Proof of Concept : Generative Design for Metro Station

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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 developing new tools and new services for our client around BIM.
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.
What is SYSTRA?

- **6,200** employees around the world
- **€ 600m** Revenue in 2017
- **80** countries
- **60%** turnover achieved internationally
- **Top 5** position ENR Mass Transit and Rail
- **60 years’** experience in Transportation
SYSTRA has been involved in 1 in 2 metro projects worldwide.

60% of automated metros worldwide involve SYSTRA.

Singapore – Circle MRT line

Crossrail – London, UK

1st metro line in Bogota, Columbia
SYSTRA has played a key role in more than 50% of the world’s high speed rail lines.

South Europe Atlantic, France

Ostlanken - Stockholm to Malmö, Sweden

HS2 – London to Manchester, UK
MMMP MECCA (elevated metro line)

**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)

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

**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)

HS2 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

SYSTRA Role

2026 Expected Opening
88km Length
250 BIM Collaborators
500 BIM Models

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
**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
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.
ENTRANTS

DEGRES DE LIBERTE

DEMANDES

PROGRAMME

AMENAGEMENT

MOUVEMENTS PASSAGERS

SOLUTION CIRCULATION

NORMES ARCHITECTURALES

ARCHITECTURALES

SOLUTION STRUCTURELLE

MACRO OBJECTIFS

> EXPERIENCES UTILISATEURS

> ECO – CONCEPTION

> CONFORT

> COUT

> DEMANDES PROGRAMME

> MOUVEMENTS PASSAGERS

> NORMES ARCHITECTURALES

> AMENAGEMENT

> SOLUTION CIRCULATION

> SOLUTION STRUCTURELLE

RISQUES:

> DIFFICULTE AVEC TRADUCTION DES CHOIX ARCHITECTURAUX

OUTILS EN RELATION:

> LEGION

> REVIT

> FORGE

RISQUE TECHNOLOGIQUE:

HAVE SEEN

ADAPT

UNKNOWN

OPPORTUNITES:

> INTRODUCTION DES SIMULATIONS FLUX PASSAGERS DANS LA PHASE AMONT

> LIEN AVEC LE PROJET

OPTIMISATION

CONCEPTION

FONCTIONNELLE STATION

ANALYSE FLUX PASSAGERS

PROGRAMME STATION

SURFACE COMMERCIAL

TRACE EMPLACEMENT

POSITION DU METRE

CATALOGUE OUVRAGES

SIMULATION

FLUX PASSAGERS

EN PLAN

PROFIL EN LONG

CATALOGUE

POSITION+

EMPRISE STATION METRO

PROGRAMME STATION

SIMULATION EVACUATION PARVIS STATION

FLUX PASSAGERS OPTIMISATION CONCEPTION FONCTIONNELLE STATION OPTIMISATIONS

A01
**ECHELLE TERRITOIRE**

**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:**

**CONTRAINTES**
- ZONES EXCLUES
- POSITION DES EQUIPEMENTS
- TOPOGRAPHIE
- TRACE

**OBJECTIFS**
- PROPOSER PLUSIEURS SOLUTIONS
- MINIMALISATION DES EQUIPEMENTS
- MAXIMISATION DE LA COUVERTURE
Team + Benchmark

- Workshops of Station Design
- Benchmark of Solutions
- Sprints for GD Methods
- Execution
PoC Execution
Design Assumptions

- Elevated
  - access within the station's footprint
    - elevated concourse
    - concourse at grade
  - ... other elements...
- Underground
  - lateral accesses
  - ... other elements...
Design Assumptions
Design Assumption

**INPUT DATA**
- Unit width
- RunOff length
- Platform_minimal_width
- Minimal_level_height
- ...  

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

**VARIABLES**
- Width and length of platform
- Positions and direction of vertical circulation
- Configuration of zones
- Paid/Unpaid
- ...
Criterias for the Proof of Concept
Design Procedure

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—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
Learning dataset

Generative design optimization result

NEXT STEPS

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