

CONSULTIUS ENGINEERING
Shaping the future

Parc des Princes Expansion



Overview of Concept

Our vision goes much further than simply a stadium project, with the proposal involving a development of the surrounding area in tandem with the primary objective of the expansion. We have respected the present structure where possible due to the special place the Parc holds in the hearts of the Parisian people, as well as the wider footballing world. Furthermore, to honour the late architect of the existing stadium, Roger Taillibert (21 January 1926 – 3 October 2019), all design considerations have been made to complement the current aesthetics and improve fundamental features desired in a stadium: acoustics; spectator experience; and notoriety.

To provide an overview of the design, the below points highlight the main areas we have decided to focus on:

- Demolition and reconstruction of the south stand, including the roof
- Excavation and reinstatement of the pitch at a lower level
- Extension of lower tiers of all stands
- Construction of new "razors" to replicate those demolished

The new south stand and the extension of the lower tiers will provide increased capacities of 6,500 and 5,500-6,500 respectively, meeting our target of 12,000.

Design Highlights

The design really hits the objectives outlined by QSI and will be warmly welcomed by the PSG community and the French authorities. The main highlights of the design are listed below:

- The new south stand will be a single tier "wall of noise", following inspiration of Borussia Dortmund's infamous **Yellow Wall** (Figure 1) and Tottenham Hotspur's new monstrous south stand (Figure 2). The Parc needs this selling point to house their raucous fans, and we intend to unofficially, but affectionately, name the new intimidating stand "**Le Mur**", literally translating to "the Wall" in French. To intensify the deafening atmosphere, the soffit of **Le Mur** will be formed of acoustic panels to amplify the noise throughout the inner bowl. The stand is parabolic, with the gradient increasing in sections to provide unobstructed and excellent views of the pitch from the front row all the way to the dizzying back
- The extended lower tiers are to place the fans as close to the pitch as possible, again complementing the already imposing atmosphere. Even smaller grounds, such as Fratton Park, Portsmouth, UK, have demonstrated how effective this is at producing impressive decibel levels
- The demolished iconic "razors" encompassing the façade will be reborn, using sustainable materials to form lightweight structural steel trusses and clad in GRC panels, these will mimic the existing "razors" to ensure flow between new and old, respecting the heritage of the stadium and Roger Taillibert

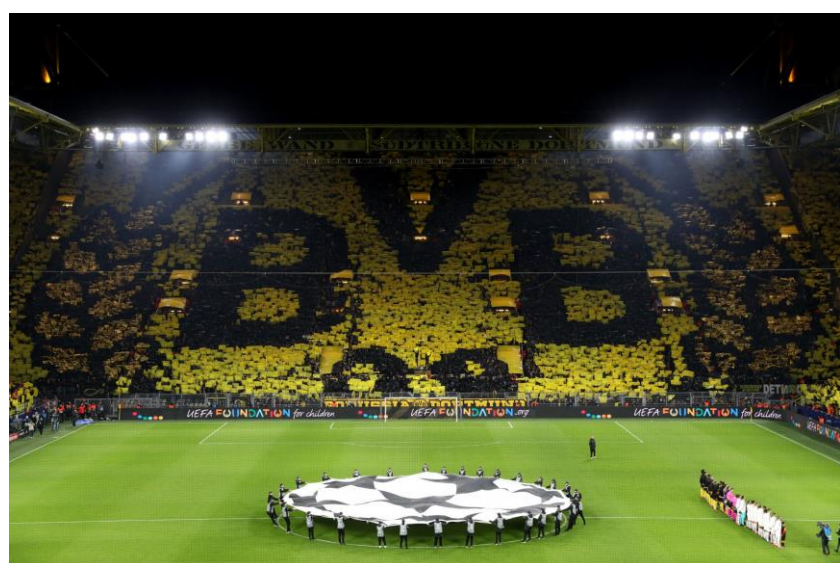


Figure 1. Borussia Dortmund "Yellow Wall"



Figure 2. Tottenham Stadium, South Stand

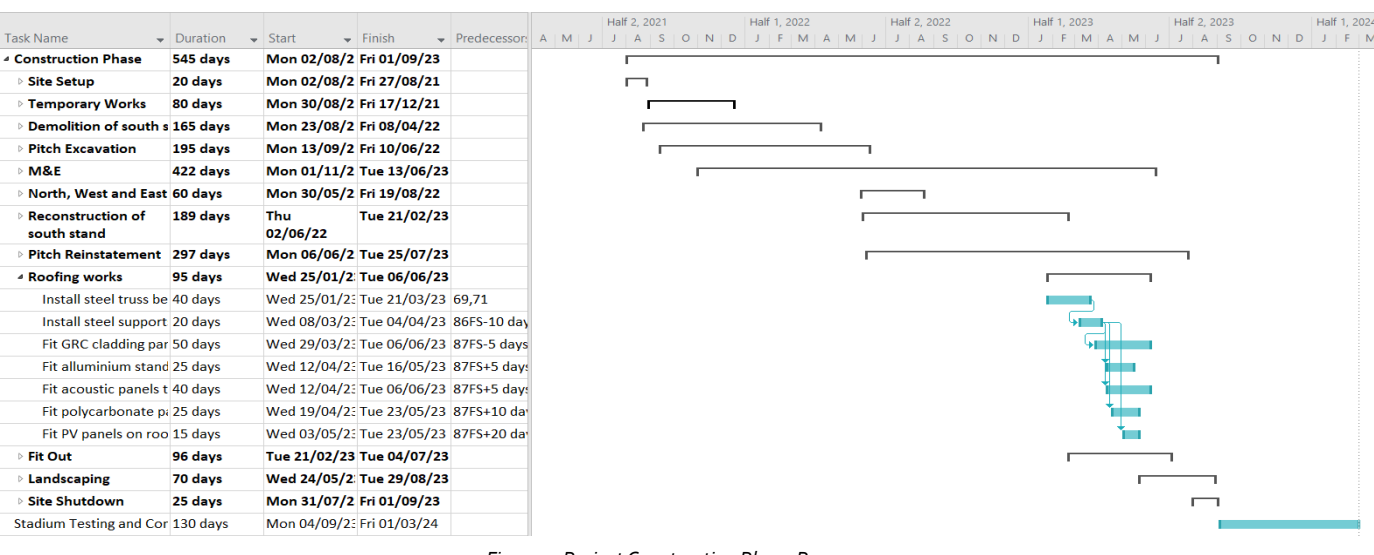


Figure 3. Project Construction Phase Programme

alongside a critical path linking these tasks together in a coherent manner, an accurate timeline of this stage of the project is shown. Any anticipated stadium requires a recommended testing and commissioning period of 6 months, and the scheme will be completed by March 2024 – including the recommended testing period.

It is the intention to proceed with as much precast construction as possible, not only resulting for an easier installation method and reduce the project duration, but also to produce higher quality elements and complement the sustainable considerations in the construction phase.

Cost

Delivering the project within budget is another critical aspect, resulting in a comprehensive cost analysis undertaken by the team. There are numerous uncertainties involved in construction projects, hence, several assumptions have been made in the cost analysis:

- 5% contingency is included in all costs
- Material costs take account of the transportation costs of the materials
- A yearly inflation rate of 2% is considered in the final cost

Stage	Stage cost (£m)	Material cost (£m)	Labour cost (£m)	Machinery cost (£m)
Setup	1.20	1.86	1.37	0.03
Temporary works	10.41	1.35	8.33	0.73
Excavation	9.75	0.41	5.35	0.35
M&E	1.78	0.08	0.77	0.04
M&E stand construction	2.27	2.11	0.38	0.08
Stand construction	17.77	15.10	2.48	0.18
Pitch reinstatement	2.20	2.49	0.36	0.07
Roofing work	20.00	18.39	2.09	0.40
Pitch test	2.00	1.29	1.35	0.07
Landscaping	6.92	4.36	2.49	0.07
Site restoration	2.00	0.30	1.25	0.05
Total cost	87.2	55.3	29.9	2.2

Table 1. Cost Breakdown by Construction Stage

Table 1 shows the cost breakdown for each construction stage, while Figure 4 shows the percentage breakdown. Most of the budget is spent between October 2022 and May 2023, where most of the South stand and roofing construction works are to take place.

While QSI possess vast financial resources, it is important to provide a proposal which is attractive with regards to economic considerations. The costings have been reduced by Consultus through the structuring of the programme to maximise simultaneous working, reducing the duration as well as the hiring costs of necessary plant and machinery to complete the works. Furthermore, due to the temporary relocation of the team during construction, a quicker programme results in a smaller fee to pay for an alternative venue to play home matches at. To decrease material costs, these will be locally sourced to reduce transportation costs and demolished concrete will be reused for the new precast concrete while soil removed during the pitch excavation will be utilised in backfilling and for the wider development adjacent to the stadium.

Sustainability

Sustainability is, arguably, the most important consideration through the design, construction, and operation stages. The goal is to produce a sustainable, energy efficient, and innovative design which can be recycled when it comes to the end of its life or if further expansion is required.

The United Nations Sustainable Development Goals (SDGs) consist of 17 goals. Focusing on these goals, the construction industry can contribute towards sustainability by coordinating its actions and efforts with the UN's SDGs. The goals most relevant to this project include goals 6, 7, 9, 11, 12, and 13, shown in Figure 5 which showcases and summarises our ideas and solutions to help achieve these goals.

The project will utilise, not only building information modelling (BIM) but push the limits even further by creating a digital twin of the stadium to analyse the live operation of the Parc, which can be used to track the matchday data to identify where to increase efficiency and provide a more sustainable and spectator friendly experience.

Furthermore, the stadium will incentivise sustainable transport options by offering discounted matchday tickets and provide clean energy to the surrounding neighbourhood through the implementation of a PV farm on the roof of the Parc, assisting the main grid.

Introduction

Home of the footballing giants, Paris Saint-Germain (PSG), is the iconic and revered Parc des Princes Stadium. The ambitious owners, Qatar Sports Investments (QSI), have challenged Consultus Engineering to design a viable expansion option, increasing the capacity by 12,000 to total 60,000 and help catapult PSG to the peak of European club football.

QSI have requested particular focus on the below considerations:

- Compliance with international best practice stadium requirements
- Expansion expected to involve adaption of existing roof structure but consider alternatives
- Main drivers:
 - Cost
 - Sustainability
 - Programme
- Consideration of transport connections
- Consideration of constructability
- Provide advice on security measures

As part of the preliminary attentions, we identified the critical stakeholders concerned with the project: QSI; the PSG community; French authorities.

Renders of Proposed Design

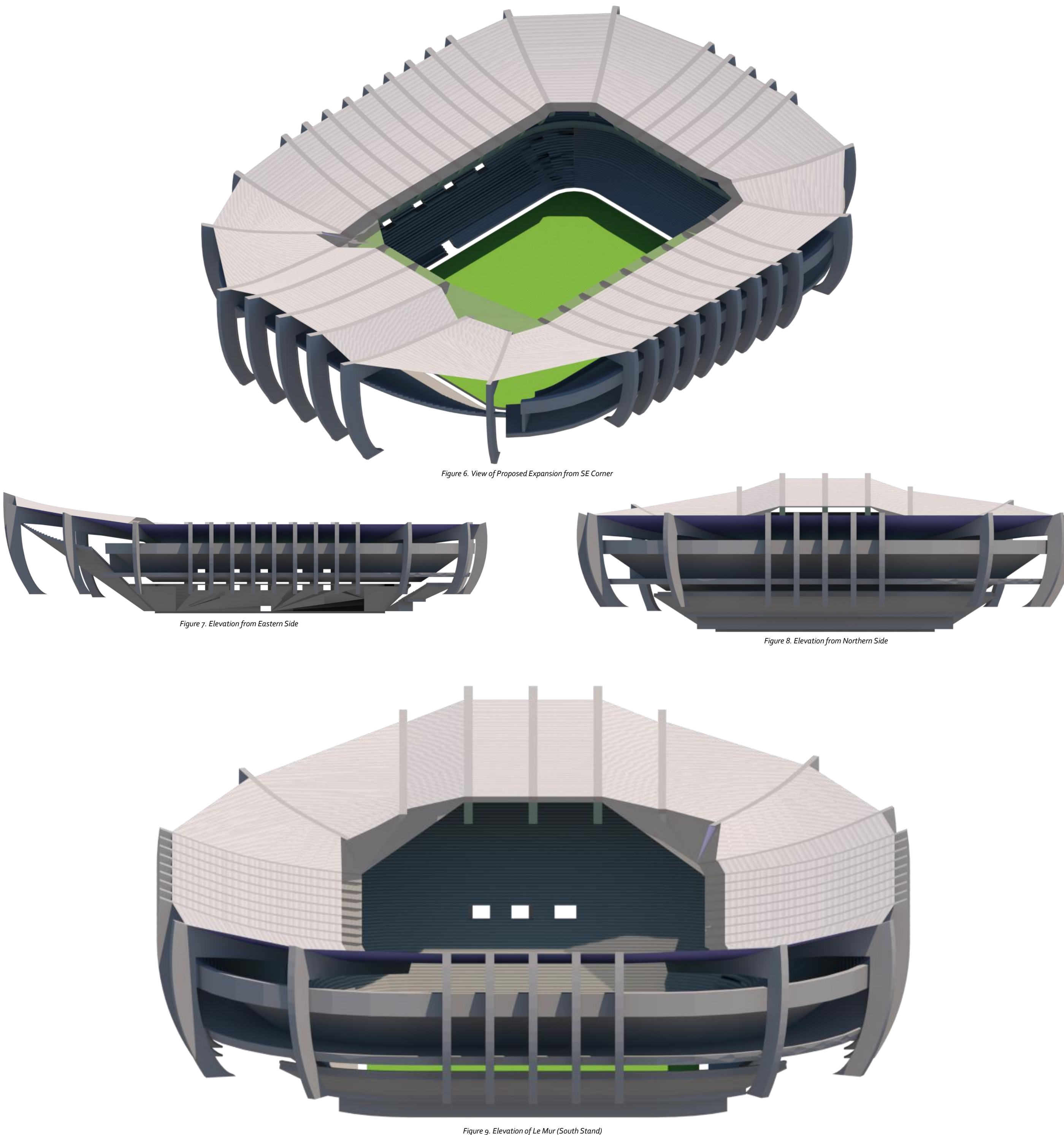


Figure 6. View of Proposed Expansion from SE Corner

Figure 7. Elevation from Eastern Side

Figure 8. Elevation from Northern Side

Figure 9. Elevation of Le Mur (South Stand)

CAD Drawings of Proposed Design

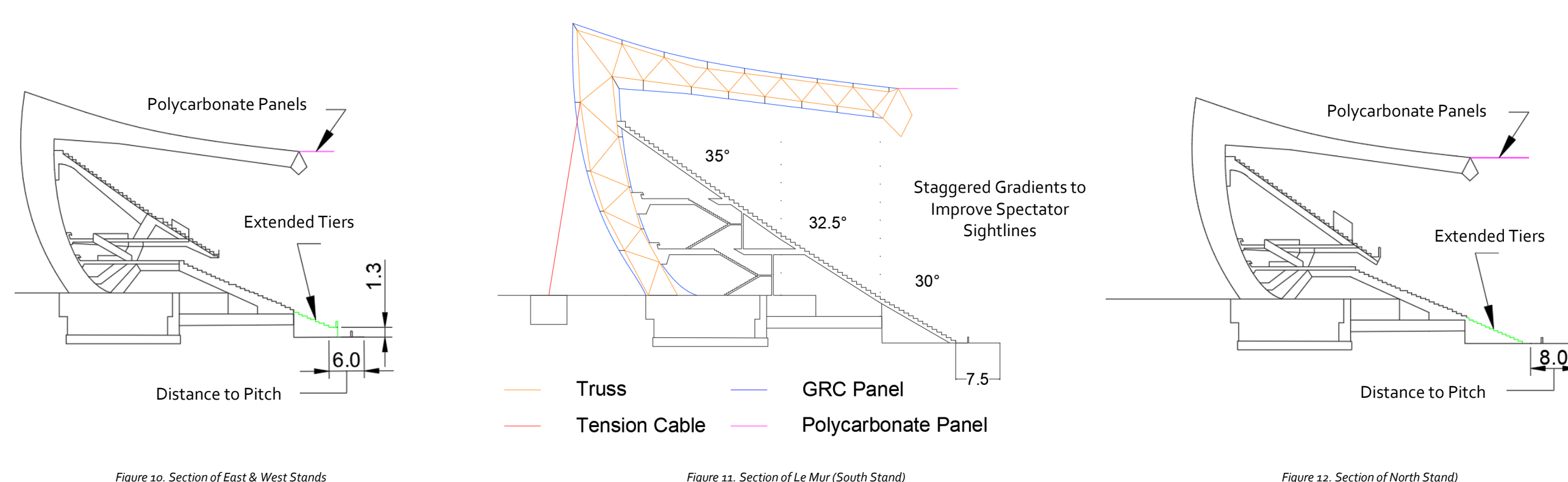


Figure 10. Section of East & West Stands

Figure 11. Section of Le Mur (South Stand)

Figure 12. Section of North Stand

Construction Sequence

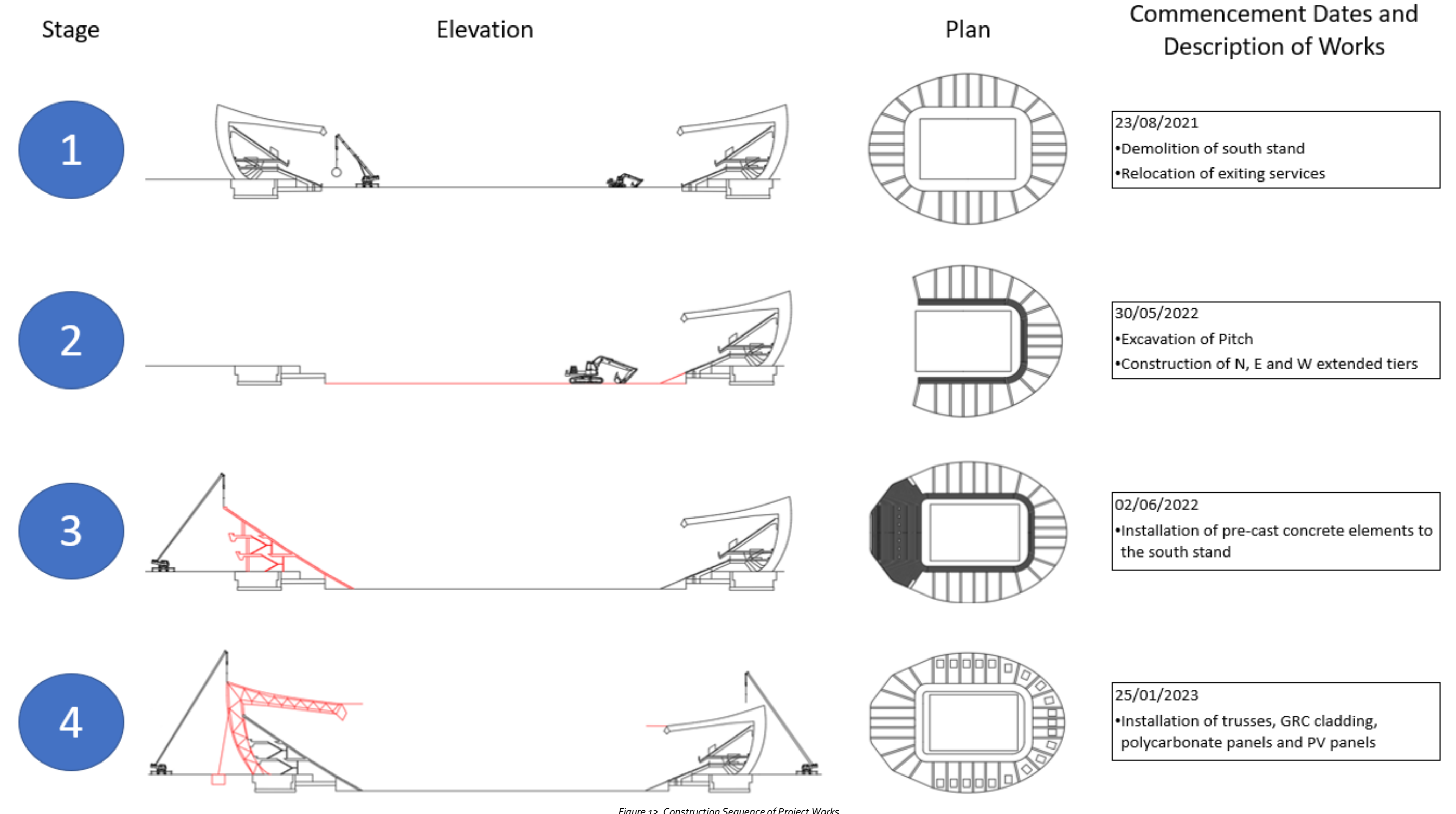


Figure 13. Construction Sequence of Project Works

Materials

The main considerations with material choices are centred on the properties, the sustainability, and the aesthetics. For this project sustainability is a core focus resulting in sustainable material choices such as recycled concrete and steel for the structural elements, with these being fabricated off-site to guarantee higher quality and reduce the carbon footprint of the stadium. Furthermore, to ensure consistency with the new and old features of the stadium, the steel trusses will be clad in GRC panels to replicate the existing razors. The new south stand will have acoustic panels installed in the soffit to build on the impressive atmosphere with the outer layer of the roof being formed of aluminium standing seam panels. The inner perimeter of the roof will comprise of polycarbonate panels, providing shelter for the extended tiers below and also allowing light to enter the inner bowl. As previously mentioned there will be a farm of PV panels on the N, E and W roofs to take advantage of the sloping roofs and harness renewable power.

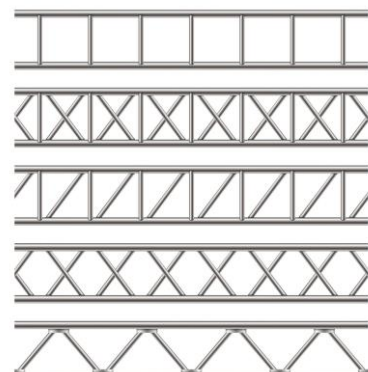


Figure 14. Steel Trusses



Figure 15. Precast Concrete Panels



Figure 16. Aluminium Standing Seam Panels



Figure 17. GRC Panels

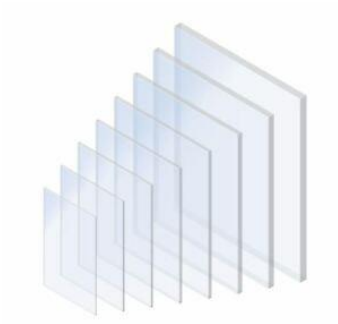


Figure 18. Polycarbonate Panels

Constructability

While the design stages are expected to be conceptual and more creative the final design must be physically viable. A huge amount of thought must go into logistics, construction planning, and feasibility studies to ensure due diligence has been carried out to produce a solution which will work on site as it does so on drawings.

Due to the tight site footprint, site logistics will be very difficult to manage. Successful negotiation with the Paris authorities permitted site offices and storage to be set up in an area to the West of the stadium (Figure 19) on condition of the park being redeveloped during the project. This enabled a much easier flow of plant, machinery, and materials throughout site. This tight footprint also meant that tower cranes were considered an issue, fortunately, mobile cranes possess sufficient strength to lift the heaviest of the designed elements and can also be removed from site when not required as well as flexible enough to move throughout the site compound as desired.



Figure 20. Removal of South Stand for Access to Inner Bowl

During construction, the south stand is to be completely demolished, providing very easy access into the inner bowl (Figure 20) with a temporary ramp formed of the excavated soil to allow entry into the excavation. The plant and material options have been selected thanks to their simplicity. The prefabricated structural elements can be transported directly into the inner bowl on articulated lorry's and then lifted off by excavators or the mobile cranes directly into place. Mobile Elevating Work Platforms (MEWPs) will be used for the M&E works with cherry pickers enabling operatives to install the acoustic, polycarbonate, and GRC panels.



Figure 19. Site Plan

Security

Due to the high terror threat and to cope with the increased flow of fans in the stadium, significant updates in security systems are to be implemented in this expansion scheme. This aims to provide a safer environment for the visitors and fans. The enhancement on the security system involves upgrades in existing measures as well as introducing new technologies to the stadium which include:

- Restructuring the seating plan, mainly focused on segregation of rival supporters.
- Additional security staff to be employed to monitor and provide support.
- Upgrade existing CCTV cameras to 4K IP, panoramic security cameras and more CCTV's are to be installed. The new CCTV's enable deliveries of sharp and clear images for more effective surveillance.
- Introduce 'Airport-like' security check, such as X-ray baggage check and archway metal detector. This allows quicker and more fluent security check processes for visitors which reduces their waiting time and enhances their experiences.
- Introduce a new AI system for more efficient police collaborations. The system can identify the nearest police officer and inform him/her automatically whenever an incident occurs in the stadium or in the surrounding areas. This allows immediate responses from the police authority depending on the situation.
- Simulations can be run through the digital twin to optimize evacuation strategies.



Figure 21. AI Security



Figure 22. 4K Panoramic CCTV

Transportation

The impact of this expansion project on the capacity of existing metro lines was analysed, especially during game days where the stadium is assumed to reach full capacity.

Coupled with our initial strategy to deploy shuttle services from the Gare du Nord, our pedestrian avenue will entertain fans between their journeys to and from the stadium. We project this will smoothen out congestion spikes during key times. During operation, our digital twin will allow us to visualise data harnessed that describes where people tend to distribute themselves in and around the stadium. This will allow for well-informed decisions on how to address any issues with queues and human traffic.



Figure 23. Paris Metro Train

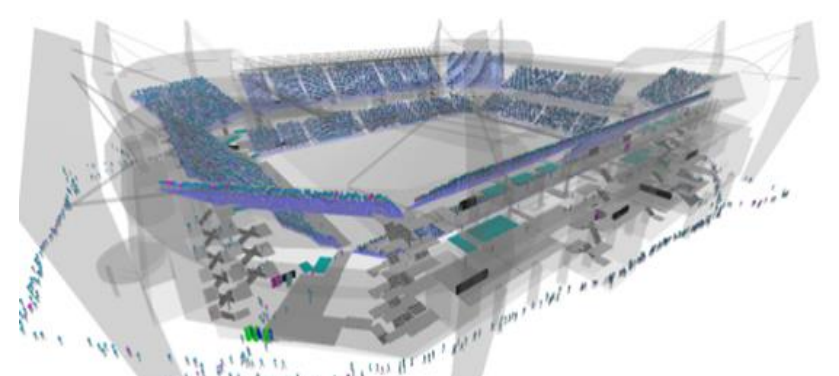


Figure 24. Digital Twin Analysis to Reduce Transport Congestion

Digitalizing the Parc des Princes

- At Consultus Engineering, we want to take QSI's vision of developing a world-class stadium
- As part of the operation and maintenance scheme, digital tools will be employed to optimize solutions and display to the world that the Parc des Princes is at the forefront of innovation



Figure 25. A Digital Parc des Princes

- By creating a digital twin of the stadium, QSI can boast owning the first of its kind in Europe while setting a significant milestone for PSG and France
- Unparalleled levels of analytical insight and asset management
- Big data management optimizes our solutions and allows us to evaluate them against our sustainable goals or safety standards
- Opens the door for deep learning, making it possible to ask questions of the model

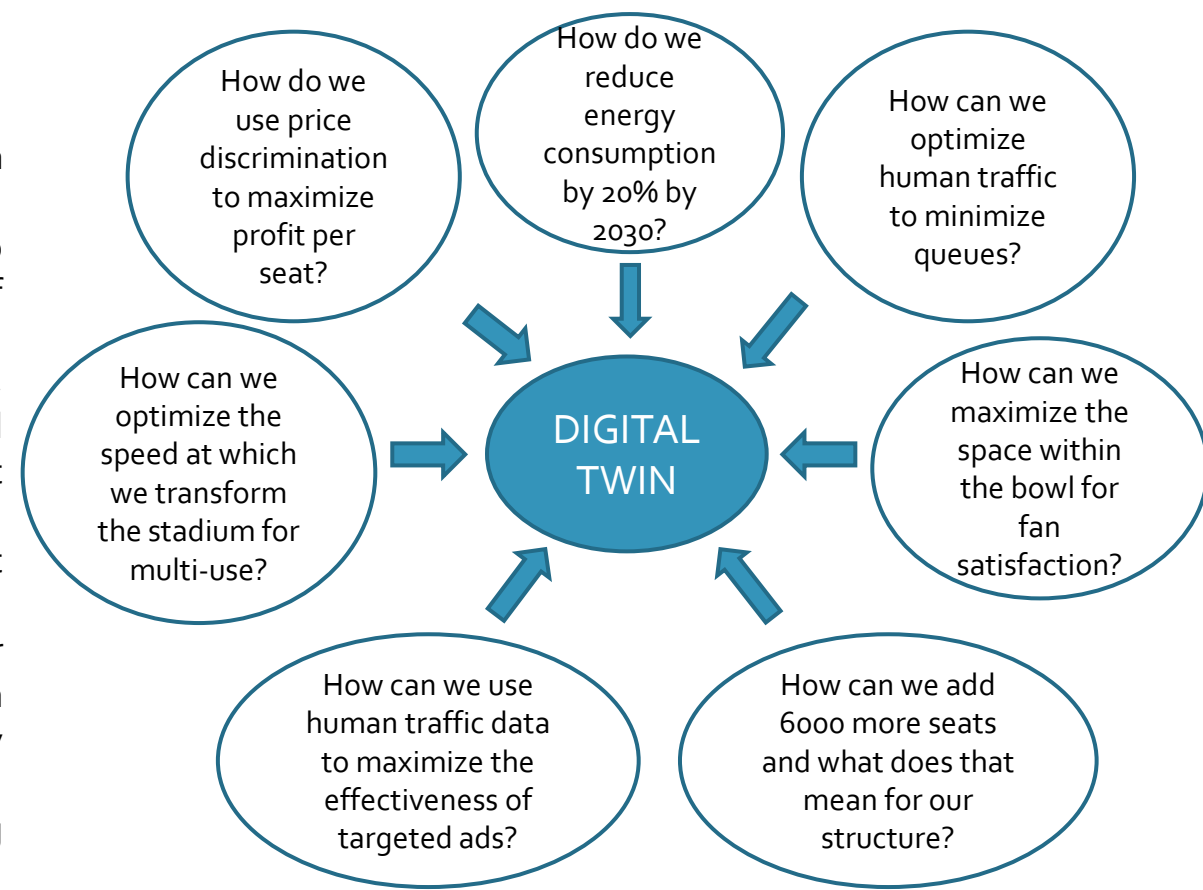


Figure 26. An Intelligent Model for the Parc des Princes

Over the Périphérique - More Than Just a Stadium



Figure 27. Over the Périphérique - Wide Development

This development aims to leave something valuable behind. Built using recycled concrete from our demolition, this pedestrian avenue will feature green buildings for residents and fans, sustainable urban drainage systems and its very own recycling scheme.

- New public open space for the local community to enjoy
- 120m long swale running along the western edge to drain impermeable surfaces
- Fans emerging from underground transportation will get immersed into the match day atmosphere straight away
- Restaurants, cafes and bars to be built predominantly from Timber to align with French government's green energy goals
- Recycling scheme to reward €0.20 for bottles and cans with trademark logo returned to any of the development's facilities



Figure 28. Over the Périphérique - Concourse Area



Figure 29. Trademark Symbol for Exchangeable Recycling



Figure 30. Example of Wide Development Hospitality