AUTODESK. UNIVERSITY

Proof of Concept : Generative Design for Metro Station

Louis-Marie Borione | Ewa Szylberg

BIM Managers

About Speakers

Louis-Marie Borione BIM Manager

As Building Information Modeling (BIM) manager for SYSTRA in France, Louis-Marie Borione is in charge of BIM technical support in SYSTRA's corporate implementation project. He has 10 years of experience in change management, procedures and standards definitions, BIM model production, BIM innovation and custom developments.

He is in charge of a program for developping new tools and new services for our client around BIM.

About Speakers

Ewa SZYLBERG BIM Manager

BIM Manager and Architect she works in Systra since 2018. With experience of over 10 years working on multidisciplinary infrastructure projects, her focus is on Parametric studies in order to optimize design conception and process of creation itself.

6,200
employees
around the world

€ 600m
Revenue in 2017

60% turnover achieved
internationally

SYSTRA

80
countries

60 years'
experience in
Transportation

Top 5 position ENR
Mass Transit and Rail

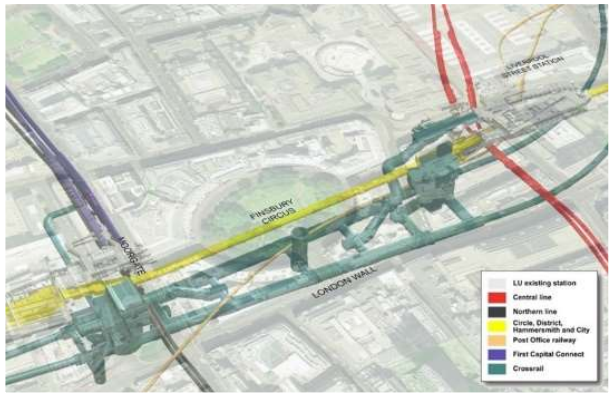
SYSTRA has been involved in

1 in 2

metro projects worldwide

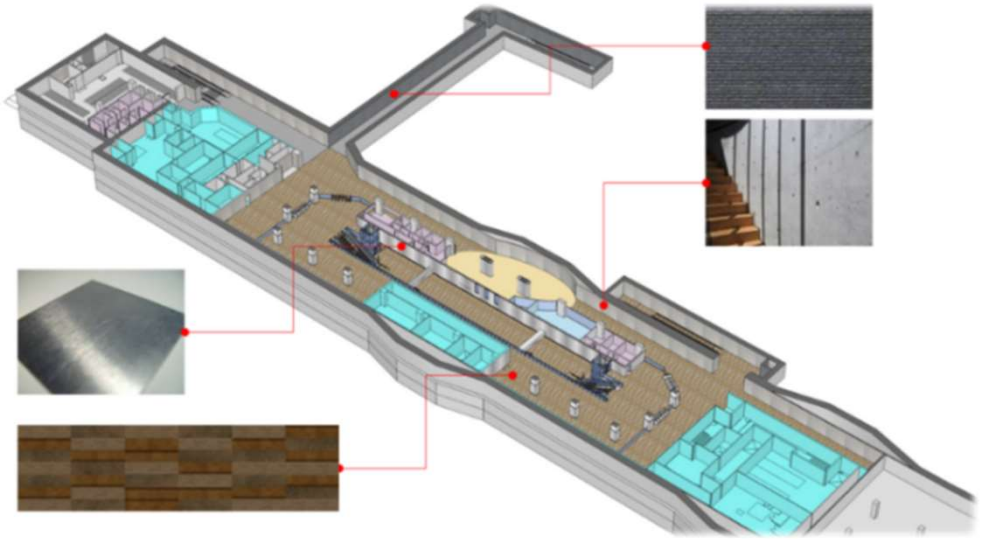
60%

of automated metros worldwide involve SYSTRA



Crossrail – London, UK

Singapore – Circle MRT line

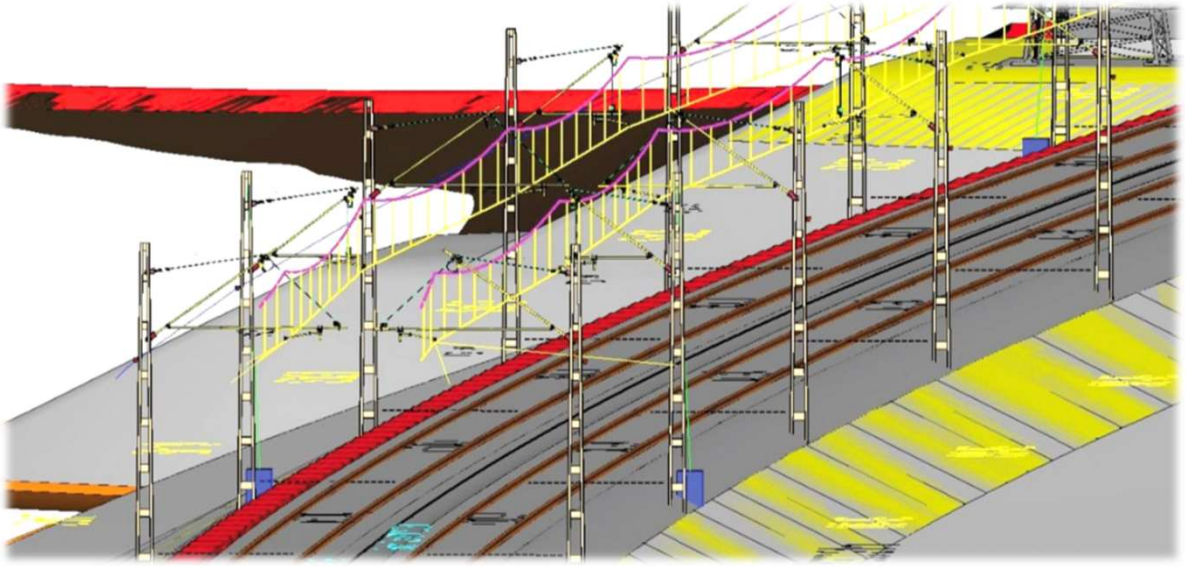


1st metro line in Bogota, Columbia

SYSTRA has played
a key role in more than

50%

of the world's
high speed rail lines

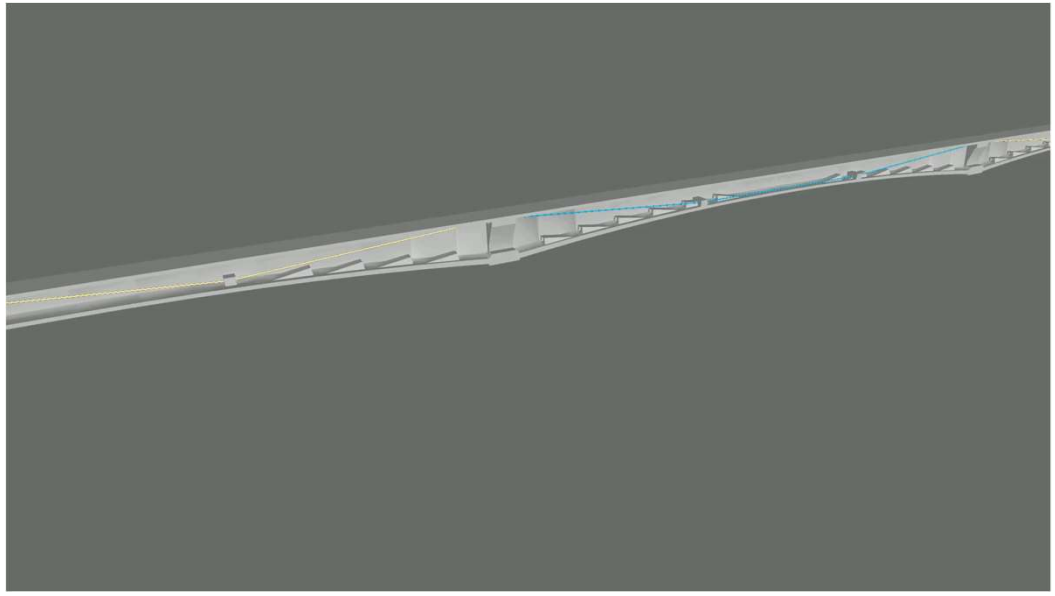


Ostlanken - Stockholm to Malmö, Sweden

South Europe Atlantic, France

HS2 – London to Manchester, UK

MMMP MECCA (elevated metro line)



17km	2010	9	17months
Length	Construction Completed	Stations	Design and Built Period

SYSTRA Role

Concept, basic design, detailed design and construction supervision

BIM/CAD applications

- 2D Drawing Production (automatic CAD quality checking, collaboration workflows, documents versioning/archiving…)
- Prestressing and Concrete 3D Models + 2D Extractions

1st BOGOTA METRO LINE (elevated metro line)

9,1km	36000	16	2022
Length	People/hour	Stations	Expected Construction

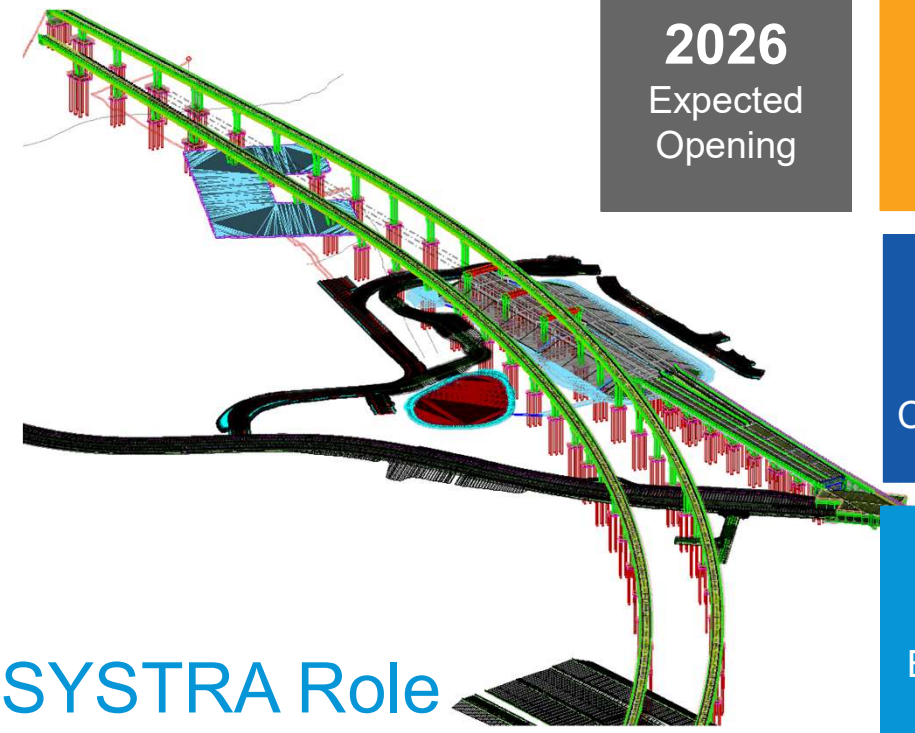
SYSTRA Role

Design and Built, Architecture and Structure, Station & Viaduct

BIM/CAD applications

- BIM for entire system infrastructure
- BIM Coordination (Architecture, Structure, Viaduct, Equipments and MEP)
- Clash Detection
- Quantity extraction

HS2 (High Speed Line)



2026
Expected Opening

88km
Length

250
BIM Collaborators

500
BIM Models

SYSTRA Role

High Speed 2 is a two-phase railway to improve journey times and frequency between London and Birmingham, Manchester and Leeds.

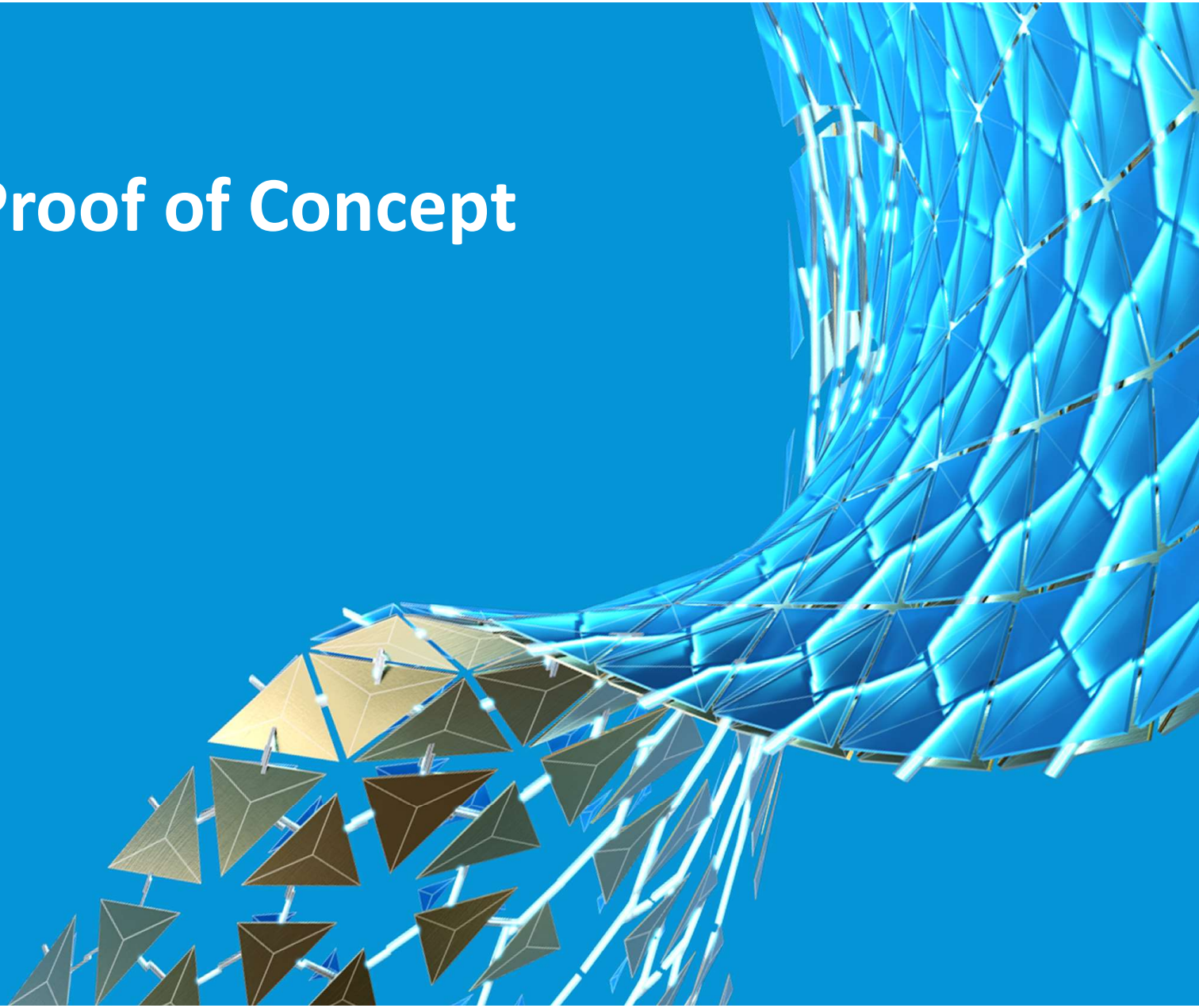
Construction Joint Venture : Balfour Beatty Vinci

Design Joint Venture : Mott Mac Donald - Systra

BIM/CAD applications

- Full BIM project : Earthworks, Alignment, Drainage, River Diversion, Highways, Structure, Geotechnics, Utilities
- Asset Information Model
- Cost estimation from BIM models
- Carbon calculation from BIM models
- Design data through BIM models

Goals of the Proof of Concept



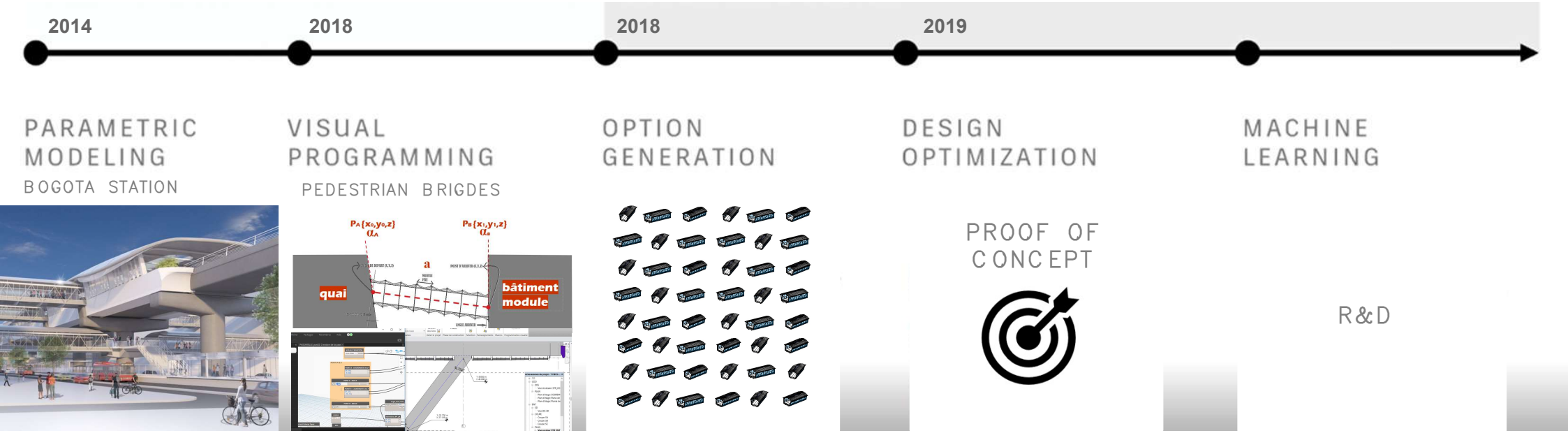


Image source: Autodesk

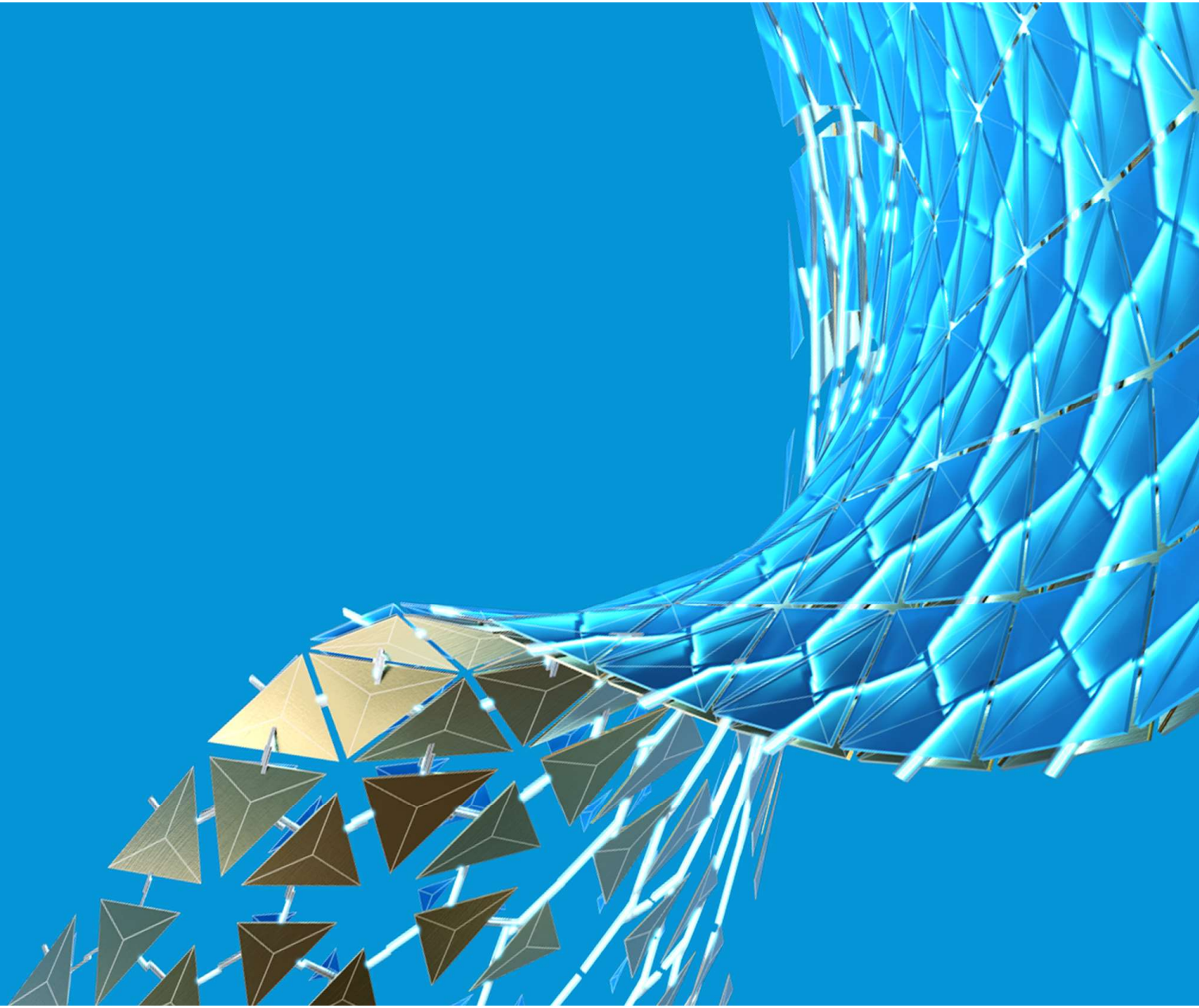
Goals of the PoC in Systra

Generative Design (GD) Proof of Concept (POC) in Systra is a project that aims to research on design optimisation feasibility. After several years of applying BIM and parametric design on projects, systra first uses computational design on Bogota metro in 2018. After this experience we tough we were mature enough to start a POC on Generative Design in 2019-2020.

Objectives of POC was to evaluate the challenge, time, resources needed and risks of implementing a GD process on a real infrastructure project.

First POC phase was limited to 1-Year –development with a detailed roadmap.

Roadmap



Roadmap

As Plan

2019 Q1 — AWARENESS, POC DEFINITION, BENCHMARK, TEAM/SKILLS — 2019 Q2

2019 Q2 — POC EXECUTION, LESSONS LEARNT, COMMUNICATION — 2020 Q2

2019 Q3 — NEXT POCs, METHODOLOGY

As Achieved

AWARENESS

*Generative design **mimics nature's evolutionary** approach to design. Designers or engineers input **design goals** into generative design software, along with parameters such as materials, manufacturing methods, and cost constraints. Unlike topology optimization, the software explores all the possible permutations of a solution, quickly generating **design alternatives**. It tests and **learns from each iteration** what works and what doesn't.*

DESIGN SPACE MODEL
+
DESCRIPTION OF GOALS
+
GENERATION ALGORYTHM

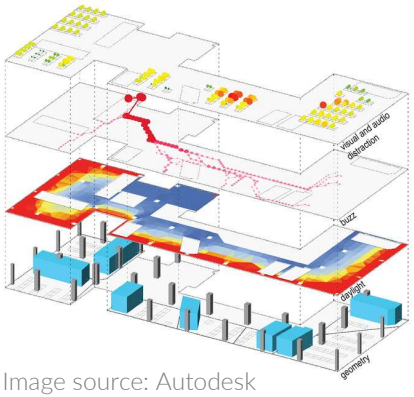
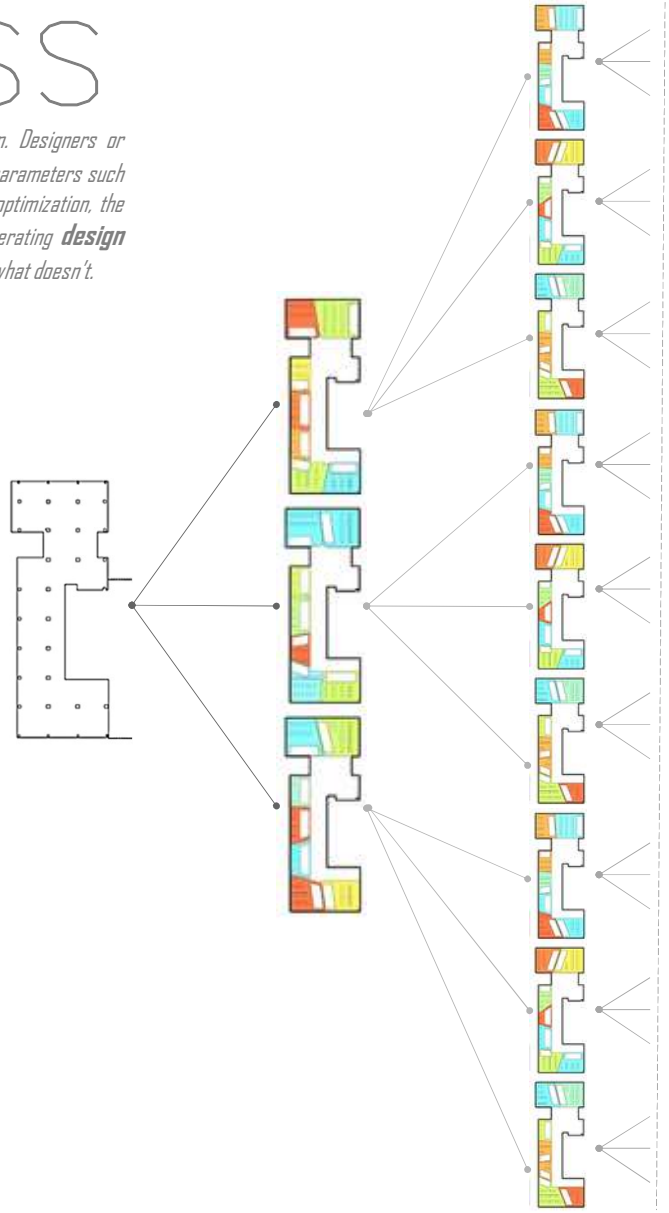
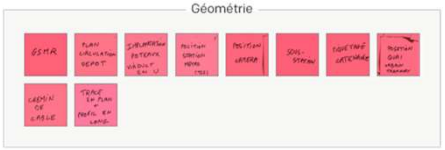


Image source: Autodesk



DESIGN SELECT

POC DEFINITION



VPP TSS SDT IME ITB IFE IED DDM DCO

OPTIMISATION CONCEPTION OUVRAGE AERIEN

OPTIMISATION CONCEPTION OUVRAGE SOUTERRAIN

OPTIMISATION CONCEPTION FONCTIONNELLE STATION

OPTIMISATION D'IMPLANTATION D'OUVRAGE SUR LINAIRE

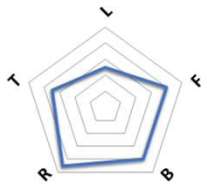
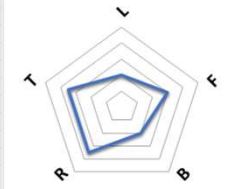
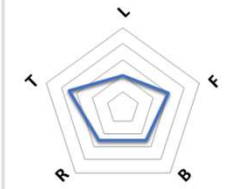
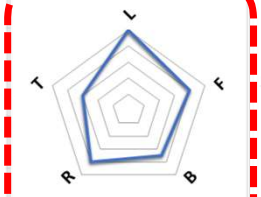
OPTIMISATION AMENAGEMENT D'UN DEPOT

OPTIMISATION D'IMPLANTATION A L'ECHELLE D'UN TERRITOIRE

OPTIMISATION SIGNALISATION

OBJECTIFS

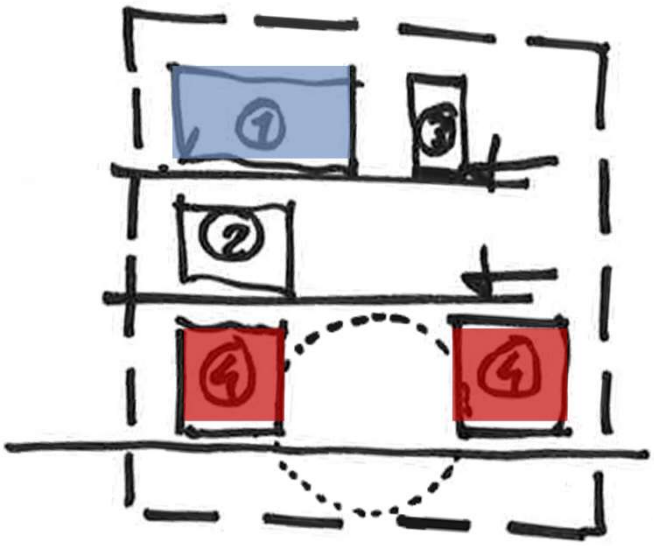
LEARNING	L
FEASIBILITY	F
BENEFITS	B
REUSE	R
TECH. SCOPE	T

						
OPTIMISATION CONCEPTION IMPLANTATION LINEAIRE	OPTIMISATION CONCEPTION OUVRAGE AERIEN	OPTIMISATION CONCEPTION OUVRAGE SOUSTERRAIN	OPTIMISATION CONCEPTION FONCTIONNELLE STATION	OPTIMISATION AMENAGEMENT D'UN DEPOT	OPTIMISATION D'IMPLANTATION A L'ECHELLE D'UN TERRITOIRE	OPTIMISATION SIGNALISATION

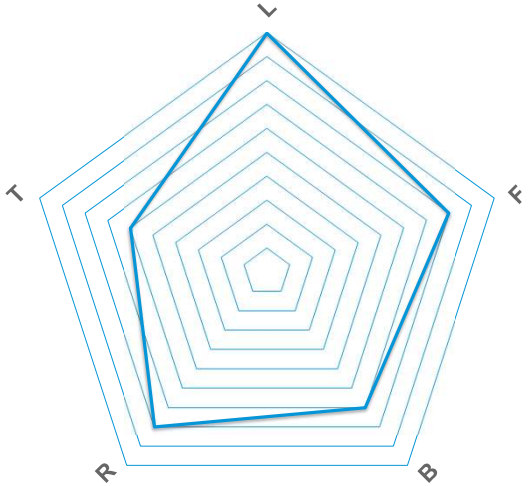
OPTIMISATION CONCEPTION FONCTIONNELLE STATION

PROGRAMME STATION
SURFACE COMMERCIAL
TRACE EN PLAN + PROFIL EN LONG
POSITION + EMPRISE STATION METRO
CATALOGUE OUVRAGES
SIMULATION EVACUATION
PARVIS STATION
FLUX PASSAGERS

OPTIMISATIONS



analyse flux passagers



ENTRANTS

> DEMANDES PROGRAMME

> MOUVEMENTS PASSAGERS

> NORMES ARCHITECTURALES

DEGRES DE LIBERTE

> AMENAGEMENT

> SOLUTION CIRCULATION

> SOLUTION STRUCTURELLE

MACRO OBJECTIFS

> EXPERIENCES UTILISATEURS

> ECO – CONCEPTION

> CONFORT

> COUT

OPPORTUNITES:

> INTRODUCTION DES SIMULATIONS FLUX PASSAGERS DANS LA PHASE AMONT

> LIEN AVEC LE PROJET

PREPARE

RISQUES:

> DIFFICULTE AVEC TRADUCTION DES CHOIX ARCHITECTURAUX

OUTILS EN RELATION:

> LEGION
> REVIT
> FORGE

RISQUE TECHNOLOGIQUE:

HAVE SEEN — ADAPT — UNKNOW

A01

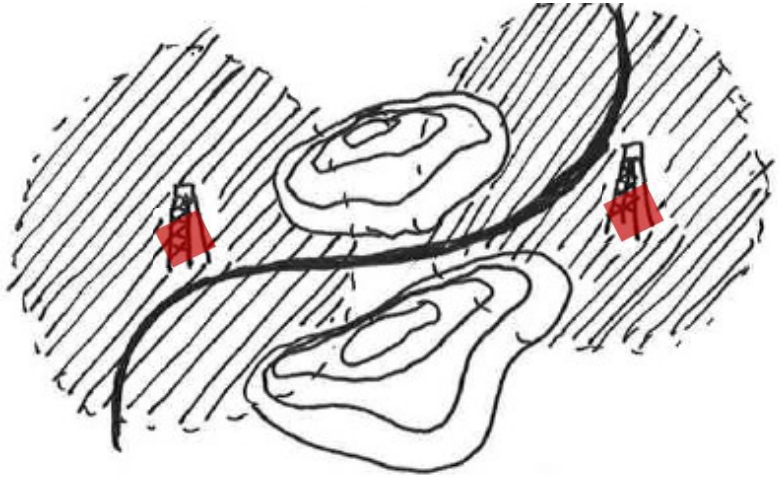
ECHELLE TERRITOIRE

POSITION SOUS STATIONS >

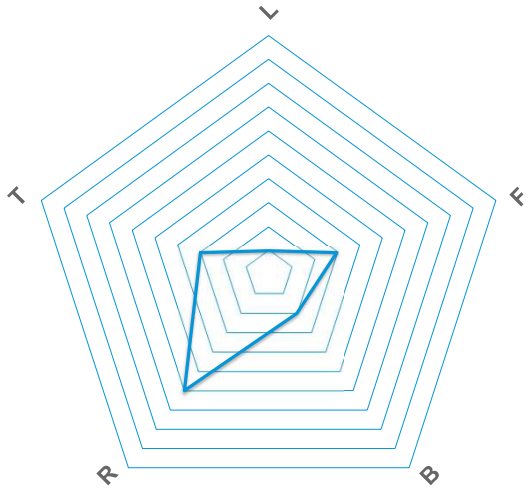
POSITION GSMR >

TRACE EN PLAN EN PROFIL EN LONG >

OPTIMISATIONS



connexion SIG



CONTRAINTES

> ZONES EXCLUES

> TOPOGRAPHIE

> TRACE

VARIABLES

> POSITION DES EQUIPEMENTS

OBJECTIFS

> PROPOSER PLUSIEURS SOLUTIONS

> MINIMALISATION DES EQUIPEMENTS

> MAXIMISATION DE LA COUVERTURE

OPPORTUNITES:

> CONNEXION AVEC DES METIERS PEU EN LIEN AVEC BIM

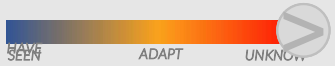
RISQUES:

> MANQUE DES DONNEES
> LIEN AVEC DES OUTILS METIER INCONNUS
> LIEN AVEC SIMULATIONS FONCTIONNELLES

OUTILS EN RELATION:

> MARCADET
> RailTopoModel

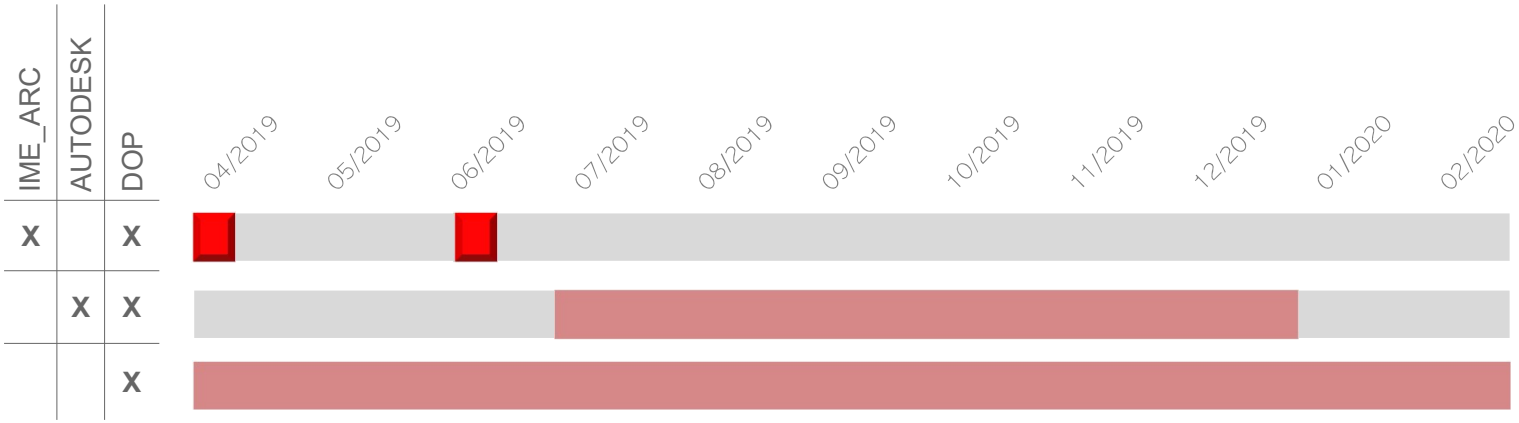
RISQUE TECHNOLOGIQUE:



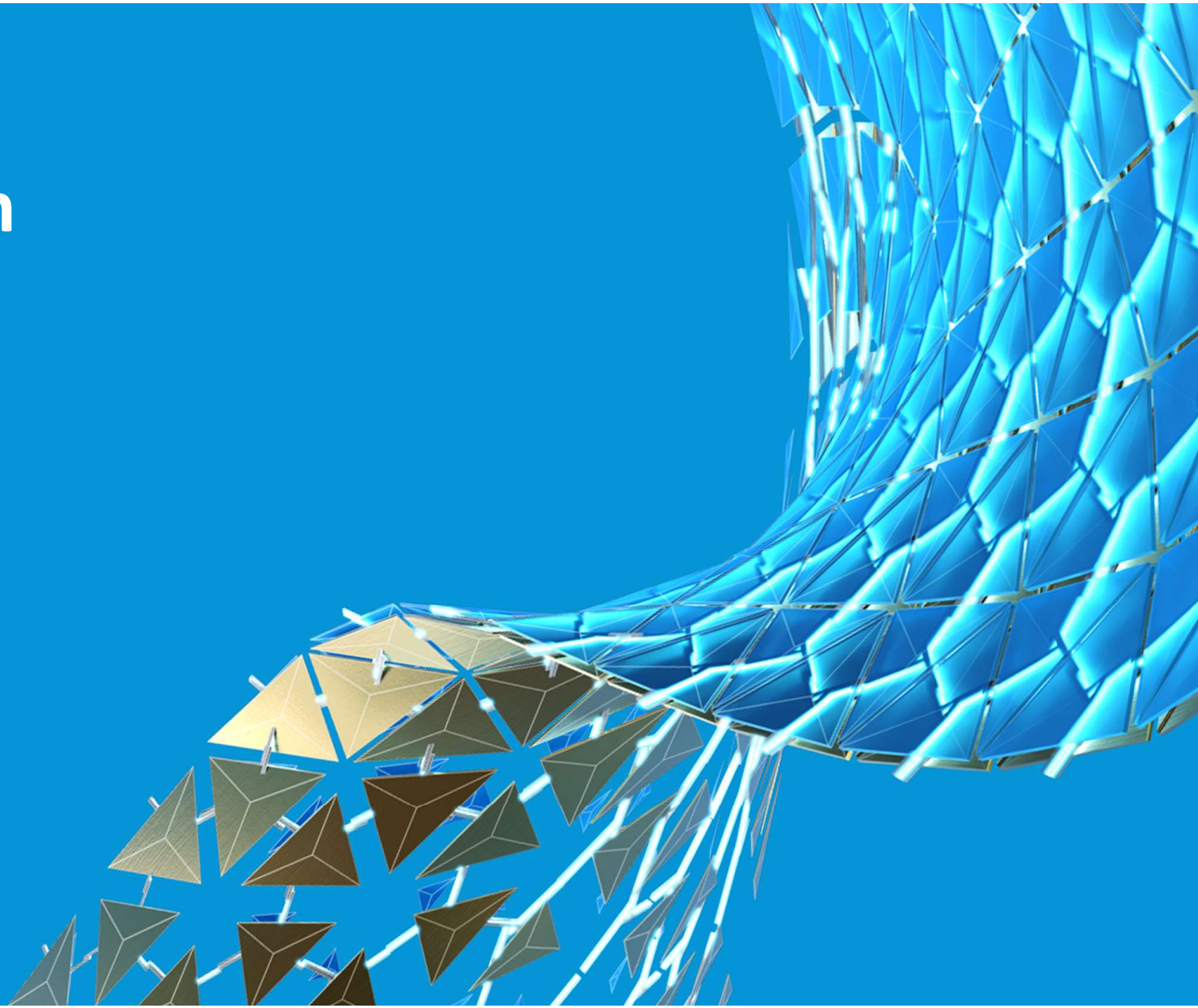
S02

Team + Benchmark

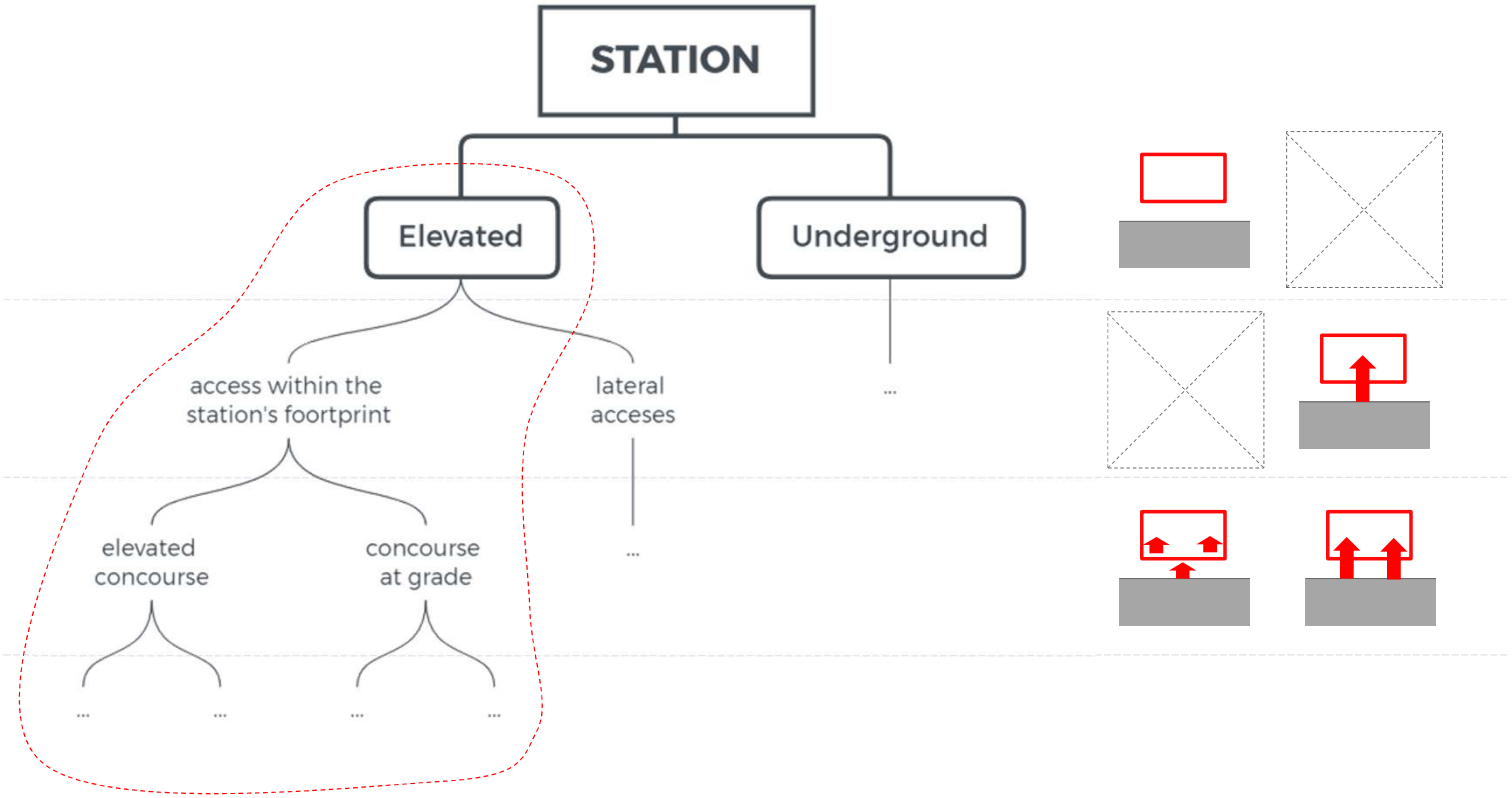
- **WORKSHOPS OF STATION DESIGN**
- **BENCHMARK OF SOLUTIONS**
- **SPRINTS FOR GD METHODS**
- **EXECUTION**



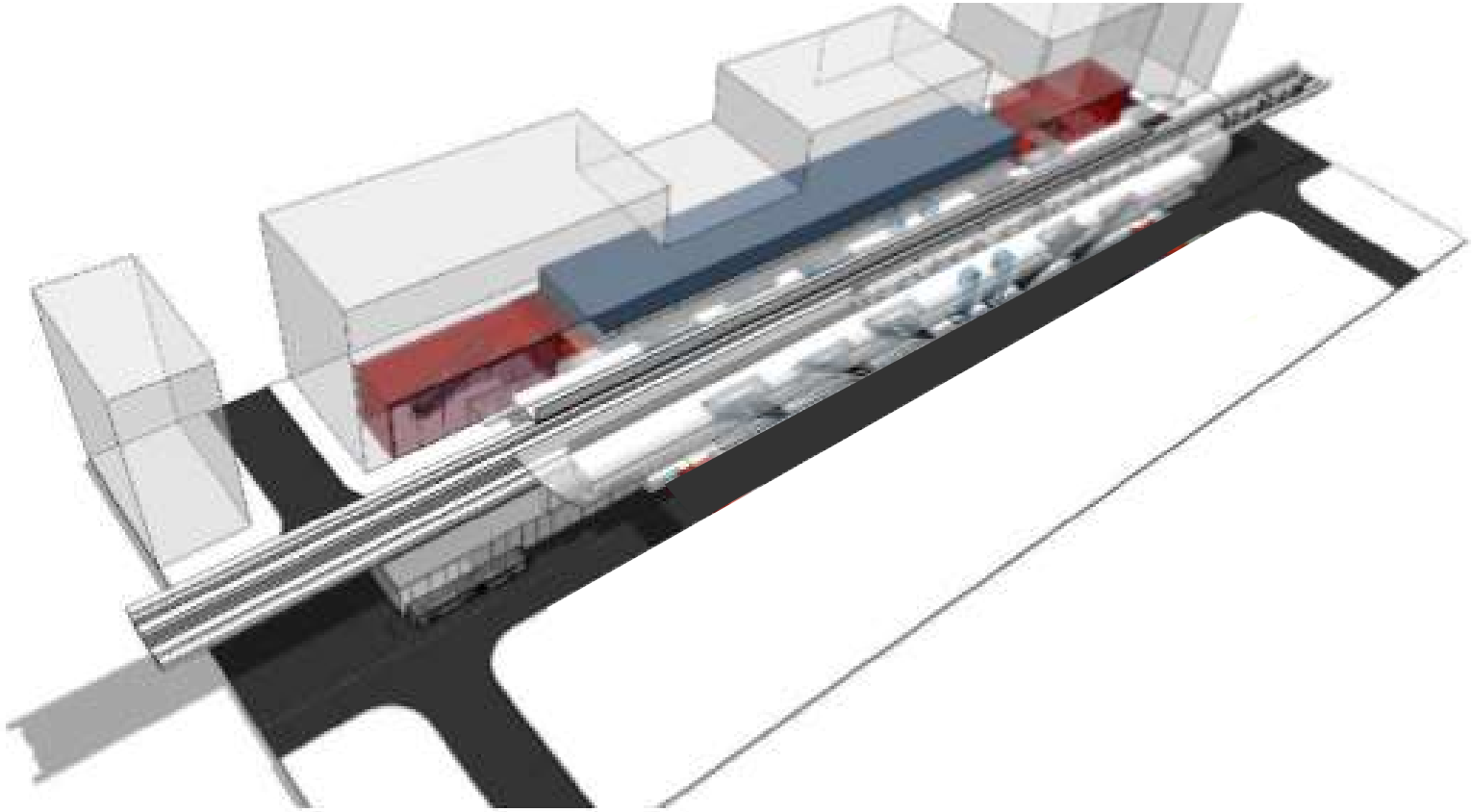
PoC Execution



Design Assumptions



Design Assumptions



Design Assumption

- *Unit width*
- *RunOff lenght*
- *Platform_minimal_width*
- *Minimal_level_height*
- ...

INPUT DATA

- *Platform, Concourse thickness*
- *Zrail, zGround*
- *Rolling stock*
- *Total stairs length*
- *Mezzanine level (true/false)*
- ...

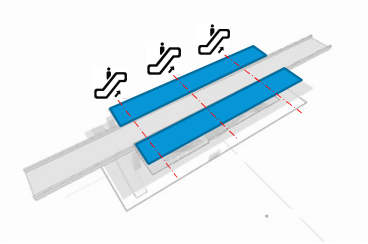
PARAMETERS

- *Width and lenght of platform*
- *Positions and direction of verical circulation*
- *Configuration of zones Paid/Unpaid*
- ...

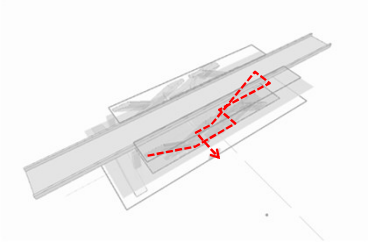
VARIABLES

Criterias for the Proof of Concept

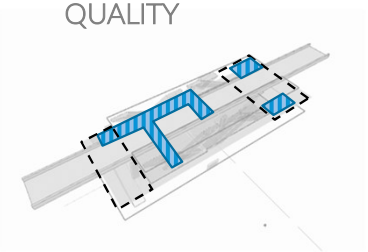
COMFORT OF CIRCULATION



TIME OF EVACUATION



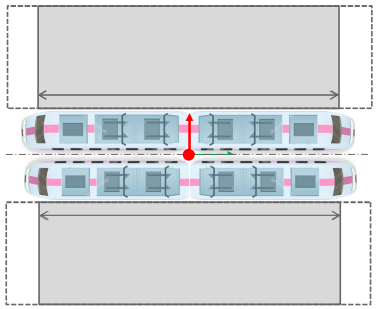
LAYOUT QUALITY



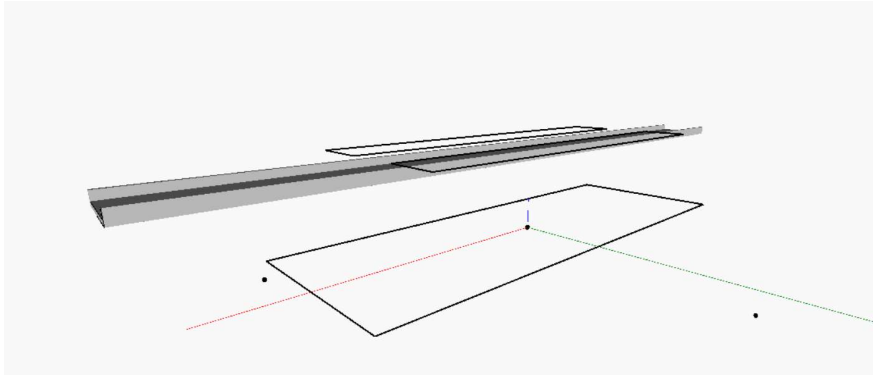
Design Procedure

PLATFORM LEVEL

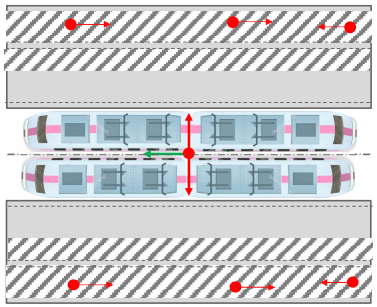
①



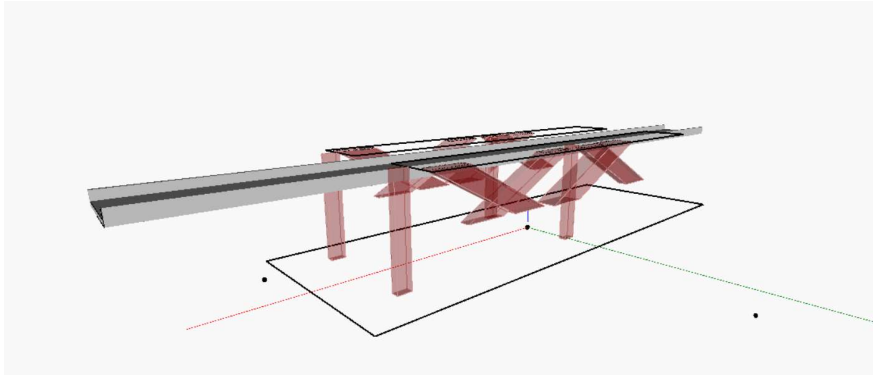
CREATE PLATFORM BOUNDARY



②



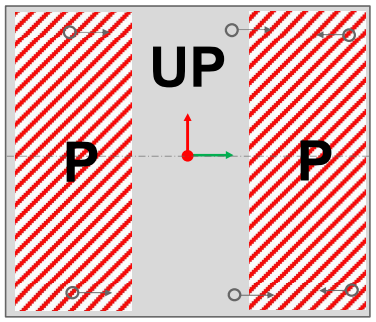
GENERATE VERTICAL CIRCULATIONS



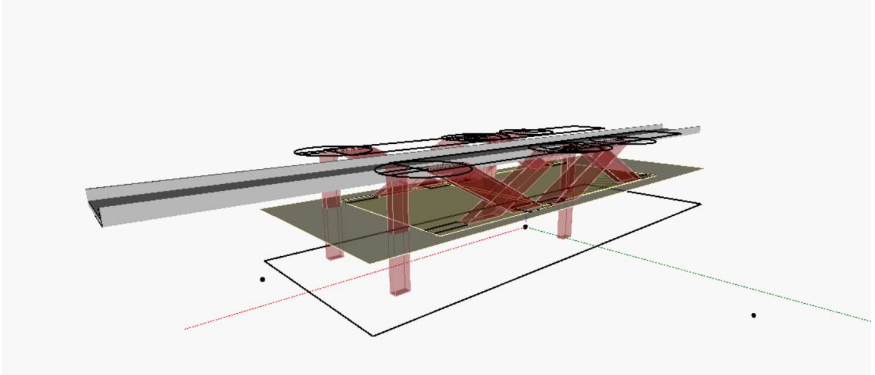
Design Procedure

CONCOURSE LEVEL

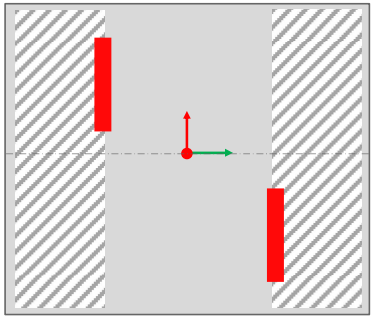
③



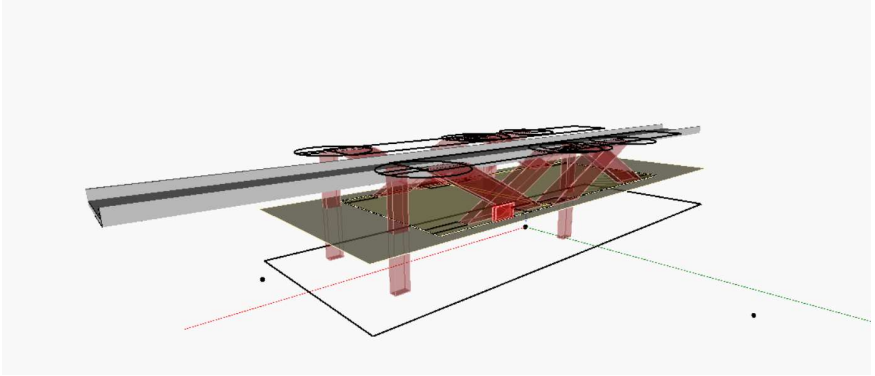
SUBDIVIDE CONCOURSE LEVEL INTO PAID/UNPAID AREA



④



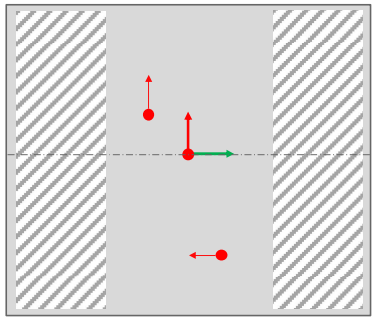
GENERATE TICKETING



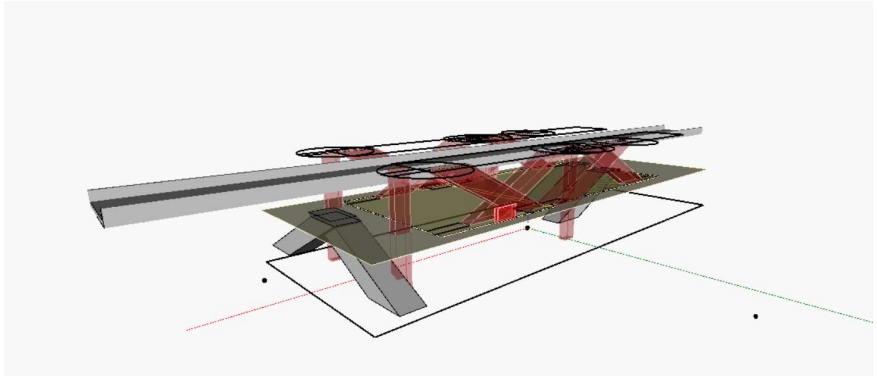
Design Procedure

CONCOURSE LEVEL

⑤

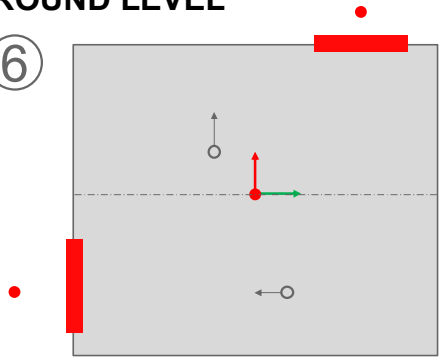


GENERATE VERTICAL CIRCULATIONS

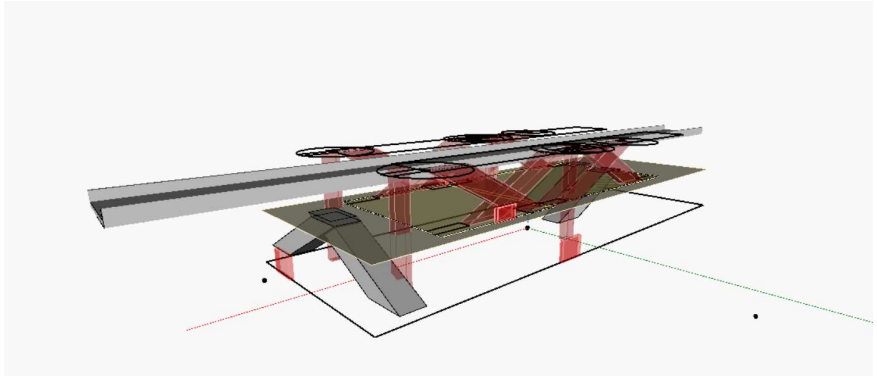


GROUND LEVEL

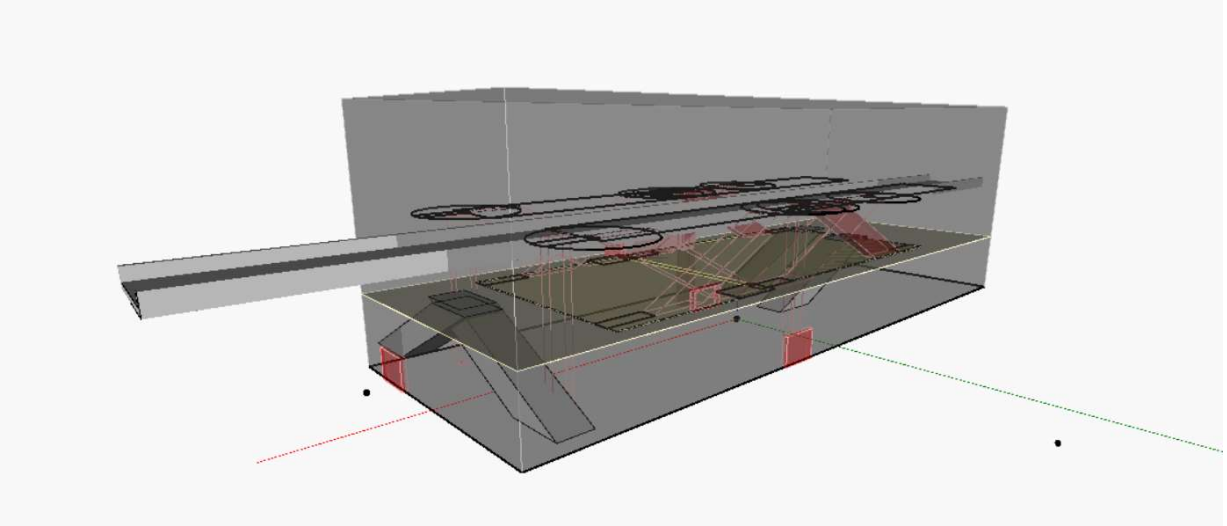
⑥



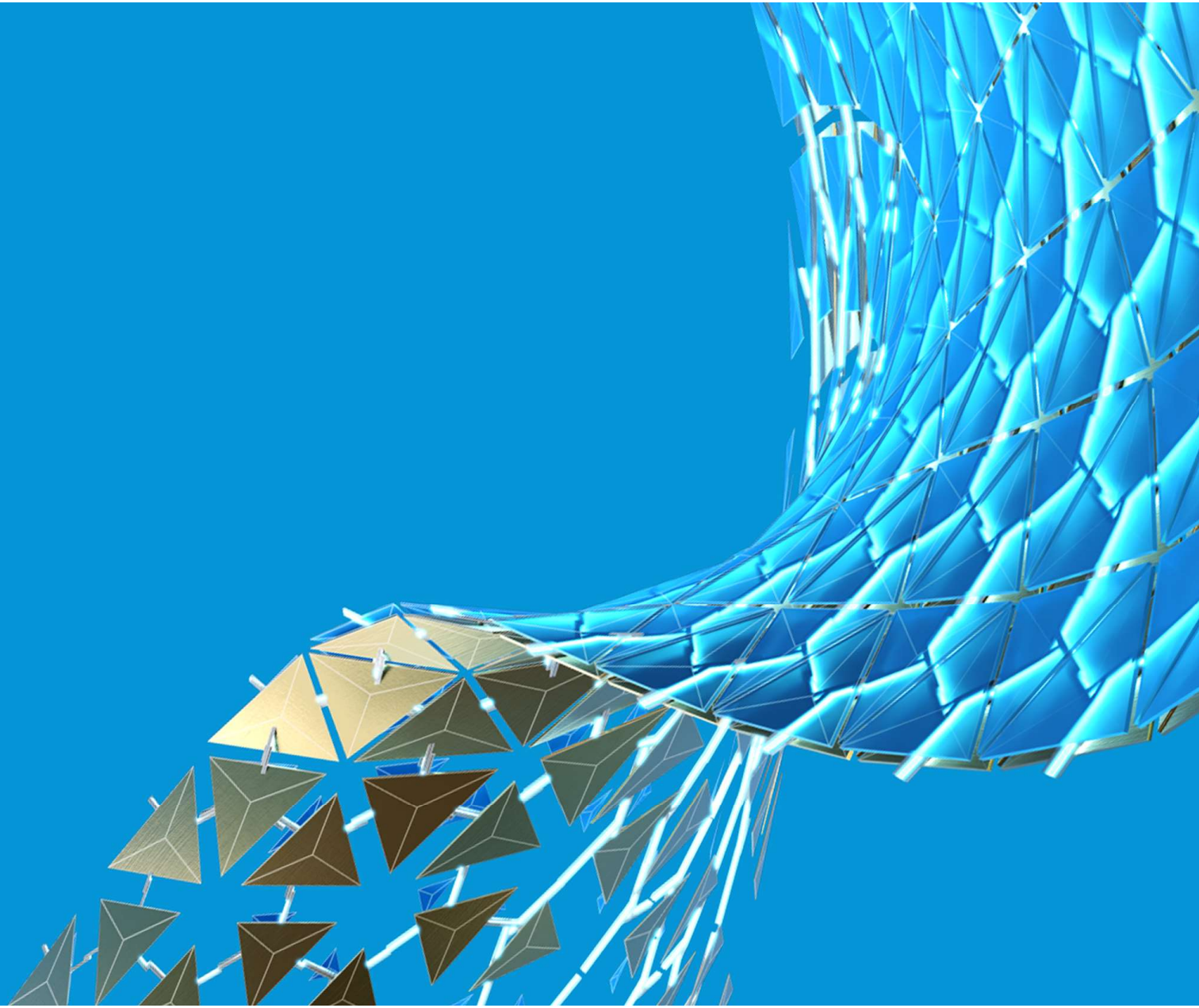
PLACE ENTRANCES



Design Procedure



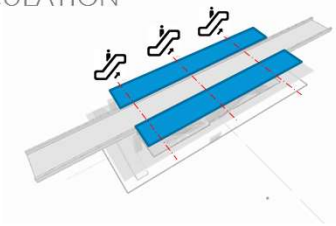
Results

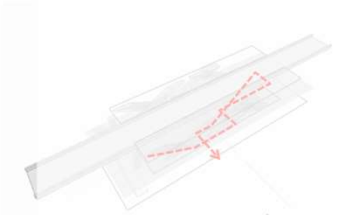


RESULTS–CRITERIA

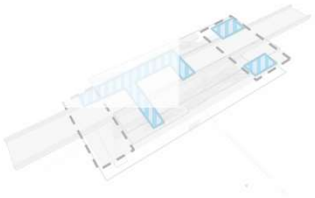
COST
TIME OF
EVACUATION

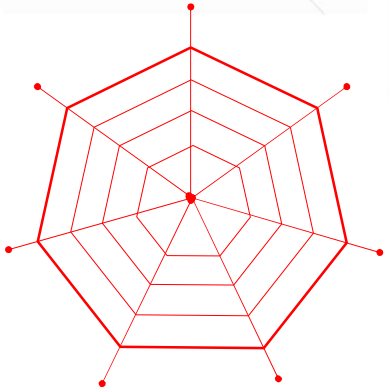
USER
EXPERIENCE
COMFORT OF
CIRCULATION



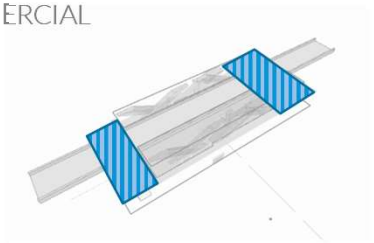


PROFIT
LAYOUT
QUALITY

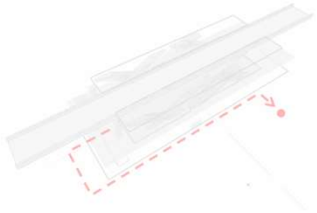




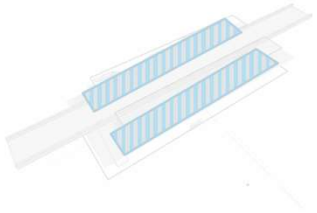
PROFIT
COMMERCIAL
AREA

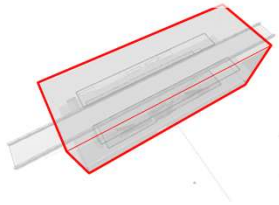


USER
EXPERIENCE
DISTANCE
TO BUS
STOP



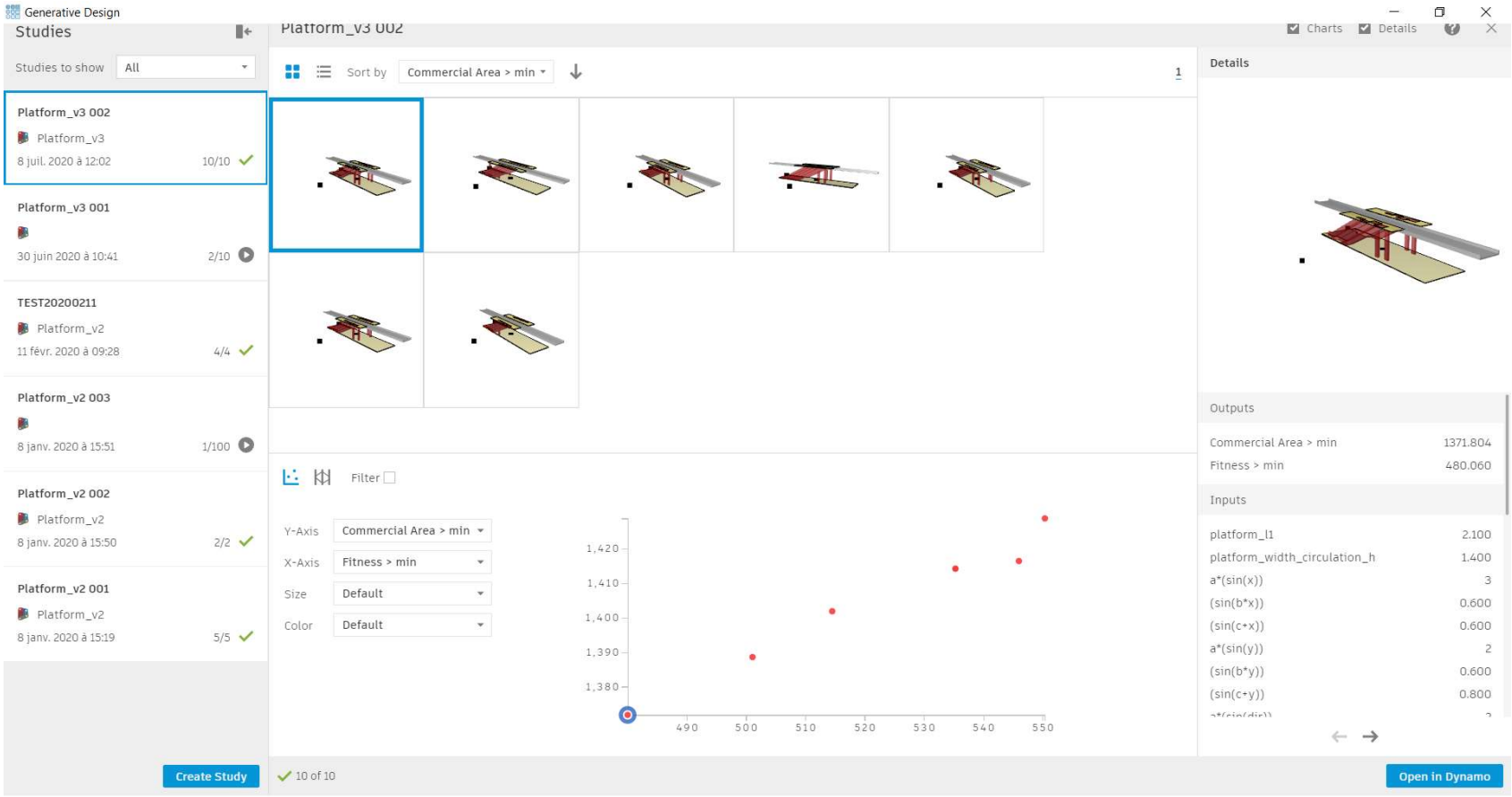
COST
TECHNICA
L AREA



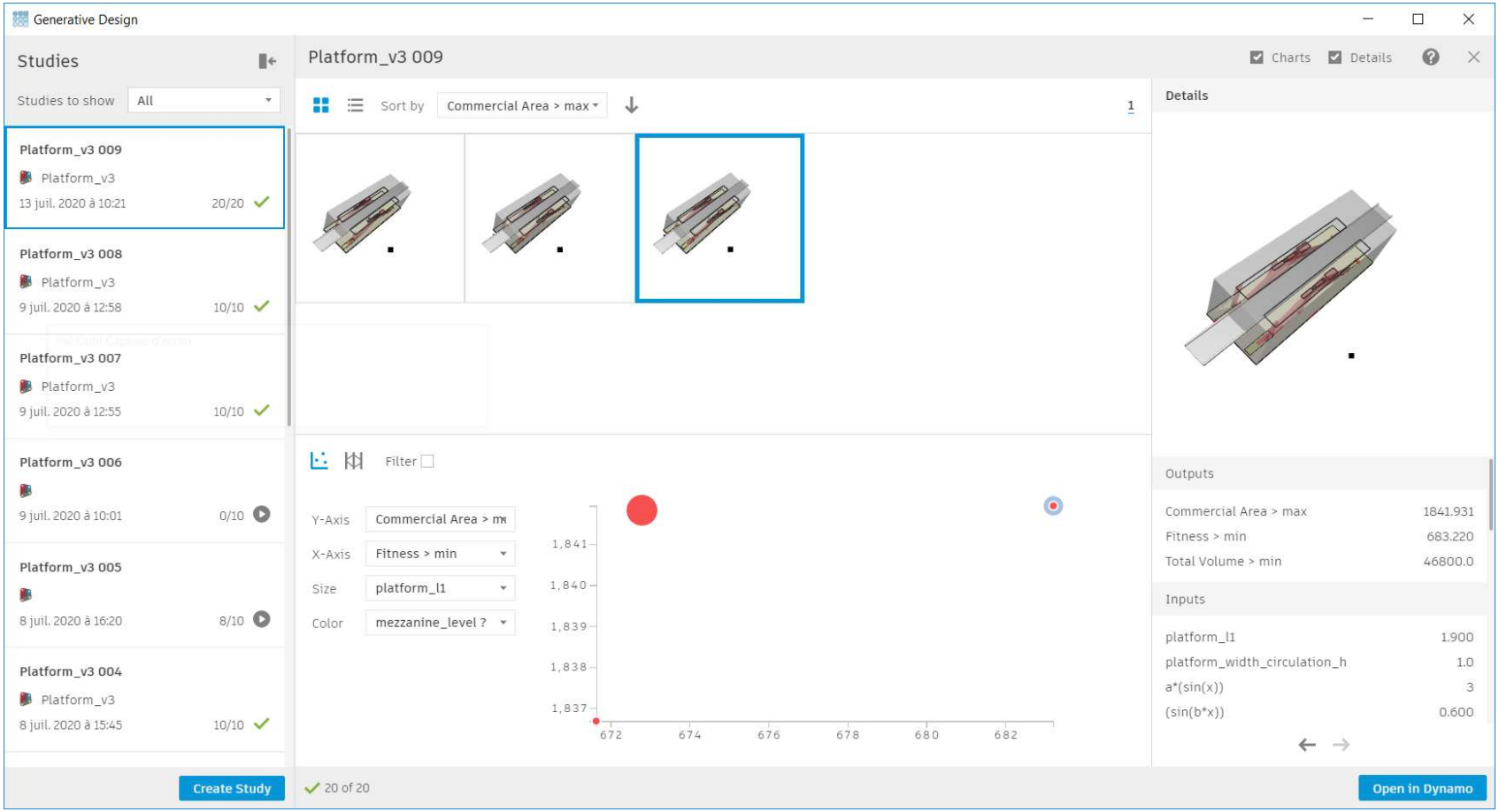


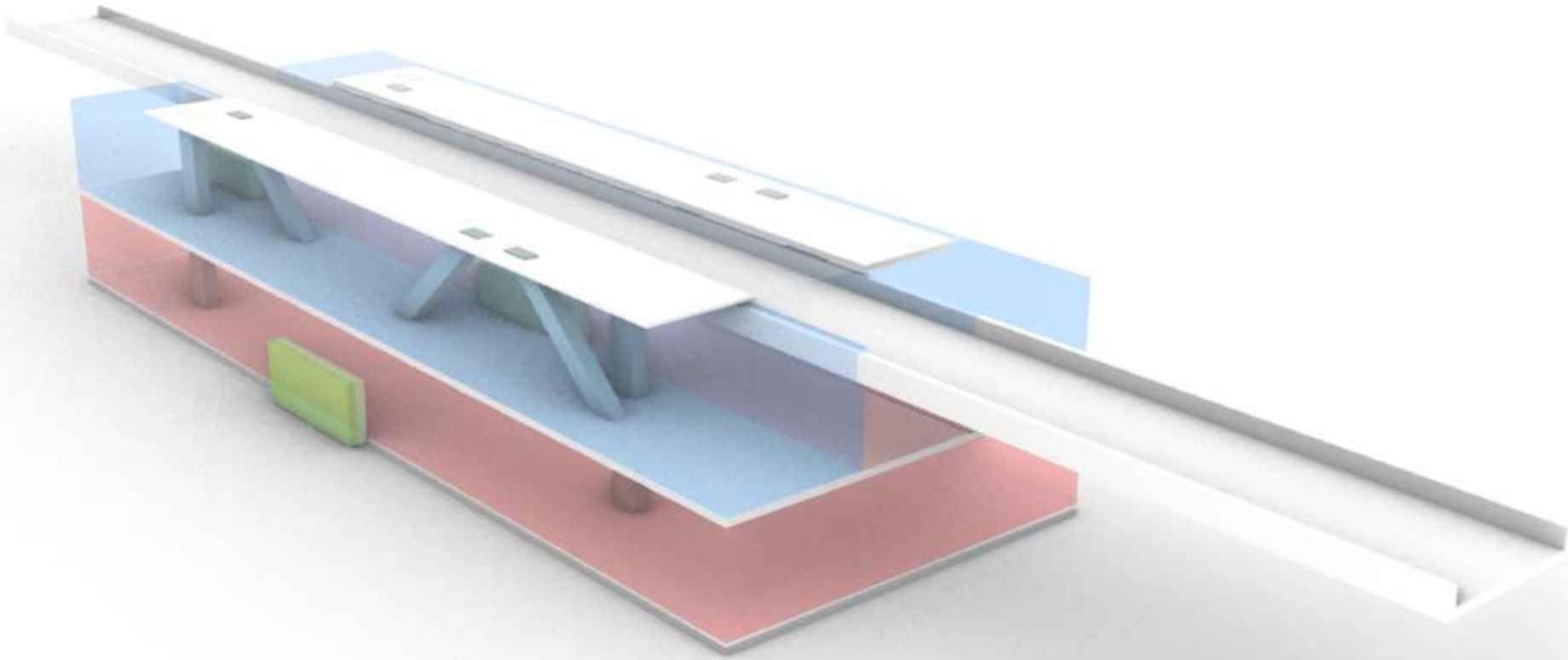
COST
VOLUME OF
STATION

RESULTS–EVALUATION

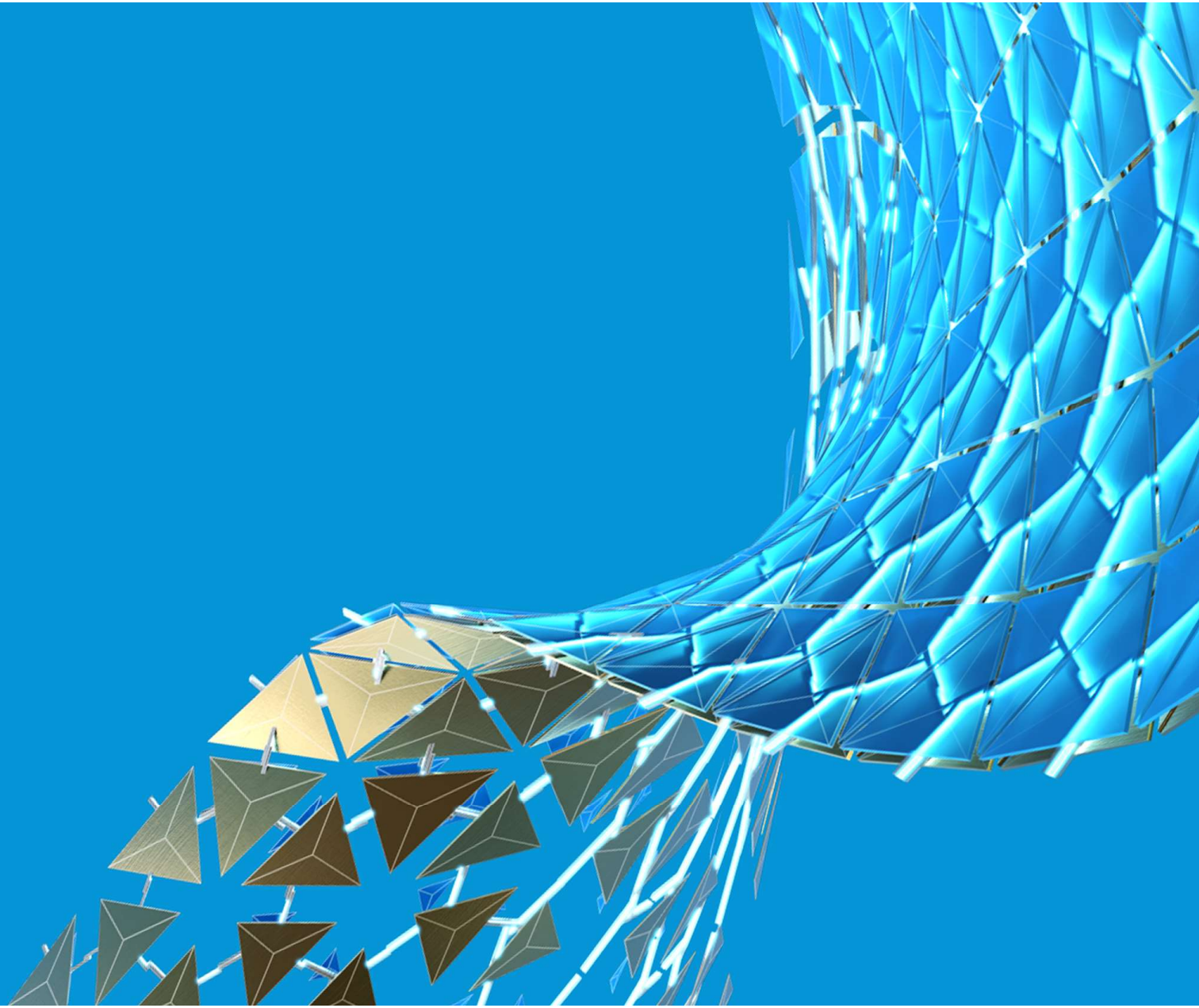


RESULTS—EVALUATION





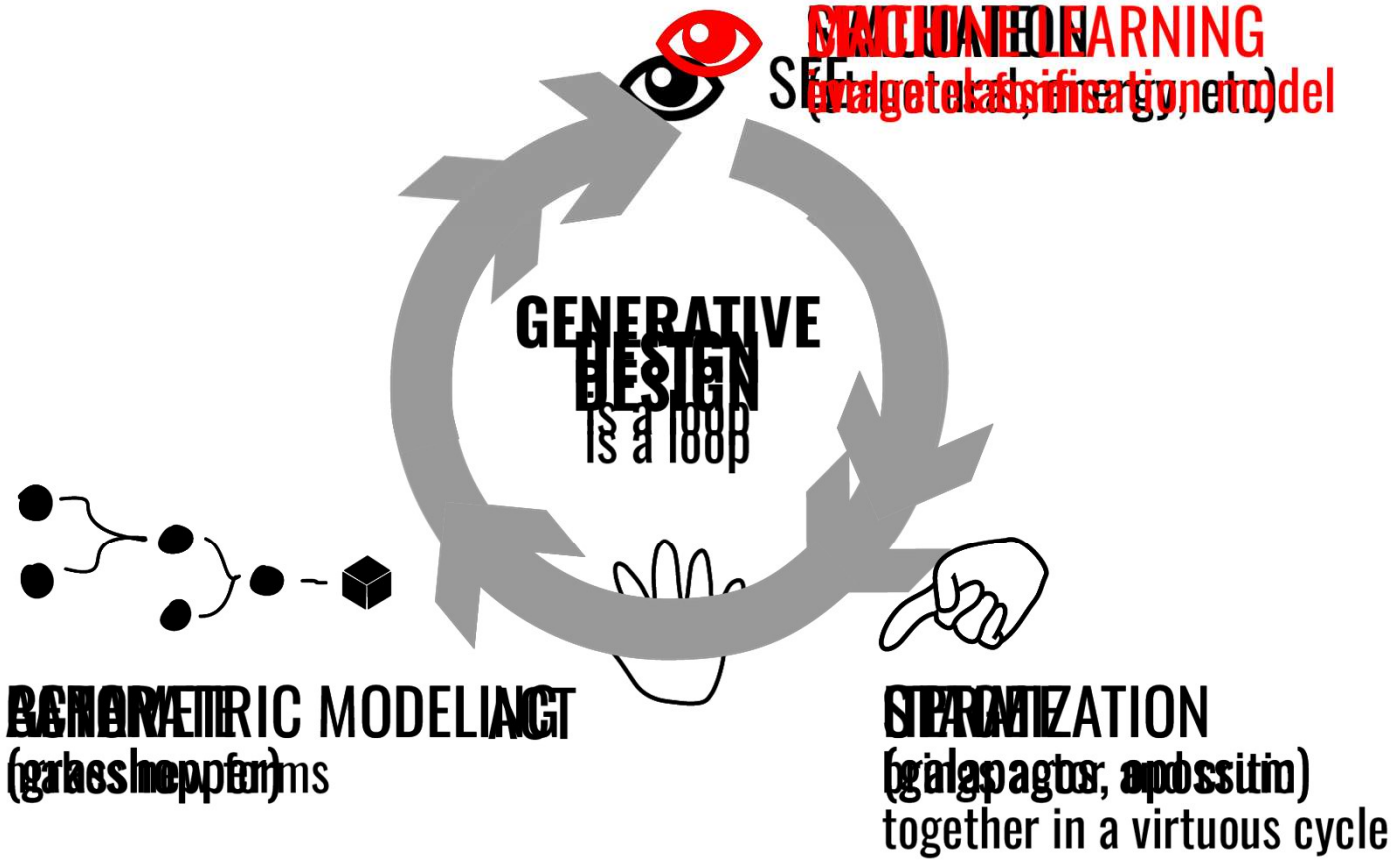
Conclusions



GOOD PRACTICES

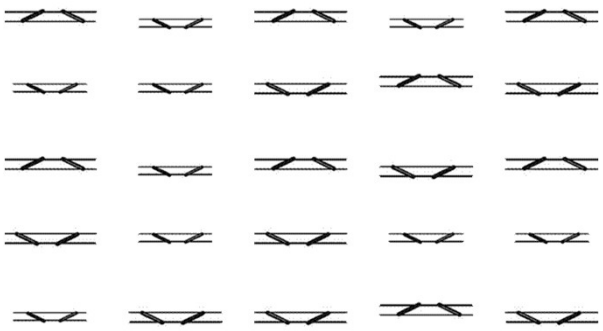
TEAM : PARTICIPATION OF AUTODESK EXPERT
TEAM : PARTICIPATION OF ARCHITECTS
EARLY SCOPE LIMITATION
OBJECTIVES AND LIMITS
REUSE OF EXISTING LIBRARIES AND METHODS
….

NEXT STEPS

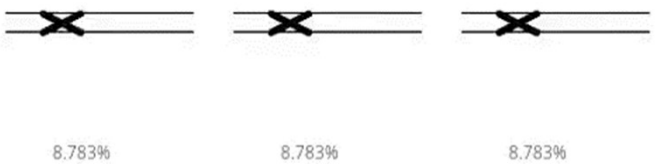


Source: Kyle Stenfield http://fresheyes.ksteinfe.com/background.html

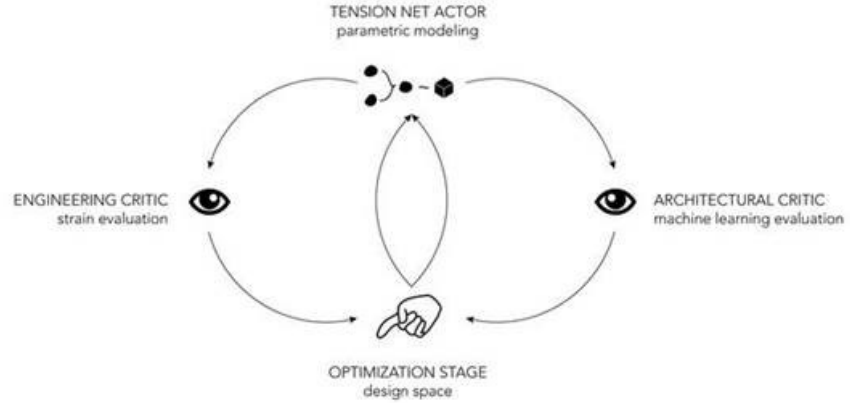
R&D



Learning dataset



Generative design optimization result



Source: Kyle Stenfield http://fresheyes.ksteinfe.com/background.html

NEXT STEPS

INTEGRATION OF CRITERIA
OPTIMISE PERFORMANCE VIA TESTING
MORE PARAMETERS TO BECOME VARIABLES
….