinguisher	Equipment to show how BIM and NFC can facilitate FM	NFC - It can show the inspection schedule of fire extinguisher and other legal requirements. The status of it can be known immediately with geolocation referenced on site. It can show the ability of NFC for drawing relevant information swift with geolocation referenced on site. It can also demonstrate how BIM can facilitate maintenance work.
	Old Hanging Light	Similar to the old English light switch in the building, it can indicate the history of heritage.	NFC - It can show the inspection schedule of fire extinguisher and other legal requirements. The status of it can be known immediately with geolocation referenced on site. It can show the ability of NFC for drawing relevant information swift with geolocation referenced on site. It can also demonstrate how BIM can facilitate maintenance work.

15. Platform Comparison

The key consideration of selecting these software on the list is the connection with revit since revit is the most popular BIM software in the industry. BIMx, which is a platform connected to ArchiCAD, is an exception.

Cloud Platform	Origin	Nature	Format	Desktop	Mobile Device	Cloud	Information	Note	Web	Purposes	Cost
Design Review	Autodesk, US	Simple and direct file based collaboration tool. For markups and easy understanding of project.	DWF	Design Review 2013	n/a	n/a	Defaulted information, limited by software. No external link available		www.autodesk.com	Storage of dwf and pdf for communication of project	Free
Autodesk360	Autodesk, US	Web storage & Viewer for simple viewing and markup. Simple collaboration.	DWF	Autodesk 360	ipad, iphone, Android apps	Autodesk Cloud only	Defaulted information, limited by software		www.autodesk.com	Storage of dwf and pdf for communication of project	Free
Autodesk Glue	Autodesk, US	Web based Collaboration tools	DWF/ NWD	BIM 360 Glue	Ipad apps	Autodesk Cloud only	Defaulted information, limited by software		http://www.autodesk.com/products/bim-360-glue/overview	Storage of dwf and pdf for communication of project	License fee http://www.autodesk.com/products/bim-360-glue/buy
Fuzor	Kellog Studio, US	Fundamentally a visualization Tool. Self-Extracted EXE file that do no rely on external software to open. Viewer included. This is good for communication	CHE/ EXE	Fuzor Plug in to Revit. Project file known as CHE file. Can export EXE file for viewing (no external viewer required)	ipad, iphone, Android apps	Use Google and dropbox as storage for file transfer purpose, can also use local connection.	More information than Autodesk default. External URL can be activated. Customized information available.	Use of game engine, thus heavy demand on hardware display unit.	http://www.kalloctech.com/	Presentation and analysis for the view	License fee http://www.kalloctech.com/purchase.jsp
Aconex	Aconex, Australia	Web based Collaboration Tool. BIM is only part	IFC	Web browser	Ipad, iphone, Android web browser	Aconex Server, can also provide local cloud service.	Self-contained Project Management System whereas information are		http://www.aconex.com/	Building management	License fee http://info.aconex.com/re

		communication matrix. Mainly on Construction workflow.					uploaded into Acoonex server and link to BIM model with the system. Good for Communication.				quest-a-demonstration-2.html
Ecodomus	US	Middleware for bridging BIM and FM. Strong linking capability between information.	DWF	Web browser (Only IE)	Ipad apps	Ecodomus Server, can also provide local cloud service.	Flexible in information included. Not making use of external URL for linking information but use internal upload document storage and linkage to BIM and Point Cloud objects.		http://www.ecodomus.com/	Facility Management and Asset Management	License fee http://www.ecodomus.com/index.php/contact-us/
AIS	ASD, HK	GIS based information database.	Database	Internal ASD AIS browser	n/a	Internal	Linked documents to the GIS system.		n/a	Asset management	n/a
BIMx	Graphisoft, Hungary	Web based Collaboration tools		BIMx	ipad, iphone, Android apps	Graphisoft cloud	Virtual Building Explorer, Linked 2D drawings to BIM and defaulted information, limited by software	Model from Autodesk Revit must be transformed into IFC format and import to ArchiCAD. Then, they can be uploaded to	http://www.graphisoft.com.hk/bimx/	Project communication and storage of models and documents	License fee http://helpcenter.graphisoft.com/technotes/bimx/bimx-license-types/

16. Resources of Each Main Task

Task	Time (Based on the scale of project)	Manpower	Cost (Unit Rate)
Historic research	2 months	2 people involved	Commercial decision with the responsible consultant mainly based on the contractual period
UAV Photogrammetry	1 days	2 people involved	Hourly Cost
Laser Scanning	2 days	2 people involved	Daily Cost
BIM modeling	1 months	2 people involved	Commercial decision with the responsible consultant mainly based on the contractual period
2D Drawing plus QR code Production	5 days	1 people involved	Commercial decision with the responsible consultant mainly based on the contractual period
3D video and 3D interactive control	5 days	1 people involved	Commercial decision with the responsible consultant mainly based on the contractual period
NFC and RFID	1 months	2 people involved	Commercial decision with the responsible consultant mainly based on the contractual period
AR	1 months	2 people involved	Commercial decision with the responsible consultant mainly based on the contractual period

17. Recommendation, Way Forward and Conclusion

The HIM framework is targeting towards 2 groups of audience: visitors and maintenance crew. Both of them requires the display of the BIM model and provided with linked information at which they can be displayed according to their own need.

With better graphics and interactivity, the user-friendly Fuzor platforms apparently has the advantage over other technical or professional platforms. Especially it is the only platform offers a self-extracting viewer file which does not require any pre-installed viewer. User-friendly platform and high quality of visualization make Fuzor become the most suitable platform for visitors. It can also provide an interactive control experience for navigation of the model so-called gamification of BIM. The most attractive characteristic of Fuzor is that it can create an exe file for the interactive control. No software is needed for this exe file. But, the computer installed needed to possess a high configuration for graphics, for example, the installed computer possess 2GB ram display card. URL can be attached to objects and files on cloud can be read. The 3D video can demonstrate to the public for showing the existing condition of heritage and the past status of it. Fuzor has high potential in the area of public presentation like new develop infrastructure, buildings' history shown in museum, heritage information modeling, etc. Cost is needed for the licenses of using Fuzor's service. There are different subscription plans. Commercial discussion must be undergone for long-term service in HIM.

Whereas of maintenance, EcoDomus has the absolute advantage for its detail level of information and the seamless linking between BIM information and FM information. Its point cloud association in particular, is the only platform which can directly work with point cloud data and associated information. EcoDomus does have high potential in asset and facility management because of its prominent ability in the exchange of data between model and real world which means the status of construction site. Similar to Fuzor, Cost must be needed for the licenses of using its service. EcoDomus can provide a cloud service or construction of local server for storage of data. Both of them must have different cost. Commercial discussion must be undergone for long-term service in HIM.

Way Forward

Despite the recommendation, the various platforms are still not fully designed to be used for heritage conservation purpose. The way forward is to further customize the workflow so that it works more seamlessly within the HIM context. Consolidation of different technical apps into a private government Cloud is for sure the area of further study.

Detection Technology

In future, augmented reality will be the trend in the display of BIM information and FM information. The mobile device can enable us to having overlapping the future-built object with the reality. The object should not only be the visual object but possessing BIM and FM information. Unfortunately, the model is too heavy for using as AR technology. The accuracy of outdoor positioning should be improved and Indoor positioning cannot be widely used as the power and detection of signal by mobile device are not mature. Although the technology nowadays cannot achieve this fully when the technology become mature, it definitely is a potential technology for the application of FM facilitated by BIM.

BIM process

In this study, point cloud of photogrammetry and laser scanning need to be transformed into BIM model. This process was manually controlled. That means the model built manually by using the point cloud as a kind of reference. There may be random errors because of the detection by naked eyes. Developed plugins or software were already existed in the career but still not been widely use. Plugin called "Scan to BIM" can be installed into Revit. As the name of it, the point cloud can be turned into objects in Revit for the BIM model. That means it's not only geometry but does consist of the properties and parameter. Since it is a direct conversion from point cloud into BIM model, the accuracy is equal to the result of laser scanning. Reference link for Scan to BIM: http://www.imaginit.com/software/imaginit-utilities-other-products/scan-to-bim

Also, software called Kubit which merged FARO can read the high resolution point cloud directly in the software and can control the point cloud with Revit in bi-direction. Control of the modeling will be occurred at Kubit. Similar to Scan to BIM, it enables the points in point cloud to become an object with parameters. It can create major architectural elements such as wall, doors and window with a few clicks in the scan view. The process of changing point cloud to model will be thus automatic.

Reference link: http://us.kubit-software.com/

Youtube - VirtuSurv for Revit: https://www.youtube.com/watch?v=VRahU5W2bP0

Furthermore in the BIM process, the process of modeling can be skipped in the future. No modeling step will be needed. The management of point cloud will be more effective. The limitation of point cloud in current industry is that they are only points with no information so that manual work should be involved. But it is still in infant stage.

Only low resolution and partial point cloud of building can be directly viewed on the platform and with the related information, such as O&M manual, temperature, humidity, etc. The dimension can be measured directly in point cloud. EcoDomus is one example for the direct use of point cloud files.

Selection of Software

The key point of selection of software is commonness in industry. As the project of ASD and MTR mostly use Autodesk Revit for BIM process, common software used for study possess strong connection with Autodesk Revit. There may be other potential software in the world. In this study, common software will be used. Software support for Revit is relatively sufficient. Lots of software which are Fuzor, Glue, Recap, etc can support the project file format of Revit (rvt). The support from user database is powerful and comprehensive. As Revit is widespread, the Q&A system is good enough for the general use. By remembering the warning, solution can be found out from it. The BIM Standard in UK and China is set up according to Autodesk Revit. Revit serves as a starting point in the BIM standard of country level. Using Revit for study can officially match the standard for different countries. Principle of all BIM software is the same. A common format of project files should introduced for better communication and collaboration. The IFC model was so developed for the interoperability of different projects.

Difficulties

There are difficulties seen in the creation of BIM model. Manual process involved in the creation of BIM model from point cloud. Since random errors will cause from the manual process, extra effort is needed to be input for confirming the accuracy and orthodoxy.

Point cloud from laser scanning are too accurate for modeling. For CAD drawings, the dimension is approximated. The form of walls or windows are in regular shape but it cannot reflect the actual condition. But, the result from laser scanning is very precise with small deviation, for instance, the connection will not be perfectly perpendicular or parallel in the reality. It is difficult to build a model with the exactly equal condition to the reality.

AutoCAD with Point Cloud

AutoCAD is accurate in dimension. Point cloud can also insert to the AutoCAD for drawings or 3d modeling And, the quantitative surveying method are replacing with laser scanning. Point cloud are very strong in facilitating the BIM process. Since the things created in AutoCAD are only the lines with dimension, lack of information for any further use of management or conservation of the model. AutoCAD with the help of point cloud cannot fulfill the requirement of HIM. Only “M” which means modeling can be fulfilled. The latitude and longitude can be entered to AutoCAD but it is not a BIM software. The information, says coordinates and dimension, was limited. It is not suitable for the formation of BIM, not to say HIM.

Conclusion

This study is a pilot project for the development of heritage information modeling framework, which serves as a prototype for the rest of heritage buildings in Hong Kong. HIM can enhance and encourage the progress of heritage conservation in Hong Kong by centralizing the historic information into a n-D virtual model; provide a better means of heritage education to public, increase the efficiency of communication in maintenance, asset and facility management.

The developed HIM console mobile application can also form a platform for audiences to explore the historical facts through the application. Since the application is a prototype version, further development is still required for full scale HIM applications.

This pilot project provides a workable workflow and the framework of HIM -From data collection, BIM process, Output to the interface/application process. Different cloud platforms are compared to suit different usage with the application to store and consolidate the Historical data. It is a valuable research for the future conservation of heritage buildings of all sizes and nature.

Feedbacks from stakeholders

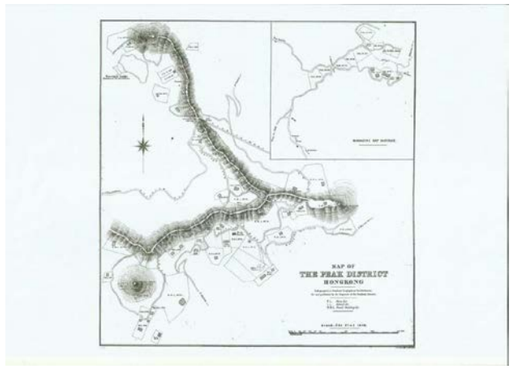
Date	Time	Stakeholders	Feedbacks	Notes
To be confirmed	To be confirmed			
To be confirmed	To be confirmed			
To be confirmed	To be confirmed			
To be confirmed	To be confirmed			

Extraction from heritage research

1. Site change (Diversion of Gough Hill Path)
2. History of English children school and Peak Fire station
3. Change of exterior of building
4. Fireplace (Character Defining Element)
5. Roof with architectural style (Character Defining Element)
6. Window and door Style (Character Defining Element)
7. Teakwood flooring (Character Defining Element)
8. Old light switch
9. Lamp
10. CDEs properties

01. Change in Terrain

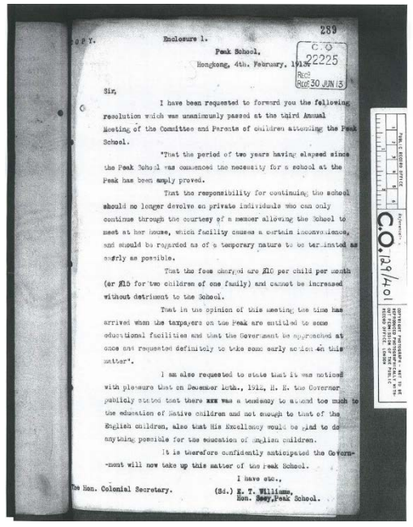
1. According to the topographic map dated year 1912, Gough Hill was originally very steep and curvy. Government Villas was located on the peak of Gough Hill and the British School was not existed at that time.



Map of the Peak District

1. According to the Government Information Archives, among the letters that Governor Francis Henry May wrote to the British Parliament minister Harcourt, one of the letters dated on February 4, 1913 was addressed to the Principal of Peak Elementary School. Accessories Letter CO129 / 401p289 mentioned the followings:

1) Approval was granted to build Peak School on 1911.
2) Between 1911 and 1913, a member allowed her students to study in her house and so she applied for government funding to build a new school.
3) The Chancellor was pleased that on December 18, 1912, the Governor announced to support local education in Hong Kong. However, attention to students from British was still insufficient. Government-funded British schools were in demanded.



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Enclosure 1.

Peak School,
Hongkong, 4th. February, 1913.

C.O. 22225 Rec'd 30 JUN 13

Sir,

I have been requested to forward you the following resolution which was unanimously passed at the third Annual Meeting of the Committee and Parents of children attending the Peak School.

"That the period of two years having elapsed since the Peak School was commenced the necessity for a school at the Peak has been amply proved.

That the responsibility for continuing the school should no longer devolve on private individuals who can only continue through the courtesy of a member allowing the School to meet at her house, which facility causes a certain inconvenience, and should be regarded as of a temporary nature to be terminated as early as possible.

That the fees charged are $10 per child per month (or $15 for two children of one family) and cannot be increased without detriment to the School.

That in the opinion of this meeting the time has arrived when the taxpayers on the Peak are entitled to some educational facilities and that the Government be approached at once and requested definitely to take some early action in this matter".

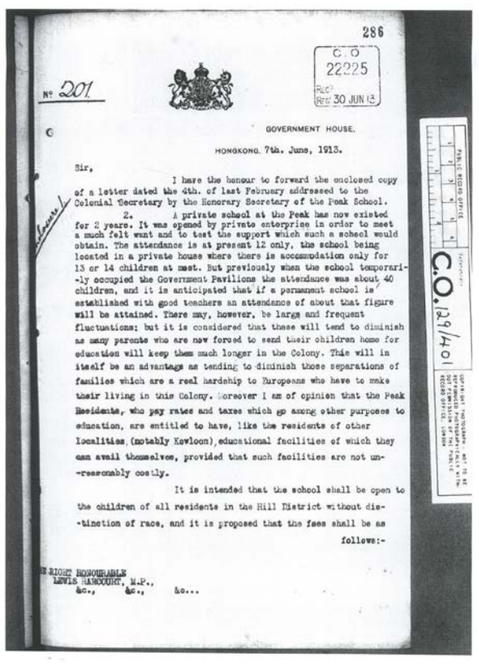
I am also requested to state that it was noticed with pleasure that on December 10th., 1912, H. E. the Governor publicly stated that there was a tendency to spend too much on the education of Native children and not enough in that of the English children, also that His Excellency would be glad to do anything possible for the education of English children.

It is therefore confidently anticipated the Government will now take up this matter of the Peak School.

I have etc.,

The Hon. Colonial Secretary. (Sd.) E. T. Williams,
Hon. Secy, Peak School.

C.O. 129/401



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C.O. 22225 Rec'd 30 JUN 13

No. 201

GOVERNMENT HOUSE.

HONGKONG. 7th. June, 1913.

Sir,

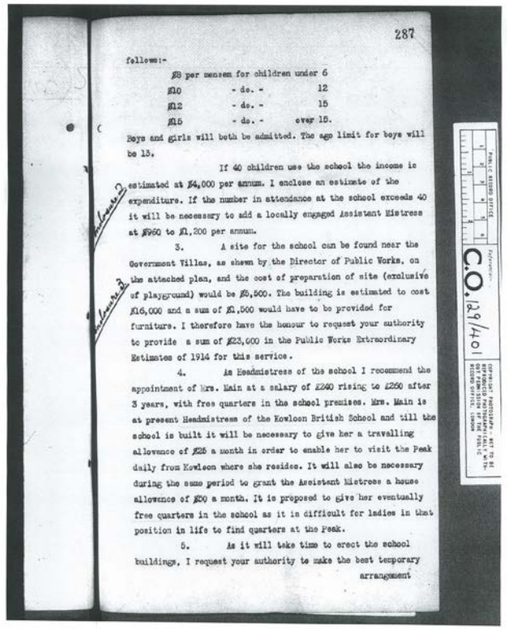
I have the honour to forward the enclosed copy of a letter dated the 4th. of last February addressed to the Colonial Secretary by the Honorary Secretary of the Peak School.

2. A private school at the Peak has now existed for 2 years. It was opened by private enterprise in order to meet a much felt want and to test the support which such a school would obtain. The attendance is at present 12 only, the school being located in a private house where there is accommodation only for 13 or 14 children at most. But previously when the school temporarily occupied the Government Pavilions the attendance was about 40 children, and it is anticipated that if a permanent school is established with good teachers an attendance of about that figure will be attained. There may, however, be large and frequent fluctuations; but it is considered that these will tend to diminish as many parents who are now forced to send their children home for education will keep them much longer in the Colony. This will in itself be an advantage as tending to diminish those separations of families which are a real hardship to Europeans who have to make their living in this Colony. Moreover I am of opinion that the Peak Residents, who pay rates and taxes which go among other purposes to education, are entitled to have, like the residents of other localities (notably Kowloon), educational facilities of which they can avail themselves, provided that such facilities are not unreasonably costly.

It is intended that the school shall be open to the children of all residents in the Hill District without distinction of race, and it is proposed that the fees shall be as follows:-

THE RIGHT HONOURABLE
LEWIS HARCOURT, M.P.,
&c., &c., &c...

C.O. 129/401



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follows:-

$5 per mensem for children under 6
$10 - do. - 12
$12 - do. - 15
$15 - do. - over 15.

Boys and girls will both be admitted. The age limit for boys will be 13.

If 40 children use the school the income is estimated at $4,000 per annum. I enclose an estimate of the expenditure. If the number in attendance at the school exceeds 40 it will be necessary to add a locally engaged Assistant Mistress at $960 to $1,200 per annum.

3. A site for the school can be found near the Government Villas, as shewn by the Director of Public Works, on the attached plan, and the cost of preparation of site (exclusive of playground) would be $5,500. The building is estimated to cost $16,000 and a sum of $1,500 would have to be provided for furniture. I therefore have the honour to request your authority to provide a sum of $23,000 in the Public Works Extraordinary Estimates of 1914 for this service.

4. As Headmistress of the school I recommend the appointment of Mrs. Main at a salary of £240 rising to £250 after 3 years, with free quarters in the school premises. Mrs. Main is at present Headmistress of the Kowloon British School and till the school is built it will be necessary to give her a travelling allowance of $25 a month in order to enable her to visit the Peak daily from Kowloon where she resides. It will also be necessary during the same period to grant the Assistant Mistress a house allowance of $50 a month. It is proposed to give her eventually free quarters in the school as it is difficult for ladies in that position life to find quarters at the Peak.

5. As it will take time to erect the school buildings, I request your authority to make the best temporary arrangement

C.O. 129/401

Also, according to the Governor Francis Henry May's letter CO129 / 401p286-p288 dated June 7, 1913, the Governor informed Secretary of State for the Colonies Mr. Harcourt that, in reality, the school was under capacity. It had only 12 students for a 40-students capacity school. Many parents decided to transfer their children back to their home country. Consequently, the family needed to live separation. Governor President believed that these family living on the peak paid their tax, they should have been treated the same and should have equally received local education for their children. Therefore, it was recommended that a new school to be built on the peak and shared among all ethnic groups.

The governor also attached a letter to the application along with a drawing, CO129/401B291, showing the school to be built in the vicinity of the Government Villas with funding from the Secretary of State for the Colonies. The application proposed to modify the curvy Gough Hill road in order to build the villa and school. The villa and the school was each had 90 feet by 50 feet footprint. At that time, Wong Nai Chung Gap road was the only access road to Gough Hill. This was later replaced by other access roads when Peak Road was constructed subsequently.

02. History of Former Peak School

Historical Interest

In the early 20th century, Sir Henry Arthur Blake (卜力爵士), Governor of Hong Kong from 1898-1903, recommended separate schools for European British children who required education in the medium of English. The demand for a school for British children was met by the opening of the Kowloon British School (九龍英童學校) at Nathan Road (彌敦道) in 1902.

The preparation for a school in the Peak area was made in 1914, and a permanent premises known as the Peak School (now Former Peak School) in No.7 Gough Hill Path (歌賦山里) was built in 1915 by the Public Works Department. Enrolment figures started at 39, and reached 158 in 1947. Apart from the Japanese Occupation (1941-1945) it was in use as a school continuously until 1966 when it was vacated. It was taken over by the Fire Services Department in 1967 and commissioned as the Victoria Peak Fire Station. It has remained as a fire station ever since.

Architectural Merit

The school was built in the popular Arts and Crafts architectural style of the Edwardian period. Its unusual 'sun-trap' butterfly plan was a feature beloved by Arts and Crafts architects. Other features of this style of architecture are the red brick half roughcast rendered walls, semi-circular door and window openings with their 'sun-ray' decoration, and bull's-eye windows. The Chinese tiled roof is a local adaptation. Internally there are two typical tiled fireplace surrounds of the period.

Rarity, Built Heritage Value & Authenticity

Apart from minor alterations and the addition of three covered carports the building has not been extensively altered and remains fairly authentic. It is a rare surviving example of Arts and Crafts architecture and of obvious built heritage value. The Former Peak School is one of the few surviving examples of Arts and Crafts architecture in Hong Kong. Other good examples of this architectural style include the Former Royal Hong Kong Yacht Club (前皇家遊艇會) in North Point and the Old

Dairy Farm Depot (舊牛奶公司倉庫) in Central.

Social Value & Local Interest

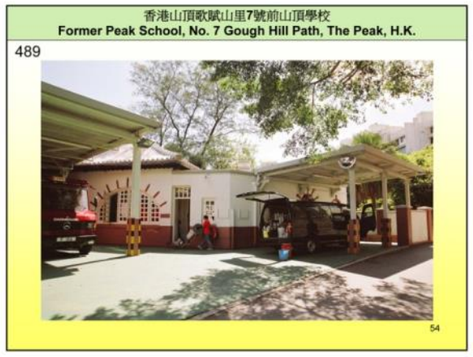
The social value of the building lies in its past use as a school and the high educational achievements of its pupils who were the children of residents on the Peak. Its conversion to a fire station in 1967 also fulfilled a need in the district. With the building's continued service to the community and its distinctive architecture it is of considerable local interest and a landmark in the area. For most of the residents nearby the building has sentimental associations.

Group Value

The immediate surroundings of the Former Peak School are mostly villas. The quiet environment follows the Arts and Crafts' association with nature. The building is also physically close to a number of historic buildings the Former Chatham English School (前漆咸英文學校) in No.1 Chatham Path, Matilda Hospital (明德醫院) in No.41 Mount Kellett Road, the Peak Café (山頂餐廳) in No.121 Peak Road, The Peak Tramway Office (山頂纜車辦事處) in No.1 Lugard Road, the Peak Depot (山頂倉庫) in No.102 Old Peak Road, Ho Tung Gardens (曉閣園) in No.75 Peak Road, the Peak Police Station (山頂警署) in No.92 Peak Road.

Adaptive Re-use

As far as is known there are no plans for the Fire Services Department to give up the building and the question of adaptive re-use does not therefore arise at present.



http://www.heritage.gov.hk/en/buildings/1444HistoricBuildings.htm

2.

According to the book "Education in Hong Kong Pre-1841 to 1941", most early British residency in Hong Kong were businessmen or officials. They were either single or married, moving to Hong Kong with their wives and children. By the age of 7, their children would leave Hong Kong and return to their home country for boarding schools. At that time, the expectation on education level for the British children was not high. Until early 20th century, 1902, the Board of Education in Hong Kong proposed to reform the education system:

1）To change the traditional Chinese view of education system and incorporate the view of the west;
2）To build Chinese schools in the urban city; and
To set up independent schools those suit the children from the west, such as King's College. Particularly, Peak School was one of the proposed schools in 1911 and this was part of this plan.

03. Change of Building form from aerial view

Historical Aerial Photos

According to the aerial maps from the Government Survey & Mapping Office, we noted the change of the building throughout its history. It recorded when the fire station was roofed over and later replaced with a new rooftop. It also indicated when the kitchen at the courtyard was built over with a rooftop, and when the carport adjacent to the gym room was erected.

From the aerial maps, we can see the transformation of the building in a chorological order:

1) The year built the additional structure at the both sides of the building.
2) The year built the additional shelter above the kitchen.
3) The year that built the additional roof of fire truck at north side and another year that replaced it
4) It recorded the growth of the southern slopes at different period of time.

No.	Photo No.	Date	Aerial route no.	Note
1	4070	11/11/1945	681/6	
2	132	17/01/1961	F43/81A/RAF/600	
3	8072	06/02/1963	--	A shelter seemed to be built next to the kitchen. The southern slope to the building had a large vacant land.
4	5461	16/05/1967	--	The building had converted into Fire Station. Both the roof at the north of the fire station and the small carport behind the gym room were not existed yet.
5	7092	12/12/1973	--	The shape of the shelter for fire engines at the north was ⊓
6	A06013	20/09/1986	--	The southern slope started to grow with woods. Entrance to the kitchen had an additional shelter.
7	CN14124	07/06/1996	--	The northern slope had grown with woods. The flat land at the south to the kitchen had grown with woods, similar to today's condition.
8	CN15564	23/10/1996	--	There was a change to the shelter for fire engines at the north. The shape was ⊔
9	CW38386	03/01/2002	--	The form of the building was similar to today's appearance. The rooftop was bluish-grey color and it was believed to be the former double roll interlocking tile roof, refers to drawing no. 001.
10	CW53695	26/11/2003	--	The rooftop was red, similar to today's appearance. The tiles were replaced with double rolls double pans, refer to drawing no. XXX

图 001

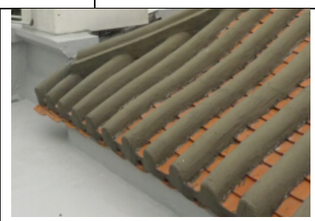


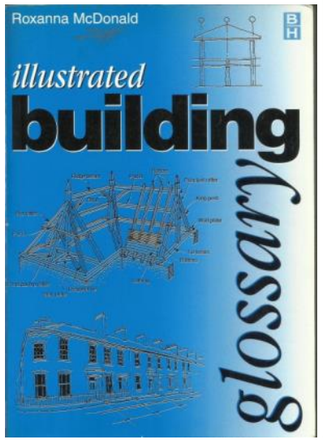
图 002

04. Roof and Architectural Style

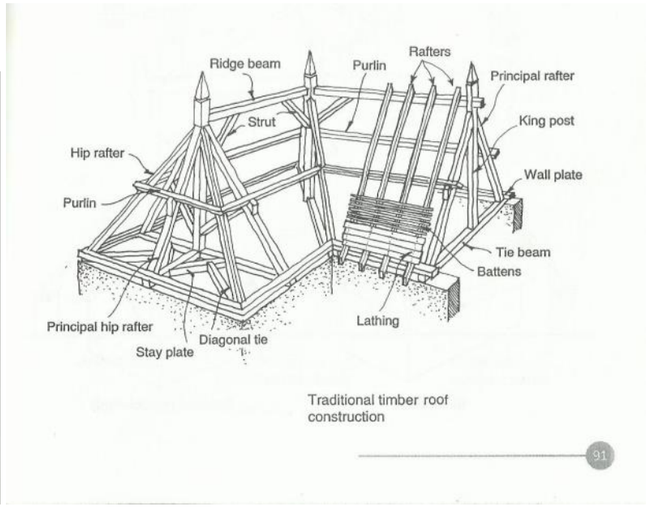
6.1 Characteristic of building roof of Arts and Crafts Movement in UK

According to the book, Illustrated Building Glossary on page 91, it noted the characteristic of the building roof from Arts and Crafts Movement:

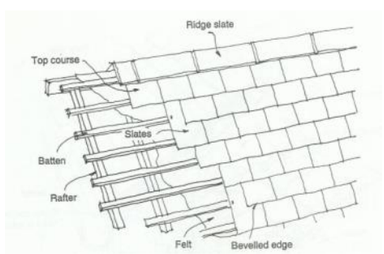
1) Using a king post at the middle to support the steep roof framing structure, and heavy and dense rafters to support the tile roof.
2) Refer to Illustrated Building Glossary on page 107, the tiles on roof are sedimentary rocks from England Wales. Because the tiles are fixed with nail, the roof can be very steep to suite the rainy and snowy weather in England.
3) Refer to Illustrated Building Glossary on page 115 and 117, the British craftsmen can create complex joint connection using lead and zinc sheets at gable, chimney and roof. This is a very traditional artisan crafts in British.



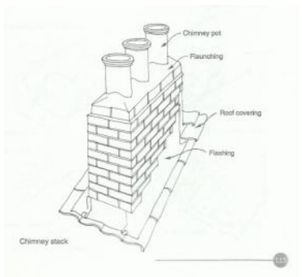
illustrated building glossary-Cover



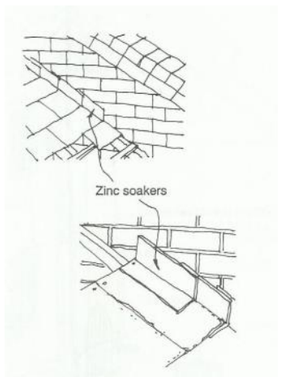
illustrated building glossary-p91



illustrated building glossary-p107



illustrated building glossary-p115



illustrated building glossary-p117

6.2 Characteristic of building roof of Arts and Crafts Movement in Hong Kong

The colonial buildings in Hong Kong carried both the West and Chinese characteristics. It combined the beam structural system from the West and the rooftop tiles from the Chinese. This method of beam and tile construction was commonly found in Hong Kong such as the structural frame and rooftop Legislative Council.

The complex rooftop connection method in the Arts and Crafts Movement could not be applied to Hong Kong because the traditional Chinese rooftop tiles are not connected by nails. Therefore, the rooftop could not be very steep. The round tiles are in semi-circular shape that makes the round tiles and slate not be cut at 45 degree angle at the interfaces. In addition, water leakage is often found in the interlocking joint. Therefore, the roof of this type of building in Hong Kong is simpler than the ones in UK.

The wooden roof frame system in Victoria Peak Fire Station was constructed with the King Post and heavy rafter to support the roof tiles. The tiles were made of traditional Chinese double rolls double pans style.

The characteristics of the Arts and Crafts Movement

a) <u>Understanding Architectural Style of VPFS:</u>
The VPFS is generally considered as an example of Architecture belonging to the Arts and Crafts Movement as practiced in Hong Kong. Hence it is worth briefing explaining the background of this style and its applications in Hong Kong as a necessary basis to evaluation the Architecture of the VPFS.

b) <u>Definitions of Arts and Crafts Movement in Britain:</u>
"The Arts and Crafts movement was a social and artistic movement, which began in Britain in the second half of the 19th C and continued into the 20th C, spreading to continental Europe and the USA; … (based on) the belief that design should be dictated by function, that vernacular styles of

architecture and local materials should be respected that new buildings should integrate with the surrounding landscape, and that freedom from historicist styles was essential"[1].

c) Architectural Aspirations of Arts and Crafts Movement:
Aspiration Tired of the flamboyant Victorian Architecture of late 19th C, a group of talented but idealistic architects and artists advocated the return to traditional English virtues, and devote their energy to building of not only mansions, but also local schools, churches, and housing estates in rural districts (or new districts), based on the vernacular English style. "The chief legacy of the movement to architecture was the appreciation of Vernacular buildings, leading to … Domestic Revival (note: also commonly known as "Vernacular Revival"), employed themes drawn from vernacular architecture"[2].

d) Fading of Arts and Crafts Movement in early 20th C:
However, as Modern Movement approaches in the beginning of 20th C, and under the inevitable market pressure for new functions and new construction technologies, the Arts and Crafts Movement subsided by the 1920s. Later examples of Arts and Crafts Movement began to simplify the details, and evolved into Art Deco, and even with Modernist touch.

e) Critique of Architectures of Arts and Crafts Movements:
Contemporary architectural historians commend this short-lived style for its inspiring revisiting of the vernacular virtue on the one hand, while citing that it was "a curiously interesting interlude (between traditional era and modernism), it was compounded … of an almost dream-like conception, … (and even) use architecture as an instrument of social welfare"[3].

2 Eight examples of the Arts and Crafts Movement in UK and its characteristics:

a) Trend of Architectures of Arts and Crafts Movement:
Despite the short duration, a number of prominent architects and architectures driving this movement is recorded in many art and architectural literatures. The Appendix D of the Report summarizes a few well-known and representative examples, and this main text shall not repeat, but only cite the general trend. Knowing the brief development of this history is essential for the appreciation of architectural features resulted thereof.

b) Early Architectures of Arts and Crafts Movement:
Although the most prominent figure of the Arts and Crafts Movement was William Morris (1834-1896), it was a number of architects who created the familiar vernacular revival scenes in late 19th C England. It probably started with early works by George Devey, (1820-1886), which includes simple housing estates composed of interesting ridgelines and traditional brick and stone construction.

c) Peak of the Arts and Crafts Movement:
The peak of this movement saw esteemed works, erected at the second half of 19th C, by Philip Webb (1831-1915), Richard Norman Shaw (1831-1912), and Charles Voysey (1857–1941), expressing matured composition of spires, chimneys, dormers and bay-windows to enrich the roofscape, varied interplay of local materials like red brick and rusticated stone, and skilful craftsmanship of complex textures and interfaces of components.

d) Final Evolution of Arts and Crafts Movements in Britain:
By early 20th C, designs by Charles Rennie Mackintosh (1868-1928) and Sir Edwin Lutyens (1869-1944), although still using vernacular materials and themes, began to evolve into Art Deco and Modernist style. By the 1930s, the Arts and Crafts Movement was almost completely taken over by the Modern Movement.

e) Summary of Representative Architectures of Arts and Crafts Movement:
The following are Eight (8) pieces of representative architectures in England of the Arts and Crafts Movement by prominent architects, ranging from early attempts in mod 19th C to late examples up to 20th C. Detail backgrounds and characterized features are depicted in Appendix of this report, and shall be repeated here. Following list can be used as an overview.

i. Gateway and Lodge to Penshurst Place, 1858, by George Devey.
ii. Red House, 1859, by Philip Webb.
iii. Standen, 1892-94, by Philip Webb.
iv. St Michael & All Angels, 1879-80, by Richard Norman Shaw.
v. Claremont Independent School, 1888, by Richard Norman Shaw.
vi. Broad Leys House, 1898, by Charles Voysey.
vii. The Orchard, 1899-1900, by Charles Voysey.
viii. Deanery Garden, 1899-1901, by Edward Lutyens.

[1] Dempsey, Amy, "Styles, Schools and Movements: The Essential Encyclopedic Guide to Modern Art", Thames and Hudson, 2011.

[2] Curl, James S, "Dictionary of Architecture", Grange Books, Kent(UK), 2005.

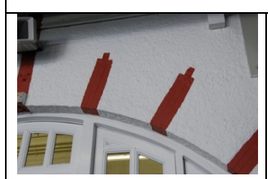
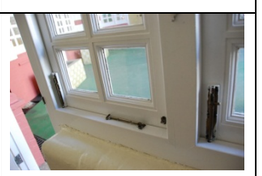
[3] Jordan, R. Furneaux, "Western Architecture", Thames and Hudson, London (UK),1997.

05. Characteristic of Door and Window

One of the main features of the Arts and Crafts Movement in architecture is avoiding decorative features on the facade and therefore the expression of the doors and windows become important to the facade design.

1. Veranda Doors and Windows

The lower portions on each end of the large arch were often small windows in conjunction with the door in the middle. The wooden window frames were subdivided into smaller glazing pieces. The upper glazing portions pieces were trim to respect the overall geometry of the large arch. This showcased the arch technology with bricks at that period of time. The rounded brick windowsill is treasurable authentic artifact.

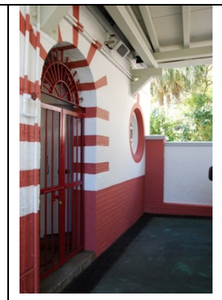
<table>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>1-1 Main entrance veranda designed in conjunction with windows on two side</td><td>1-2 Inside of the main entrance veranda</td><td>1-3 Rounded Brick on Windowsill at veranda</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td>1-4 Outside of the upper glazing portions pieces.</td><td>1-5 Inside of the upper glazing portions pieces.</td><td>1-6 Glazing pieces of the veranda</td><td>1-7 Inside of veranda windowsill and its part</td></tr>
</table>

It was believed multi-layers of paints were found at the window frame and windowsill due to accumulated paints throughout the years. If the paint could be removed, the original texture of the material could be revealed and the original design could be restored by referring to old photographs. According to the subtle pattern on the photographs, the original style, size, brick arches and join detail of the windowsills could be revealed. (Drawing 1-1~1-7）。

According to the record of restoration in year 2000, few pieces of glass were sandwiched between the thin strips of wooden window frame and this founding was consistent to current situation. It could be believed that even the veranda window had been repaired, the repair works was completed under a strict procedure which respect to its original design intent.

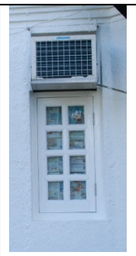
2. The Rounded Window at the Building Entrance of the auxiliary room

Small rounded window was one of the characteristic in Arts and Crafts Movement and it was often used on secondary space. For the Victoria Peak Fire Station, the designer had introduced this element at the entrance of the auxiliary room. Fined craftsmanship of the masonry was shown on the detail of the small rounded window.

<table>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>2-1 Rounded window at the building entrance</td><td>2-2 Vestibule of the Building entrance</td><td>2-3 Rounded window framework at the building entrance</td></tr>
</table>

3. Other Window and Door Treatments

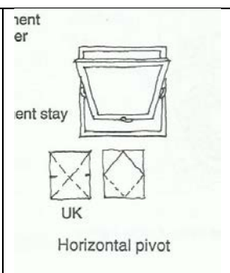
In corresponding to the veranda, the other doors and windows were designed as rectangles with wooden window frames. The frames above the rectangle doors and windows were designed with bricks and each brick was specific edge bevel, which is unique British design pattern, referring to image 7.3.1 to 7.3.4. Although multi-layers of paints covered on the walls, the pattern on the brick was still visible and this was very different from the Chinese style.

		
3-1 The east side, window without louvres	3-2 Single window on the east side, window without louvres	3-4 Single window on the southest of functional room, window without louvres

4. Aisle Doors

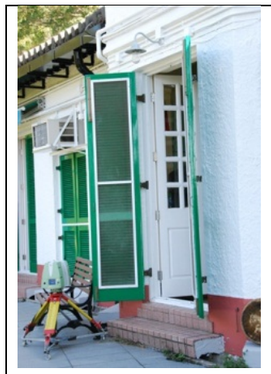
One side of the indoor corridor was using center pivot window (image 4-1). A senior firefighter described that when he joined the Victoria Peak Fire Department in 1991, he witnessed the present of windows and noted that renovation was not made ever since. Therefore, it could be believed that the row of windows was originally being part of this historical building.

Center pivot windows were very common as they suit the weather in British. The wind could enter from bottom, avoiding directly blow to people's faces, referring to Illustrated Building Glossary page 140, image 7.4-2. This traditional British residential window style was found in Victoria Peak Fire Station.

	
4-1 Center pivot window in the internal corridor	4-2 Center pivot window Traditional center pivot window in British style

5. Southern Doors and Windows with blinds

According to the old photographs, when the building was still use as the Peak School, the doors and windows at south side were using louvres. The early British colonies of Southeast Asia in 18th century, such as India, these hot places had already adapted the British window shade style in their building design. This design strategy had also been developed in Hong Kong when it was British colony. Other buildings built during the British colony time were often designed with this window style.

	
5-1 Door with blinds sets at south side	5-1 Windows with blinds sets at south side

06. Fireplace

The main function of fireplace is to keep place warm and dry, particularly in a place with high humid weather. Arts and Crafts Movement in architecture was originally started in British outskirts area and fireplace became one of the very important architectural elements. Fireplace does not only create warm to the space, but it can also keep the place dry in a humid weather. Similarly, Hong Kong is humid and its winter is cold, every main room in the Victoria Peak Fire Station has a fireplace. These fireplaces were later removed and replaced by air conditioner. Fireplace was often decided as a highly decorative centre-piece in a hall. For traditional British fireplaces, the upper portion would often be decorated with timber and other part with tiles. The fireplaces at the Victoria Peak Fire Station shared the traditional British style and each fireplace had different detailed design treatment.

Figure 4: Fireplace at Former Peak School. (Source: ARTitects Limited)

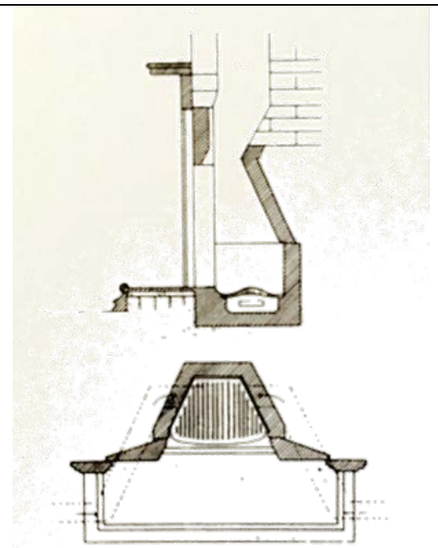


Figure 5: Cross Section and Plan of improved Edwardian fireplace dated 1911. (Source: Richard Russell Laurence)

Though photographic evidence is not readily available, the fireplace in the Former British Peak School is most likely an original artefact which dates back to 1914 when the building was constructed. The fireplace is of a simple cast-iron register grate design with a truncated fireback which surrounds the hearth. The design bears remarkable similarities to the "improved Edwardian fireplace" (Lawrence, 2009), shown in **Figure 2**, which dates back to 1911. Such types of fireplaces use coal as the source of fuel as in the 1900s, coal was considerably less expensive[4] than other available alternatives such as electrical or gas heating. The innovations in the design of coal fireplaces with the introduction of the register grate improved the efficiency to such an extent that they:

1. outperformed electric and gas heaters of the day
2. smaller form factor for both fireplace and chimney This actually presented a design dilemma for architects of the day which perhaps is best captured in the L. A. Shuffrey's "*The English Fireplace*":"It will be noticed that a gradual contraction has taken place in the size of the chimney since the abandonment of wood in favour of coal as fuel, until we now find that a flue 14 by 9 inches or even less is sufficient to take away the smoke from a modern coal fire, and that the average fire area is not much greater; the problem is how to give architectural expression to this diminutive recess." (Shuffrey, 1912)

This account also does well to explain the more to explain the compact proportions of Edwardian fireplaces such as the one in the Former British Peak School and how it evolved as a result of the technological advancements of the fireplace along with the aesthetic treatments. A contemporary of Shuffrey's in North America, L. Eugene Robinson produced the following illustration (Figure 3-6) which shows the transformation:

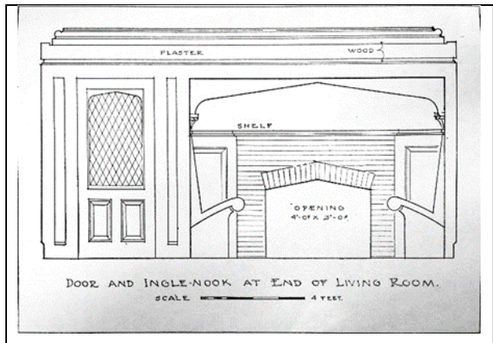


Figure 6: English Gothic Influence with large and tall opening. (Source: L. Eugene Robinson)

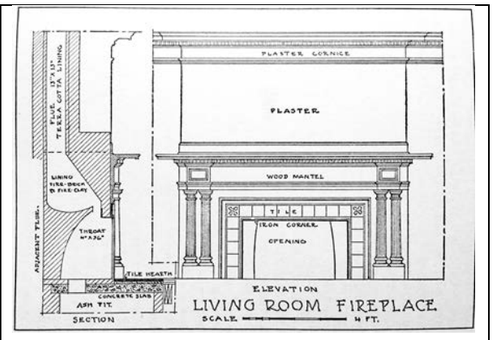


Figure 7: Elaborate treatment of the mantel piece with tile surrounds. (Source: L. Eugene Robinson)

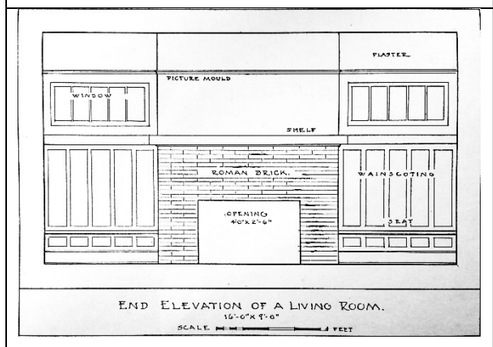


Figure 8: More simplified Mission Style Treatment from North America (Source: L. Eugene Robinson)

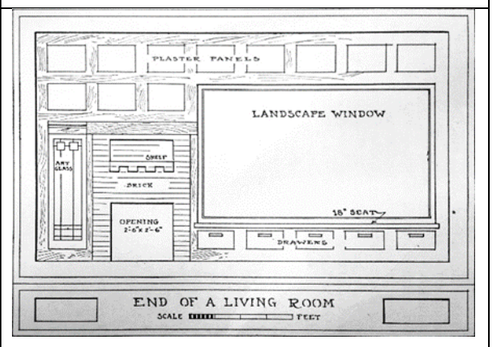


Figure 9: Art Nouveau Treatment (Source: L. Eugene Robinson)

Aesthetically, the tall and narrow proportions of the timber mantelpiece in the Former British Peak School and the simplicity of the fireplaces surround and mantelpiece reflects the design sensibilities of the Edwardian era which was a reaction against the design excess of the Victorian era. The proportion could also be said to reflect the influence of Art Deco aesthetics **(Figure 6)**. The green tiles are used for the surrounds and also the hearth rug for practical reasons as the vitreous surface facilitates easy cleaning[5]. They are a common vitreous tile used for fireplace surrounds and kitchens and many examples of their use could be found in Britain from 1890s-1930s. But what is exceptional about the fireplace is the relatively ornate chamfered design of the tiled hearth rug which is a distinct Art Deco design feature examples of which are shown in **Figures 7 and 8**.

[4] (Lawrence, 2009), pg. 165

[5] (Shuffrey, 1912), pg. 218

Figure 10: An elaborate 1920s Art Deco fireplace surround. Hearth rug is chamfered and bordered with black marble edging (Source: Richard Russell Lawrence)

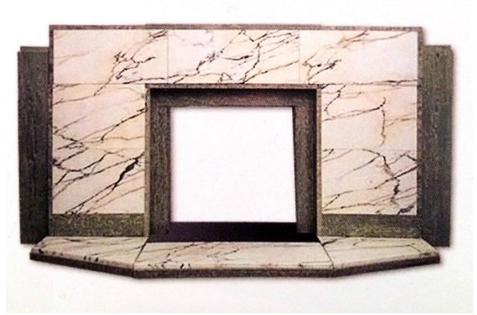


Figure 11: An Art Deco 1930s marble surround. Note the chamfered hearth rug design (Source: Richard Russell Lawrence)

07. Teak Flooring

1）The features of teak flooring

Teak timber takes 70year to process as construction material. It is oily based and rich in iron. The property of teak is highly stable. Even under extremely temperature or humidity, teak would still not deform in shape or develop cracks. Teak would not turn black with metal studs joints. It resists to corrosion and termites. Therefore, teak is highly durable.

Most Chinese would prefer timber such as Phoebe, mahogany and ebony. However, Europeans would consider teak as the best timber and this is often found in flooring of the churches and castles.

Teak timber is mainly produced in areas near the equator. The top grade teak timbers are often from Burmese. The British prefer carpet or timber flooring; however, carpet is not suitable for weather in Southeast Asia and the best choice would be teak timber flooring. HSBC in Shanghai, Customs House and Peace Hotel are fine samples of teak timber flooring and the condition is still very well after centuries.

2) Teak Timber in Hong Kong

The early colonial Hong Kong, most government buildings and houses of the wealthy families such as the University of Hong Kong Legislative Council, the Court of Final Appeal, Yau Ma Tei Police Station, Medicine Museum, Kom Tong Hall Brother, King Yin Lei, were using teak timber as flooring. By 1980s when the economy was booming, average family household would use teak flooring. Although the Victoria Station was not large, the main office and executive lounge still remain as its original teak flooring.

4）Teak wood floor planks used to be common floor finish materials in HK. Up till 1970s, we used real Burmese Teak. Each was 2in x 1 ft, and full depth of 1in, with tongue and grove. Each is made up of real wood. The top is waxed periodically, and can be shaved if worn out. Good quality residential flats and even good quality offices used these. You can still see these in old office buildings like Central Building, and many old residential flats. Teak has a characteristic of low water absorption and low expansion rate. Hence even in flooding or extreme weather hanges, they will not crack. Method of laying is prepared with battens. Each plank is nailed to batten at the tongue, and hidden when groove of next piece doves in. Up until 1980s, we still used these, but the quality was lowered.

Then by 1990s, there was a wave of alternatives. We have pine, cherry etc etc, deciduous trees; because they look more modern. These are seasonal trees, with much looser cellular bodies. When made into floor planks, contract and expand in temperature changes. When wet, they stain and bend. Worse, the workers no longer use time consuming batten methods. They apply flat boards, and adhere the planks by glue. Worse, people like long and large planks. The obvious result is that they bulge and crack in humidity and temperature change.

Modern days so called teak wood floor is no better. They are composed pieces, by sticking together small pieces together. The top may be a thin layer of Indonesian teak, but the body is composite board. Obvious result is that, they still crack and bulge.

The teak floor of Fire Station seems to be genuine teak floor. Firemen seems to confirm these were not touched in decades. Meaning they were made before the days the composite planks were invented. Architecturally they represent the traditional craft of local workers. Scientifically they represent the changing building material and technique. Socially they represent the trend of HK building industry.

3) Making of teak flooring in Hong Kong

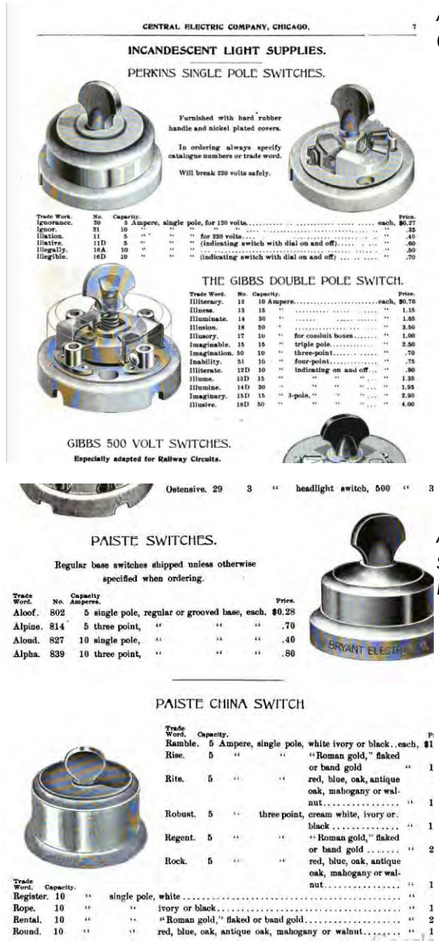
Below is the website on making teak flooring in Hong Kong from product quality, production process and final marketing sales.

08 Light Switch

Heavy Duty Single Pol Rotary Switch at Old Peak School possibly from the General Electric Company of England.

Similar single polerotary switch manufactured by the General Electric Company in the 1930s in England. (Unknown, Auctiva Emporium: SPIDYLODGE20 2015)

The light switch in the Old Peak School building is a single pole heavy duty rotary switch. Rotary switches are low voltage electrical switches for appliance and lighting. Some of the earliest documented examples of this type of switch could be seen in the Central Electric Company of Chicago below in Figure 3 and 4 were marketed for both the domestic and industrial application. A more sophisticated flush plate rotary switch was also offered for the domestic market.


CENTRAL ELECTRIC COMPANY, CHICAGO.

INCANDESCENT LIGHT SUPPLIES.

PERKINS SINGLE POLE SWITCHES.

Furnished with hard rubber handle and nickel plated covers.

In ordering always specify catalogue numbers or trade word.

Will break 220 volts safely.

Trade Word.	No.	Capacity.	Price.
Ignorance.	20	5 Ampere, single pole, for 120 volts, each,	$0.27
Ignor.	21	10 " " " " "	.35
Illation.	11	5 " " for 220 volts, "	.40
Illative.	11D	5 " " (indicating switch with dial on and off), "	.60
Illegality.	16A	10 " " " "	.50
Illegible.	16D	10 " " (indicating switch with dial on and off), "	.70

THE GIBBS DOUBLE POLE SWITCH.

Trade Word.	No.	Capacity.	Price.
Illiteracy.	12	10 Ampere, each,	$0.70
Illness.	13	15 " "	1.15
Illuminate.	14	30 " "	1.85
Illusion.	18	50 " "	3.50
Illusory.	17	10 " for conduit boxes, "	1.00
Imaginable.	15	15 " triple pole, "	2.50
Imagination.	50	10 " three-point, "	.70
Inability.	51	10 " four-point, "	.75
Illiterate.	12D	10 " indicating on and off, "	.90
Illume.	13D	15 " " " "	1.35
Illumine.	14D	30 " " " "	1.95
Imaginary.	15D	15 " 3-pole, " " "	2.80
Illusive.	18D	50 " " " "	4.00

GIBBS 500 VOLT SWITCHES.

Especially adapted for Railway Circuits.

Ostensive. 29 3 " headlight switch, 500 " 3

PAISTE SWITCHES.

Regular base switches shipped unless otherwise specified when ordering.

Trade Word.	No.	Capacity Amperes.		Price.
Aloof.	802	5	single pole, regular or grooved base, each.	$0.28
Alpine.	814	5	three point, " " "	.70
Aloud.	827	10	single pole, " " "	.40
Alpha.	839	10	three point, " " "	.80

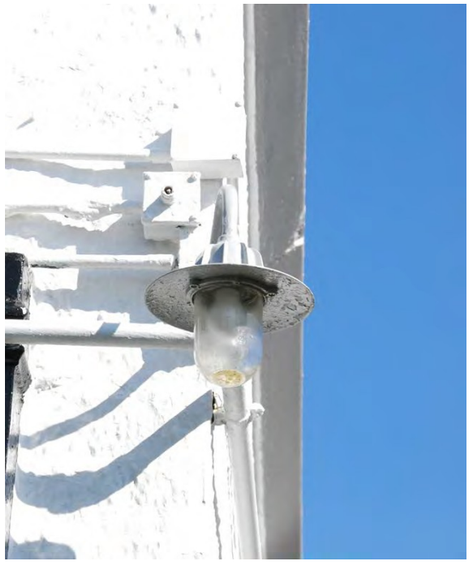
PAISTE CHINA SWITCH

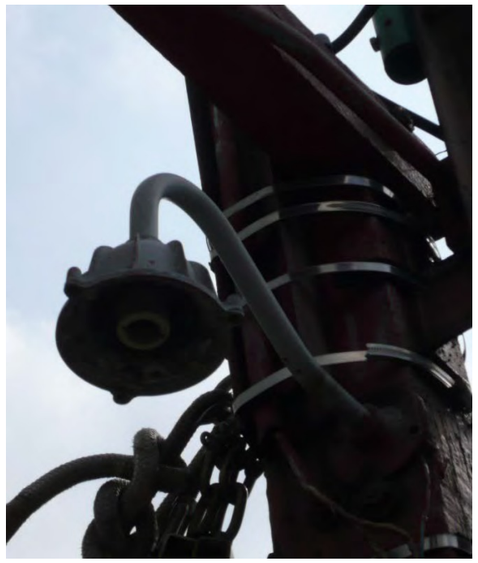
Trade Word.	Capacity.		
Ramble.	5	Ampere, single pole,	white ivory or black, each, $1
Rise.	5	" "	"Roman gold," flaked or band gold " 1
Rite.	5	" "	red, blue, oak, antique oak, mahogany or walnut, " 1
Robust.	5	" three point,	cream white, ivory or black, " 1
Regent.	5	" "	"Roman gold," flaked or band gold, " 2
Rock.	5	" "	red, blue, oak, antique oak, mahogany or walnut, " 1
Register.	10	" single pole,	white, "
Rope.	10	" "	ivory or black, " 1
Rental.	10	" "	"Roman gold," flaked or band gold, " 2
Round.	10	" "	red, blue, oak, antique oak, mahogany or walnut, " 1

A single pole rotary light switch manufactured by the Central Electric Company of Chicago circa 1898. (Central Electric Company 1898)

Another model of the rotary light switch from the Central Electric Company showing variety options available probably to suit domestic application. (Central Electric Company 1898)

09 Lamp





The exterior lighting fixture at the Old Peak School was manufactured by the Coughtrie of Glasgow, now known as Coughtrie International Ltd. The company was founded in 1941 and specializes in the manufacturing of industrial lighting (Coughtrie International Ltd. 2014). The unit used in Old Peak School is the “SW” model which is still in production after 70 years but in a simplified form without the shade. The gooseneck wall bracket is still available as an option to this day. As with the original units, the new units are still painted cast aluminium (Coughtrie International Ltd. 2014).

The Coughtrie “SW” external lighting fixture could be found in many institutional or heritage building in Hong Kong. Examples could be seen interspersed around the external walls of the Hong Kong Museum of Medical Science at Caine Lane and at the main entrance of the Dr. Sun Yat Sen Museum at Robinson Road with the optional squirrel cage installed for additional protection against possible breakage of the glass diffuser. A defunct example could also be seen on a bridge in the Tai O Fishing Village which was constructed in 1979.

The Coughtrie “SW” lighting fixture at the Old Peak School is without doubt a post-war addition to the building as in the case of most of the other examples identified above since the Coughtrie of Glasgow was not setup until 1941. By 1941 Hong Kong had already been invaded by the Japanese rendering all import of British-made products unlikely.

10 Rainwater Downpipe and Hopper

The cast iron rainwater downpipes and hoppers found in the Old Peak School are mostly original. The use of cast iron for rainwater goods is common in Hong Kong up until late-20th century where uPVC became the norm due to cost. Examples in the Old Peak School comprises of a mix of square and circular cross-section cast iron pipes with cast iron hoppers which correspond to the specific said cross sections. Heavy layers of paint had been applied to the surface of the cast ironworks over the years occurring the original hallmark plates and embossed which identifies the original manufacturer making conclusive identification of their origins and period impossible. But imprints on certain cast iron pipes and hoppers shows that the identification plates / embossed imprint still exist. Though conclusive identification is not possible, the practice of leaving a hallmark plate or year of manufacture is common practice in the late nineteenth century and early twentieth century. It is recommended that any subsequent works attempts to conduct any conservation work to this CDE should investigate this aspect further.

Figure 12: Rainwater Downpipe at Former Peak School. (Source: ARTitects Limited)

Figure 2: Rainwater Downpipe at Former Peak School. (Source: ARTitects Limited)

CDEs Properties

Item	Historic Interest	Reason for Importance	Ref Section of Heritage Report
Windows and Door	Visual and access connection between corridor and front yard	Demonstrate openness of school at that time	4.2.3
Old hanging Light	believed to be from original 1917	Testify the age of the building, and illustrate the quality of provisions at that time	4.2.4
Old Light switch	believed to be from original 1917	Testify the age of the building, and illustrate the quality of provisions at that time	4.2.4
Roof timber Structure (hidden above ceiling)	Box rafter-battens supported on simple rectangular rafters (many replaced in the past)	Construction typical of Chinese roof on western truss system, common in HK (but hidden)	4.3.2
Chinese Tiles	Now Chinese tiles re-assembled (Originally in 2-pan-2-roll until 2000)	2-pan-2-roll Chinese tiles is typical of Western bldgs in HK (but construction altered in 2000)	4.3.2
Rain Water Pipes	Cast-iron downpipes	Downpipes & hoppers probably original	4.3.2
Parquet Floor	Teak parquet of 1ftx1ft pattern, probably of traditional tongue-groove construction	Probably original (documented re-polishing works); high quality local workmanship + material	4.3.4
Steel door gates	Red painted grilled gates with minimal fan pattern	Late addition. Nevertheless designed in harmony style	4.3.3
Fireplaces	One in Gym in tiled surface, another in Dining Room in wood surface; both Art Deco Style	Fireplace is essential for warm in cold/ humid weather in Peak. Art Deco is trend for late phase of Art & Craft.	4.3.4