



ICEC 2014 - IX World Congress

## Re-Engineering Total Cost Management

Milan (Italy) - 20, 21 and 22 October 2014



# The management challenges of building a **World Cup stadium in the Amazon**

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# Authors

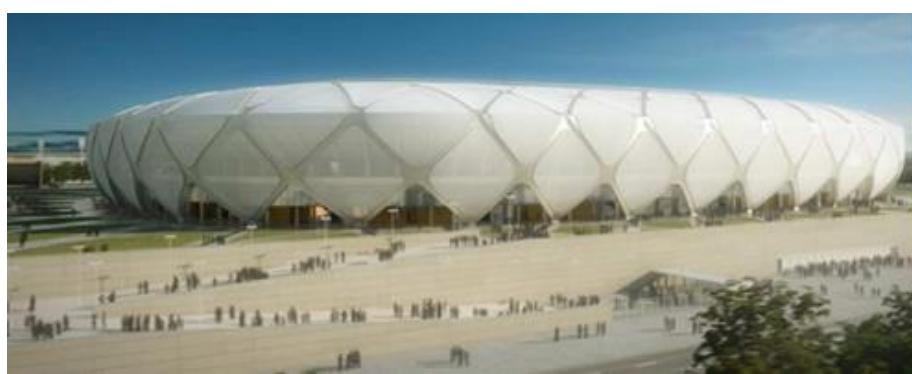


# FIFA 2014 World Cup



Source: Fifa

# Amazon Arena



Owner

• State of Amazonas

General contractor

• Andrade Gutierrez

Architect

• GMP Architekten (Germany)

Contract value

• 500M BRL (= 280M USD)

Duration

• 36 months

# Manaus



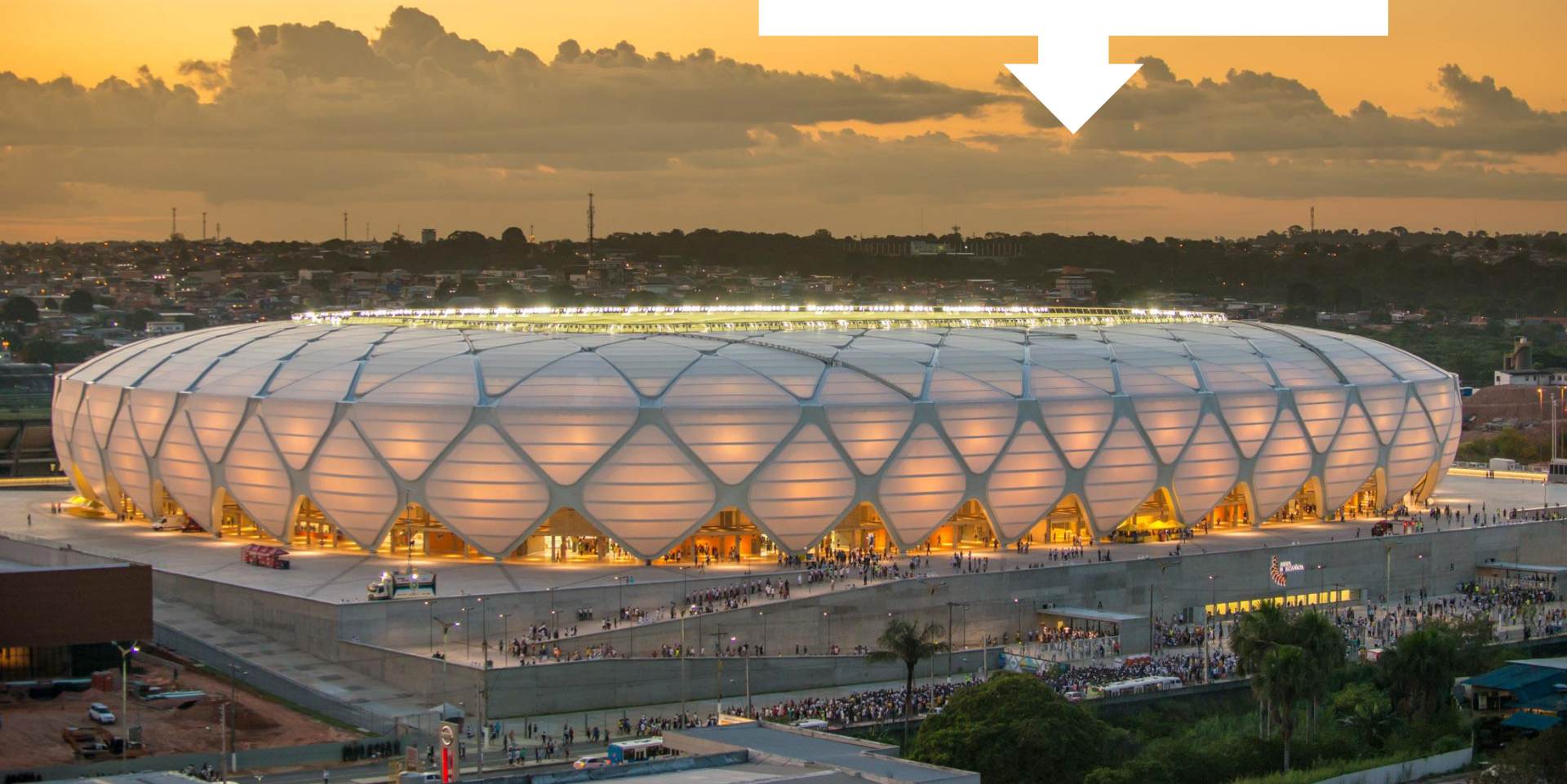
- In Amazon Rainforest
- Distance to São Paulo = 3,000 km (1,800 mi)
- Accessible only by **boat** or **airplane**
- Temperature: 20°–37° C

Manaus Turismo

# Amazon Arena



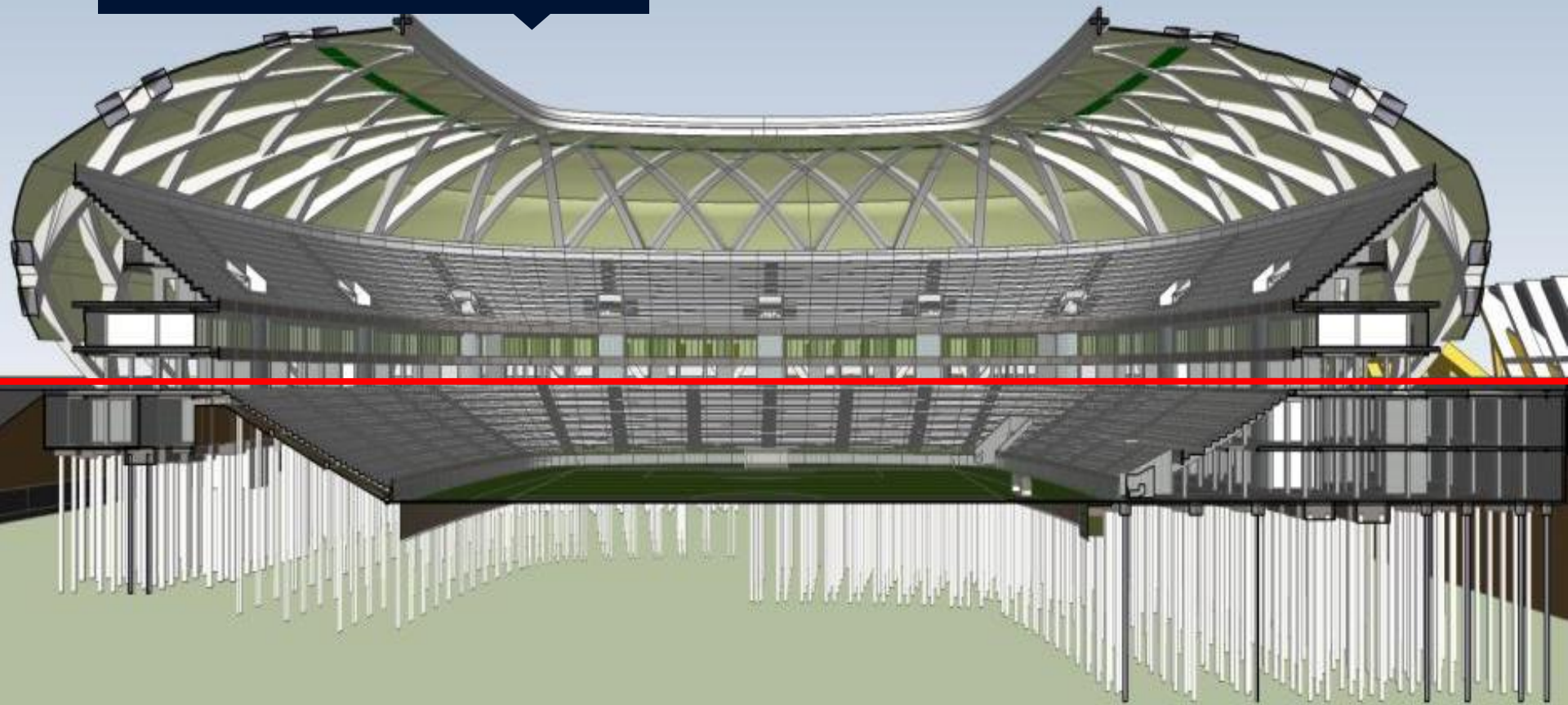
Area = 83,500 m<sup>2</sup>



Capacity = **43,300** seats



# Amazon Arena



## Floors

East: 4

West: 5

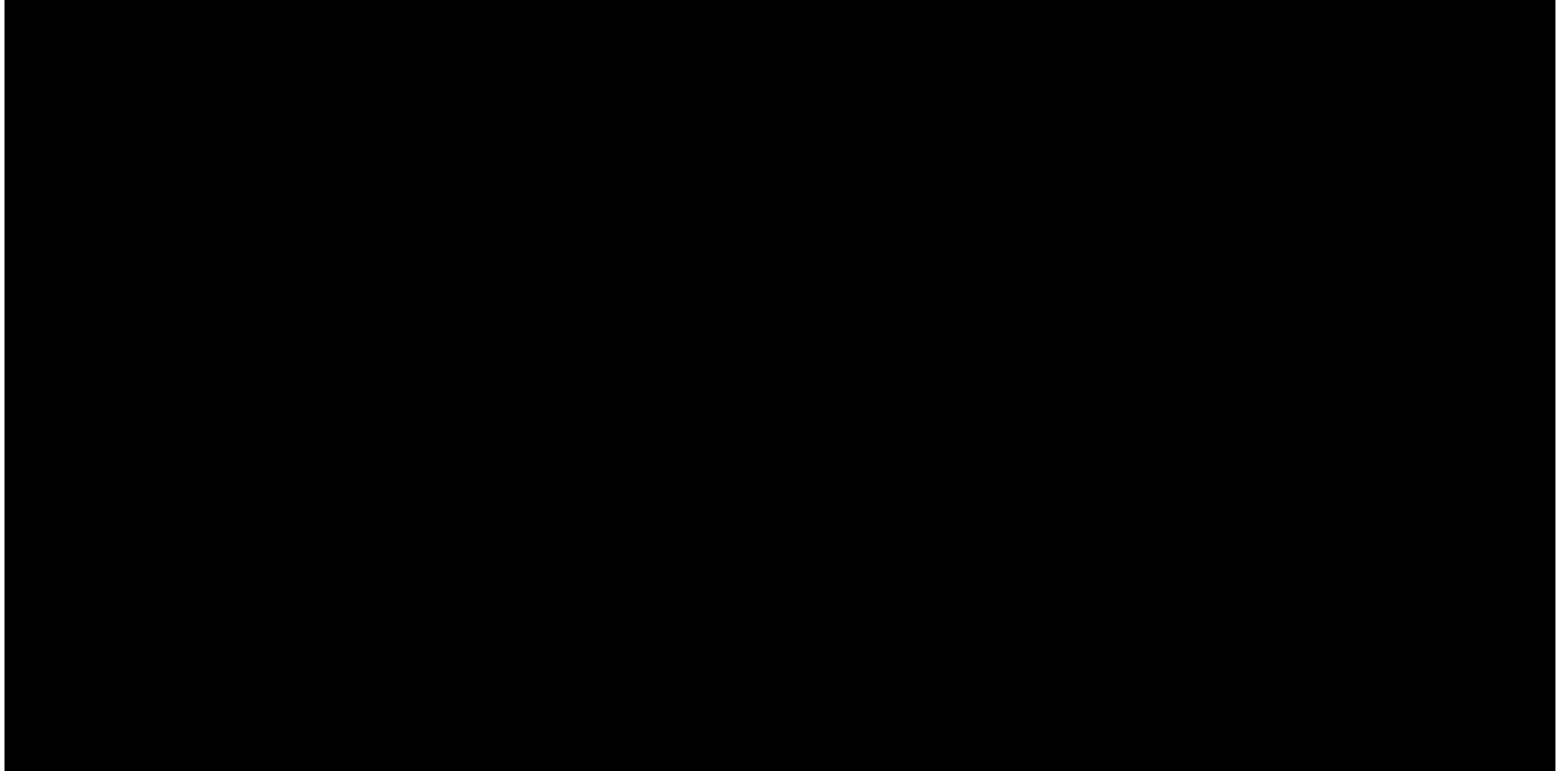
## Elevation

Roof: + 31,75m street level

Field: -11,00 m street level

# Amazon Arena

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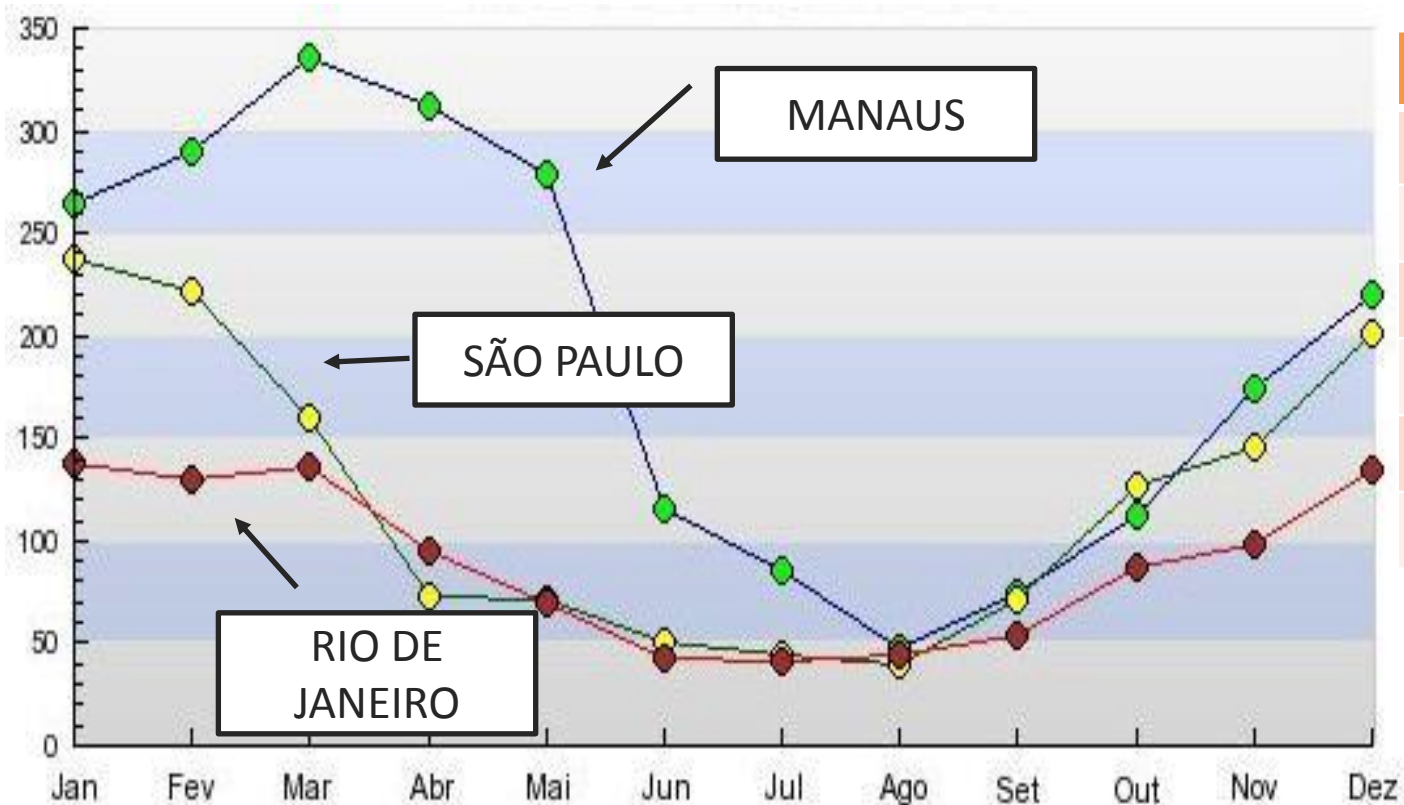


# Challenge no. 1

## Climate



# Manaus – rainfall (mm)



City	mm/year
Manaus	2300
NY	1270
Milan	1000
Amsterdam	900
Paris	650
London	600

Climatempo

**Rainfall: 2300 mm/year**  
**Intense and short rainfall = loss of productivity**

# Design

- **Preliminary** design (2009) – FIFA **2007** specifications
- **Final** design (2011) – developed by the Contractor – FIFA **2010** specifications



[www.d24am.com](http://www.d24am.com)



[www. http://arquiteturaplus.blogspot.com.br](http://arquiteturaplus.blogspot.com.br)

## Challenge no. 2

### Scope changes



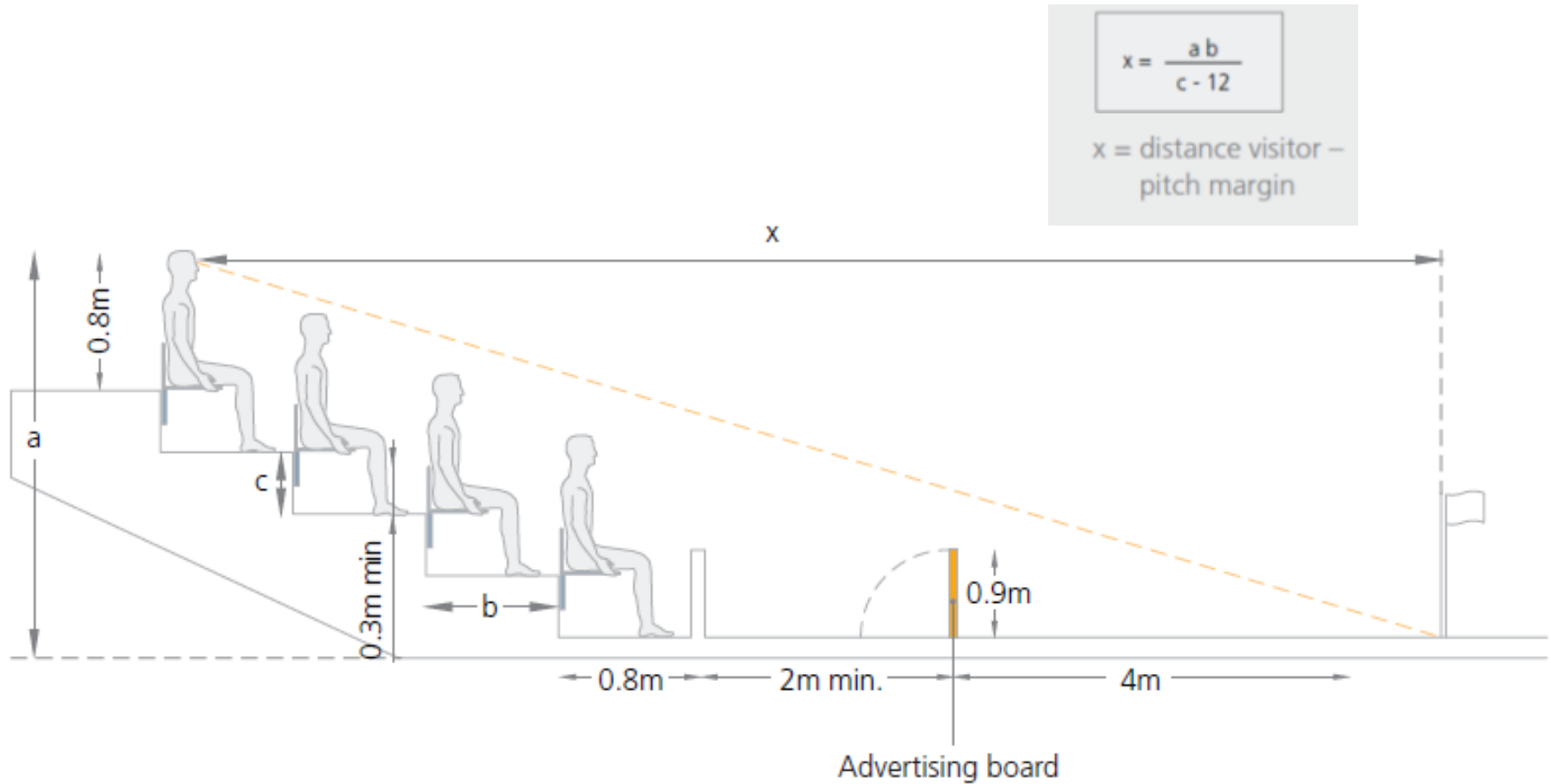
# Scope changes

## Host cities agreement:

*“(...) reserving to the Organizing Committee and FIFA the right to **MODIFY, DELETE or ADD** new requirements **AT ANY TIME** until the date of the competition”*

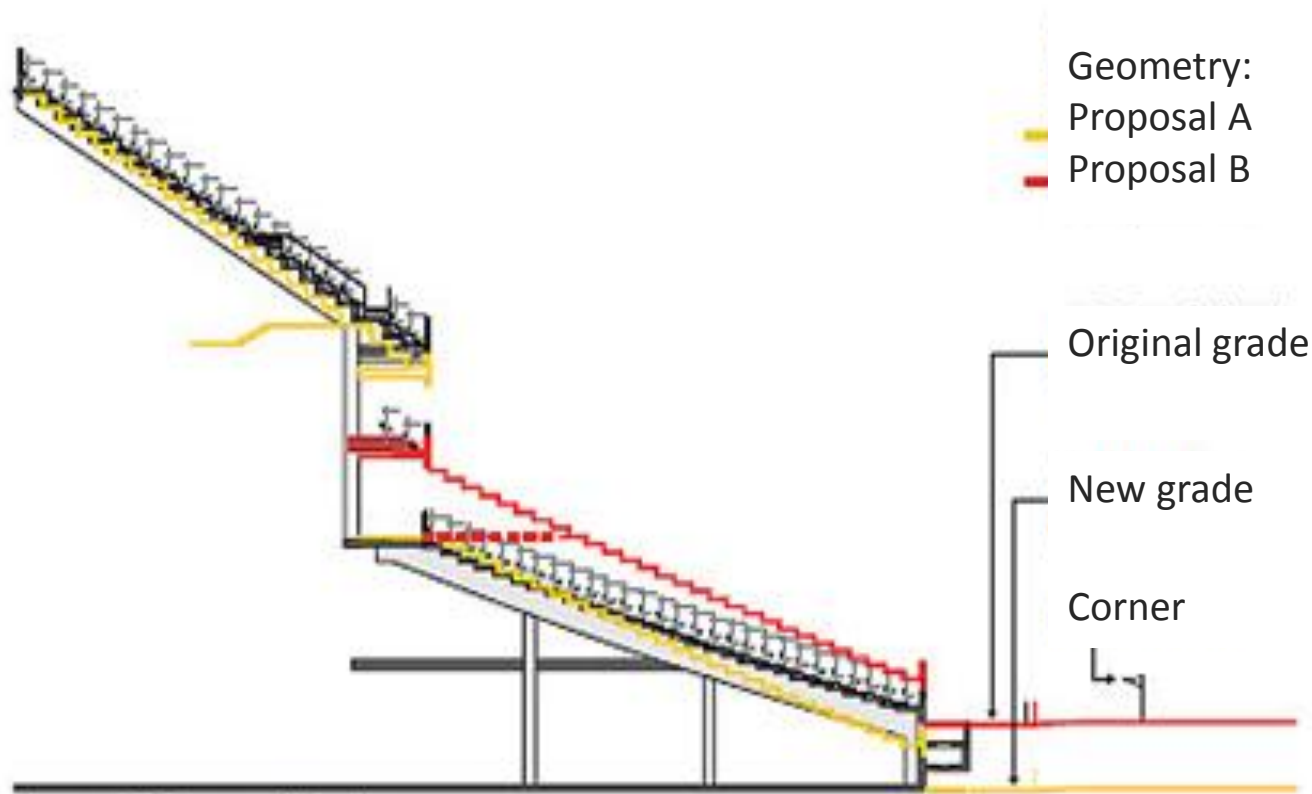


# Scope changes – line of visibility



Fifa Football Stadiums Technical Recommendations and Requirements

# Scope changes – line of visibility

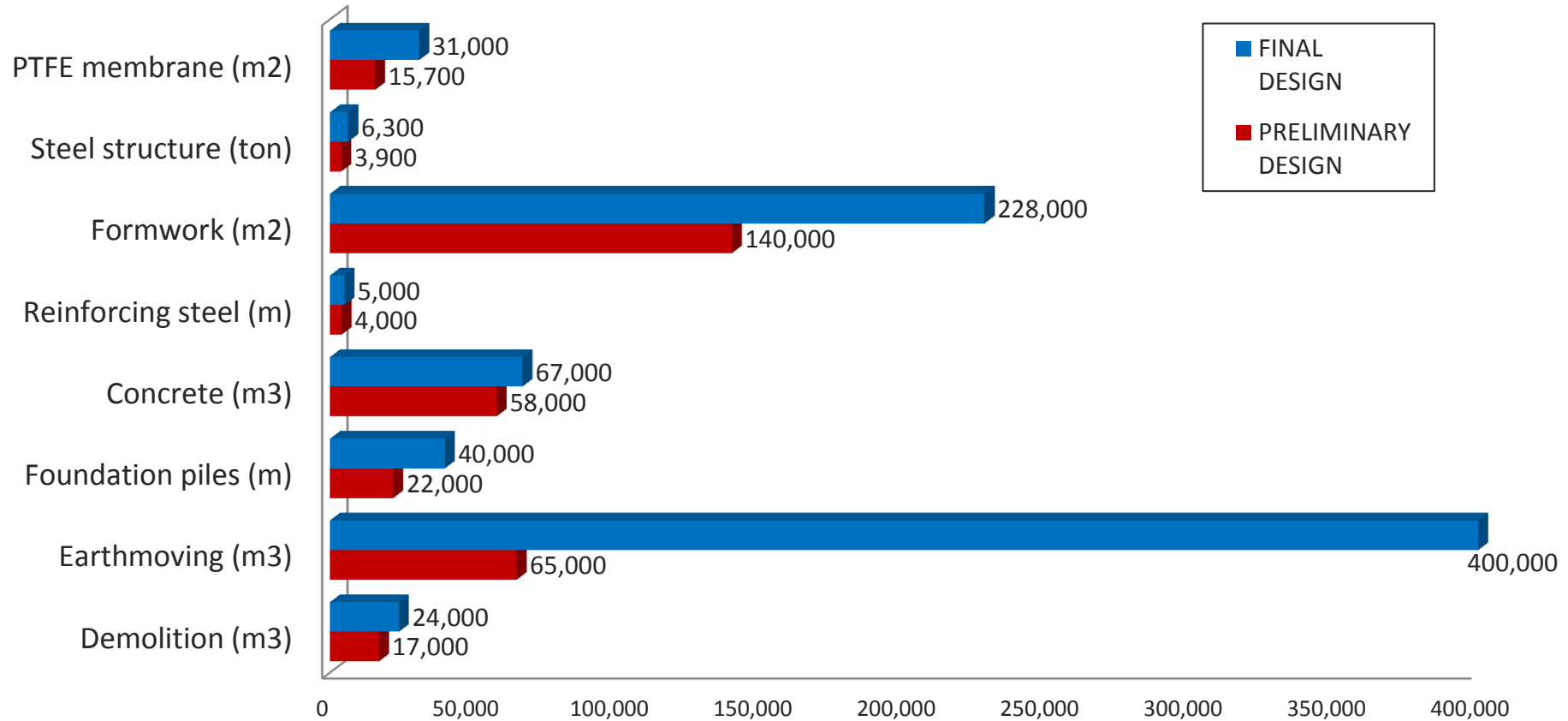


Modified geometry

Andrade Gutierrez

Lowering the lower stands and the field level for better visibility of public

# Quantities: preliminary x final design

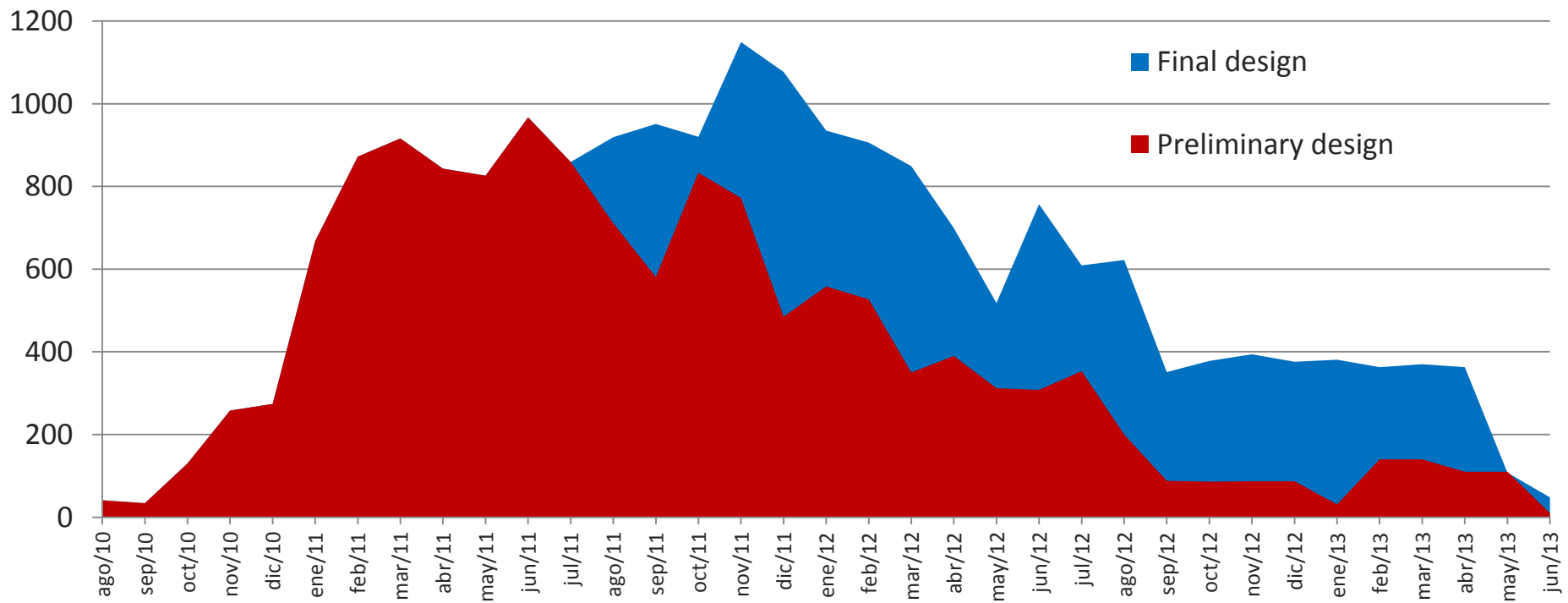


# Manpower

More work; same time



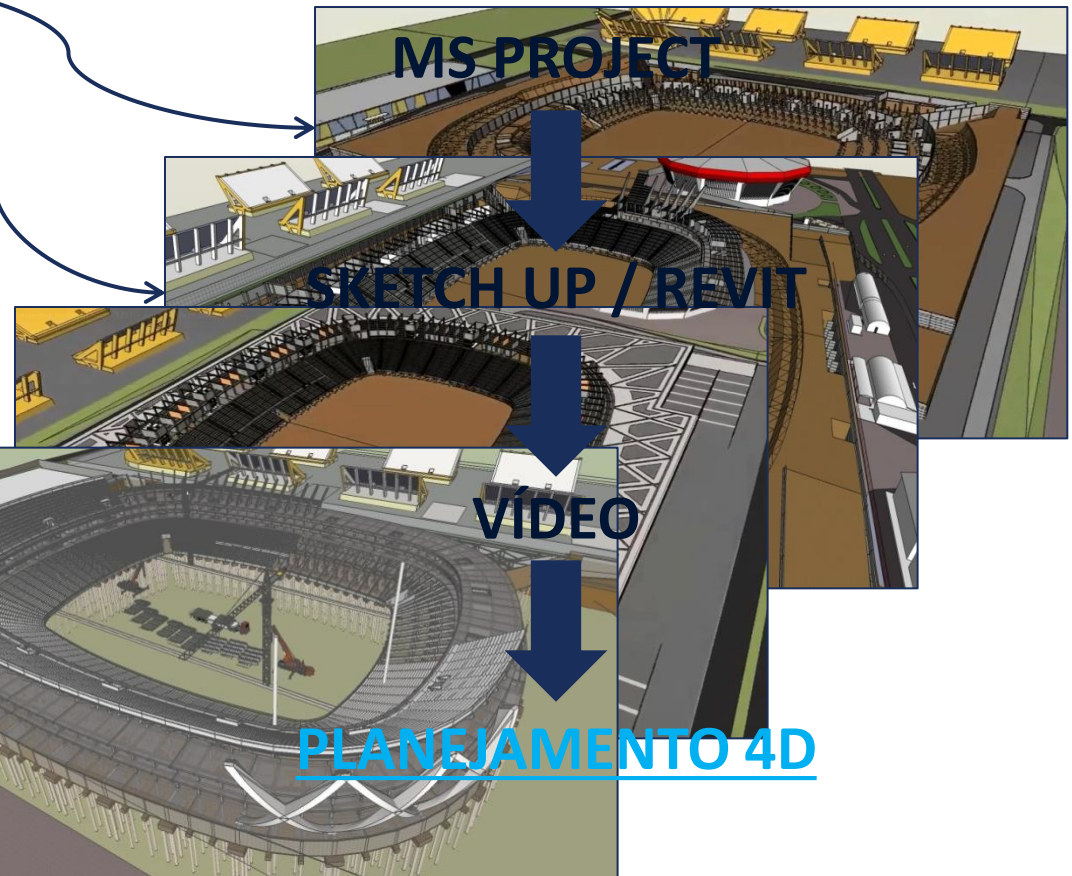
Labor (quantity)



# 4D Planning (BIM)

Microsoft Project (Trial) - Master\_web\_site\_project.mpp

Task Name	Duration	Start	Finish	Work	Resource Names	Cost	Predecessors
13.2.2 Training of Field Staff	10.00 days	Tue 10/20/06	Wed 11/15/06	0.5 mon	Cheung Man-Yuk(80)	\$0,000.00 80	
14.2.3 Training of Technical Staff	10.00 days	Tue 10/20/06	Wed 11/15/06	0.5 mon	Lalitha Dev(91)	\$0,000.00 91	
15.2.4 User's Manual	20.00 days	Tue 10/20/06	Thu 11/08/06	2 mon	Julia Jachnyczky(20)	\$0,000.00 20	
16.1 Requirements	30.00 days	Wed 4/23/06	Tue 6/5/06	3.00 mon		\$10,000.00	
17.1.1 Analyze	30.00 days	Wed 4/23/06	Tue 6/5/06	3.00 mon		\$10,000.00	
18.1.1.1 Analyze online reservations	12.00 days	Wed 4/23/06	Fri 4/28/06	1.25 mon	Mary Austin(Narah)	\$0,000.00 12	
19.1.1.2 Analyze query processes	12.00 days	Wed 4/23/06	Fri 4/28/06	1.25 mon	Lalitha Jackson(Mar)	\$0,000.00 12	
20.1.1.3 Analyze multimedia enhancements	12.00 days	Wed 4/23/06	Fri 4/28/06	1.25 mon	Lalitha Jackson(Mar)	\$0,000.00 12	
21.1.1.4 Draft preliminary requirements	5.00 days	Wed 5/7/06	Wed 5/24/06	0.5 mon	Mary Austin(Marcel)	\$0,000.00 11.75	
22.1.1.5 Review preliminary requirements	2.00 days	Wed 5/24/06	Fri 5/26/06	0.25 mon	Narah Prentiss(Jul)	\$0,000.00 21	
23.1.1.6 Incorporate feedback on requirements	2.00 days	Tue 5/23/06	Thu 5/25/06	0.25 mon	Manuel Alvarez(Bra)	\$0,000.00 22	
24.1.1.7 Acceptance Test Plan	10.00 days	Tue 5/23/06	Fri 5/26/06	1.00 mon	Mary Austin(Narah)	\$0,000.00 23	
25.1.1.1 Write acceptance test plans for c	5.00 days	Tue 5/23/06	Fri 5/26/06	0.5 mon	Manuel Alvarez(Bra)	\$0,000.00 24	
26.1.1.2 Write acceptance test plans for c	5.00 days	Tue 5/23/06	Fri 5/26/06	0.5 mon	Narah Prentiss(Jul)	\$0,000.00 24	
27.1.1.3 Write acceptance test plans for c	5.00 days	Tue 5/23/06	Fri 5/26/06	0.5 mon	Lalitha Jackson(Mar)	\$0,000.00 24	
28.1.1.4 Draft acceptance test plan	2.00 days	Tue 5/23/06	Fri 5/26/06	0.25 mon	Manuel Alvarez(Bra)	\$0,000.00 25.27	
29.1.1.5 Review acceptance test plan	2.00 days	Tue 5/23/06	Fri 5/26/06	0.25 mon	Lalitha Jackson(Mar)	\$0,000.00 25	
30.1.1.6 Incorporate feedback on acceptance	2.00 days	Tue 5/23/06	Fri 5/26/06	0.25 mon	Mary Austin(Narah)	\$0,000.00 30	
31.1.1.7 Requirements approved	1.00 days	Fri 5/26/06	Fri 5/26/06	1.00 mon		\$0,000.00 30	
32.1.1.8 Design	55.00 days	Fri 5/23/06	Tue 9/12/06	10 mon		\$10,000.00	
33.1.1.1 Top-level Design	27.00 days	Fri 5/23/06	Wed 6/21/06	3.75 mon		\$0,000.00	
34.1.1.2 Design online reservations	10.00 days	Fri 5/23/06	Mon 7/10/06	1 mon	Mary Austin(Marcel)	\$0,000.00 32	
35.1.1.3 Design query process	10.00 days	Fri 5/23/06	Mon 7/10/06	1 mon	Lalitha Jackson(Mar)	\$0,000.00 32	
36.1.1.4 Design multimedia enhancements	10.00 days	Mon 7/10/06	Mon 7/24/06	1 mon	Manuel Alvarez(Bra)	\$0,000.00 36	
37.1.1.5 Review design specifications	5.00 days	Mon 7/24/06	Mon 7/31/06	0.5 mon	Mary Austin(Narah)	\$0,000.00 35.36	
38.1.1.6 Incorporate feedback into design	2.00 days	Mon 7/31/06	Wed 8/2/06	0.25 mon	Lalitha Jackson(Marcel)	\$0,000.00 38	
39.1.1.7 Top-level design approved	0.00 days	Wed 8/2/06	Wed 8/2/06	0 mon		\$0,000.00 39	
40.1.1.8 Detailed Design	27.00 days	Wed 8/2/06	Tue 9/12/06	4.25 mon		\$0,000.00	
41.1.1.1 Draft design specifications	12.00 days	Wed 8/2/06	Mon 8/28/06	1.25 mon	Julia Jachnyczky(Mide)	\$0,000.00 40	
42.1.1.2 Detailed design of online res	17.00 days	Wed 8/2/06	Mon 8/28/06	1.75 mon	Julia Jachnyczky(Mide)	\$0,000.00 40	
43.1.1.3 Detailed design of query pro	17.00 days	Wed 8/2/06	Mon 8/28/06	1.75 mon	Chitra Iyer(Narah)	\$0,000.00 40	
44.1.1.4 Detailed design of multimedia	17.00 days	Wed 8/2/06	Mon 8/28/06	1.75 mon	Chitra Iyer(Narah)	\$0,000.00 40	
45.1.1.5 Review design specifications	5.00 days	Mon 8/28/06	Tue 9/5/06	0.5 mon	Mary Austin(Narah)	\$0,000.00 43.44	
46.1.1.6 Incorporate feedback on design	2.00 days	Tue 9/5/06	Thu 9/7/06	0.25 mon	Manuel Alvarez(Bra)	\$0,000.00 47	
47.1.1.7 Obtain approvals proceed	2.00 days	Thu 9/7/06	Tue 9/12/06	0.25 mon	Manuel Alvarez(Bra)	\$0,000.00 47	
48.1.1.8 Code and Unit Test	30.00 days	Tue 9/12/06	Tue 10/2/06	5 mon		\$0,000.00	
49.1.1.1 Assign development staff	2.70 days	Tue 9/12/06	Fri 9/15/06	0.25 mon	Cheung Man-Yuk(80)	\$0,000.00 48	
50.1.1.2 Develop code - Online reservat	10.00 days	Fri 9/15/06	Fri 9/29/06	1 mon	Chitra Iyer(Narah)	\$0,000.00 51	
51.1.1.3 Developer testing - Online reser	10.00 days	Fri 9/29/06	Fri 10/6/06	0.5 mon	Mary Austin(Narah)	\$0,000.00 51	
52.1.1.4 Develop code - Query process	10.00 days	Fri 9/29/06	Fri 10/6/06	1 mon	Marian Xiao	\$0,000.00 51	

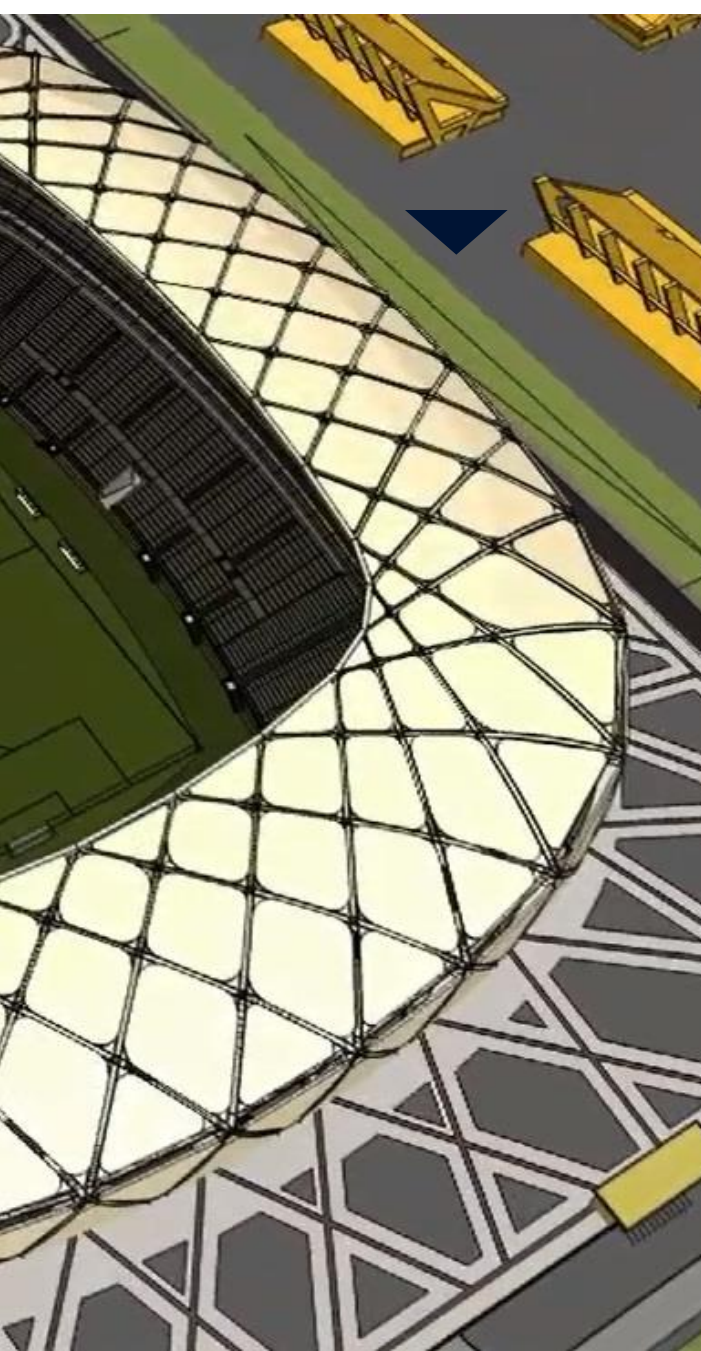


MS PROJECT

SKETCH UP / REVIT

VIDEO

PLANEJAMENTO 4D

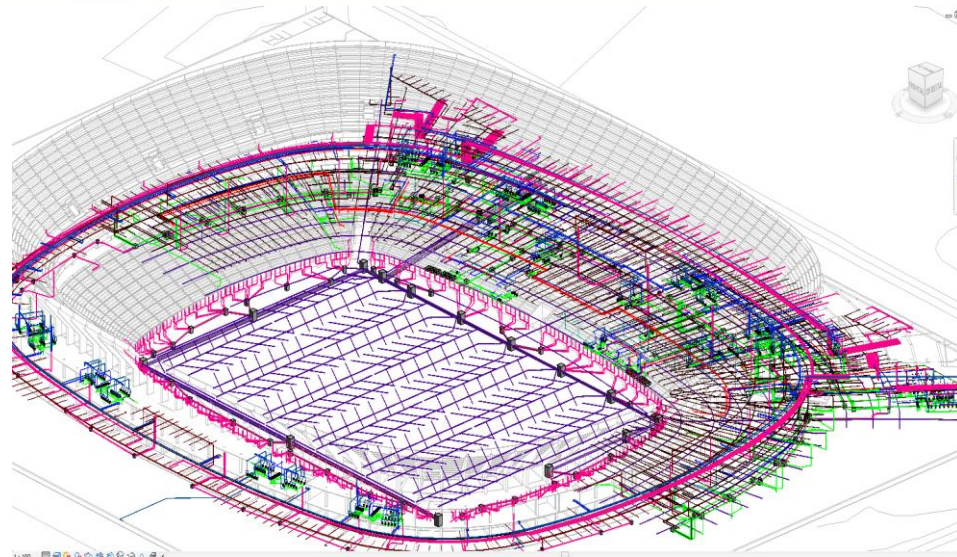


## 4D Planning (BIM)

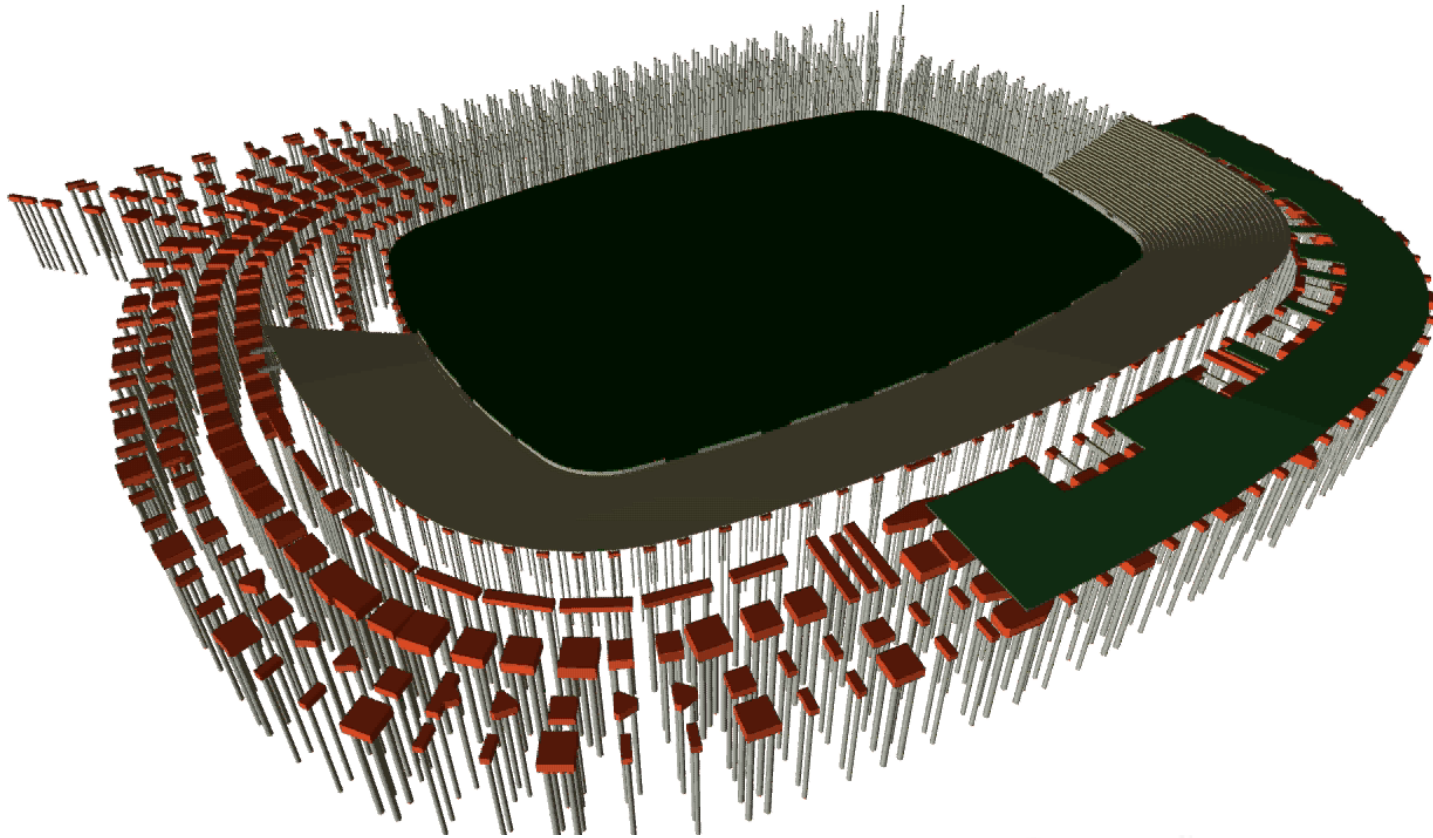
- ▶ Better definition of logistics
- ▶ Early identification of interference
- ▶ Verification of accessibility spaces
- ▶ Simulation scenarios
- ▶ Instruction of field teams

# 4D Building Information Modelling (BIM)

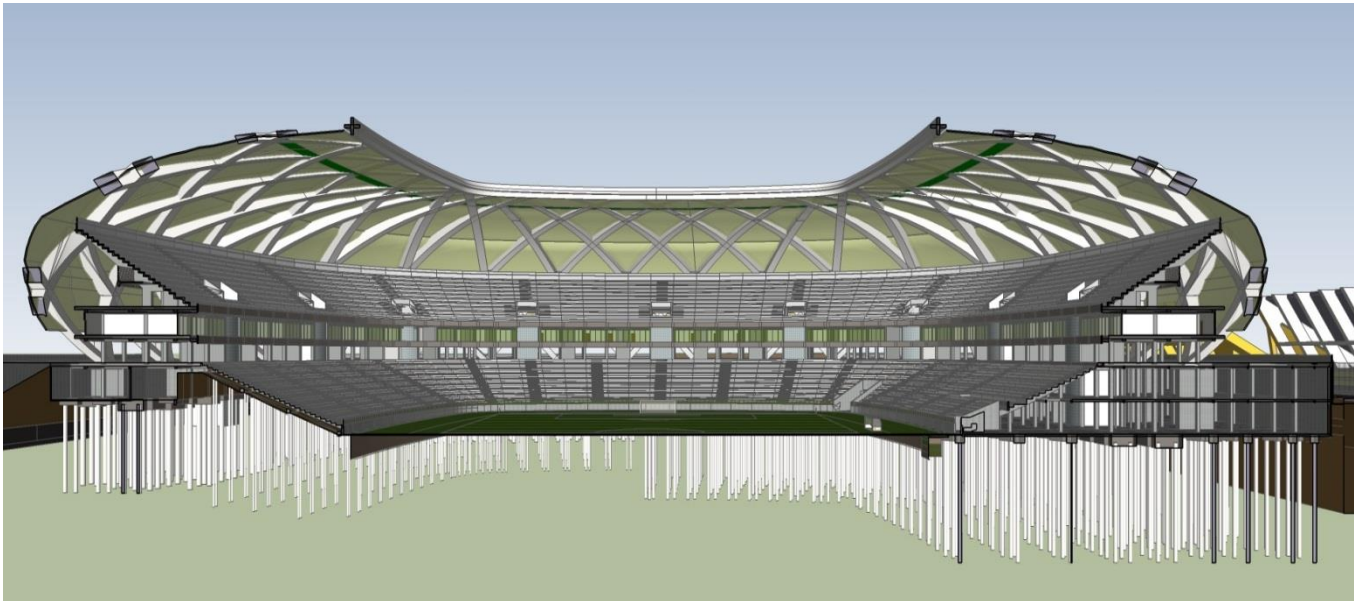
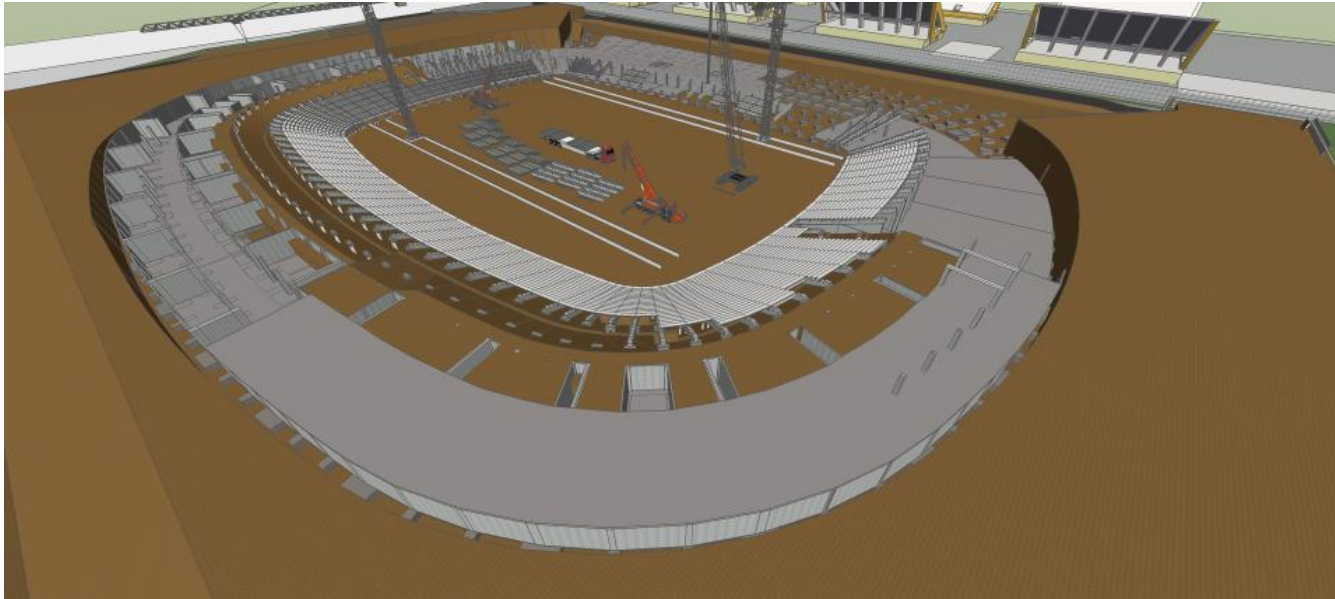
- 4D = 3D + schedule
- Software
  - ArchCad
  - Google Sketchup
  - MS Project



# Construction Scheduling – Line of Balance



# 4D BIM

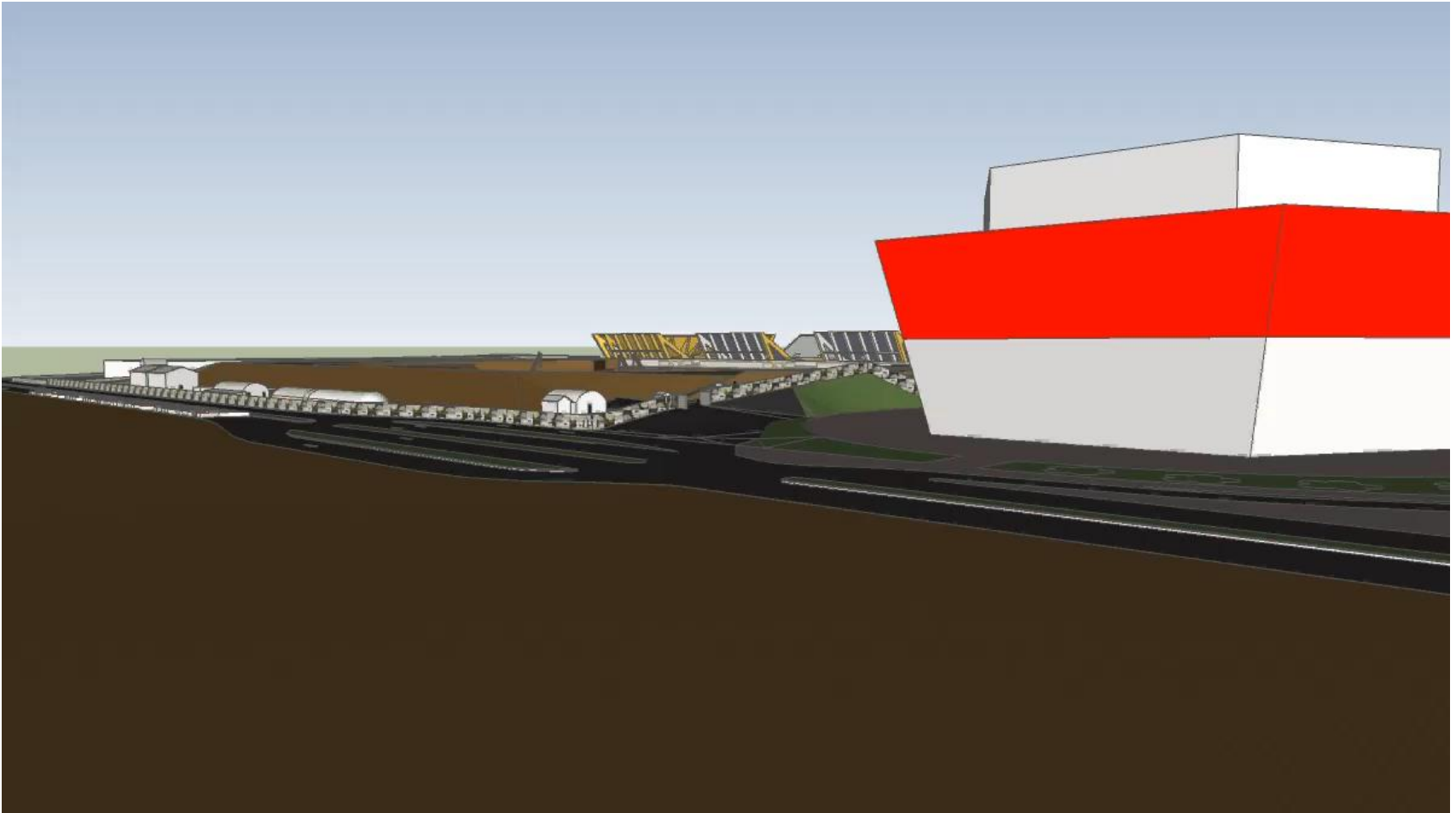


# 4D BIM

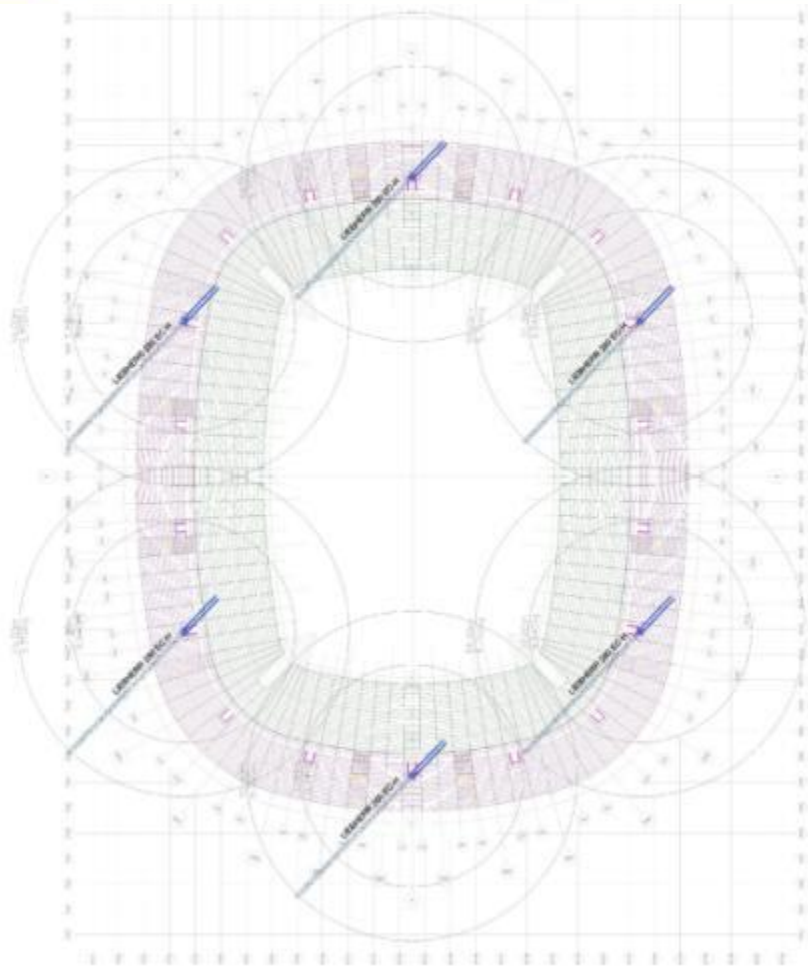




# 4D BIM

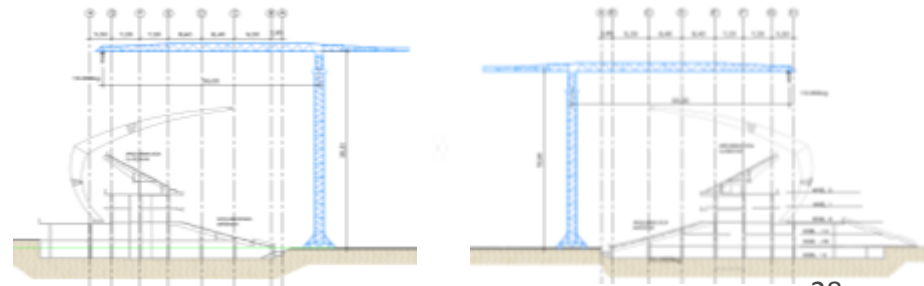
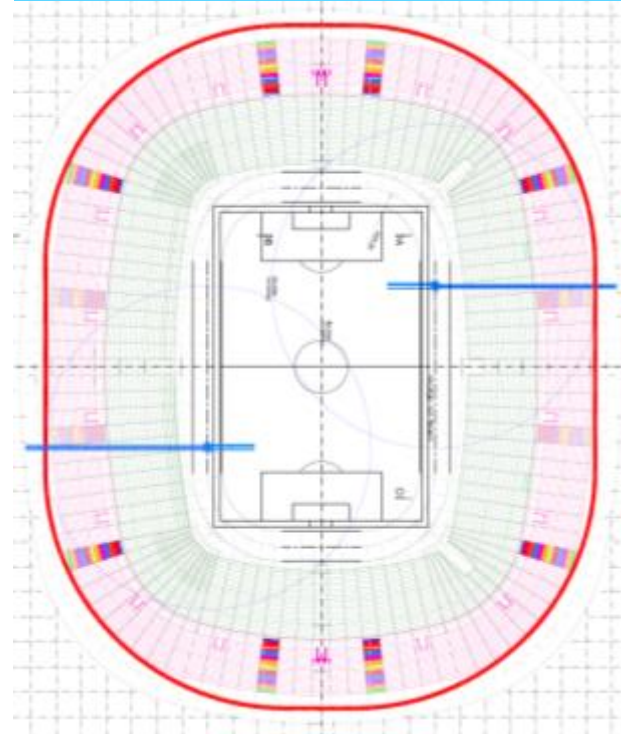


# Value engineering – cranes



6 fixed cranes

2 rail-mounted cranes



# Value engineering – cranes





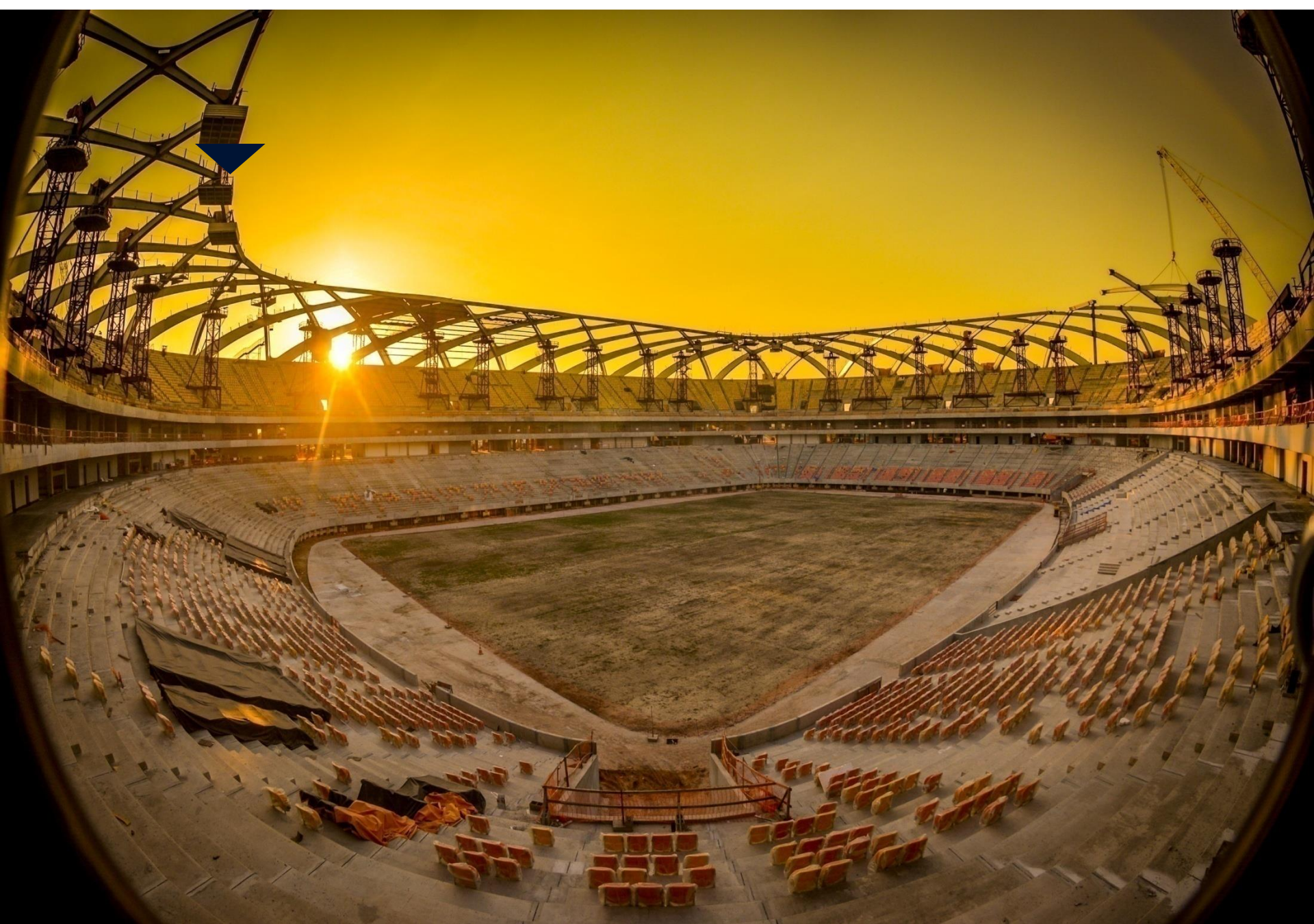


## Reinforced Concrete Structures

**Precast steps: 2484 units**

**Inclined precast beams: 216 units**







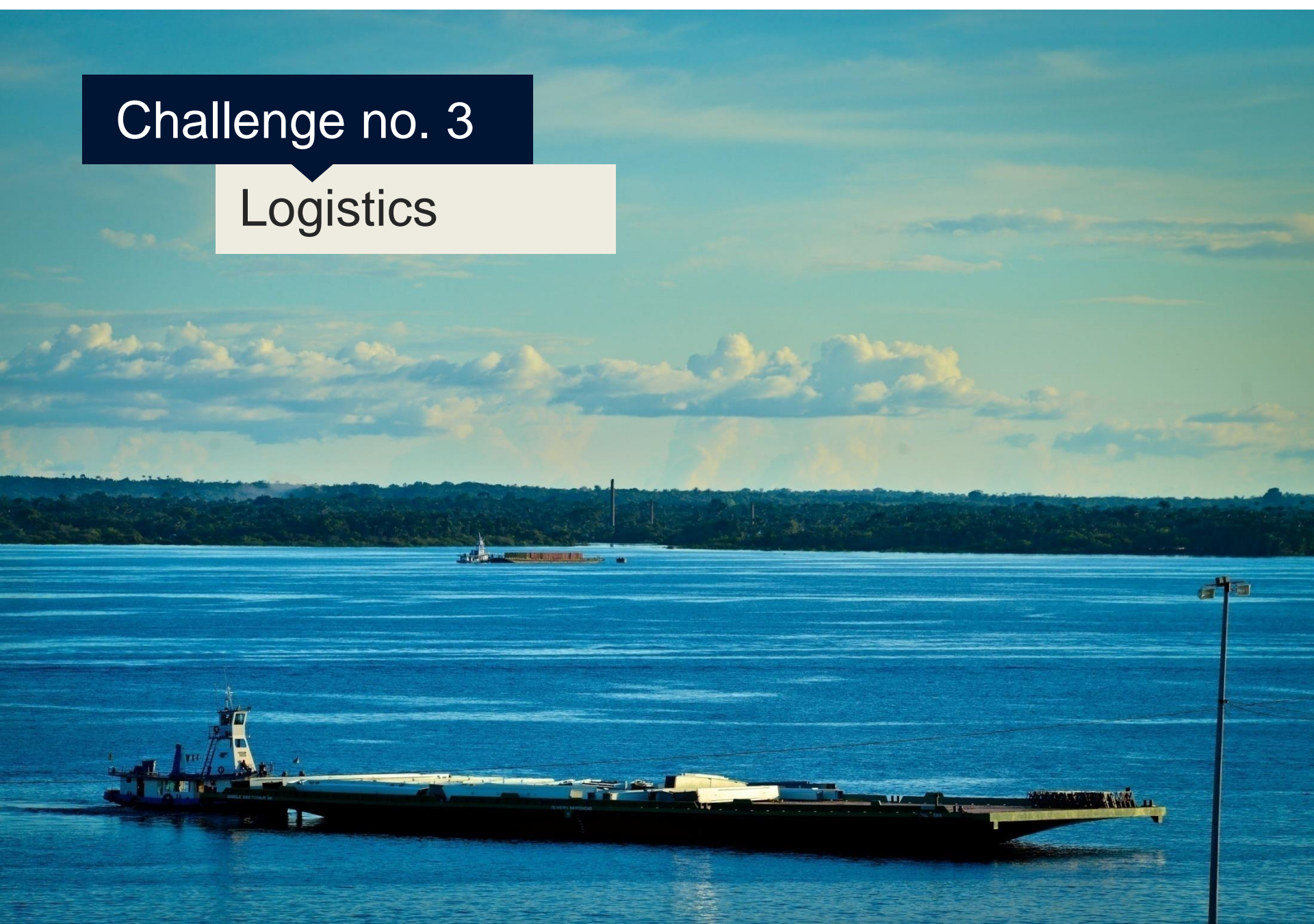


**Equipment and Vehicles**

**Total quantity: 175**

# Challenge no. 3

## Logistics





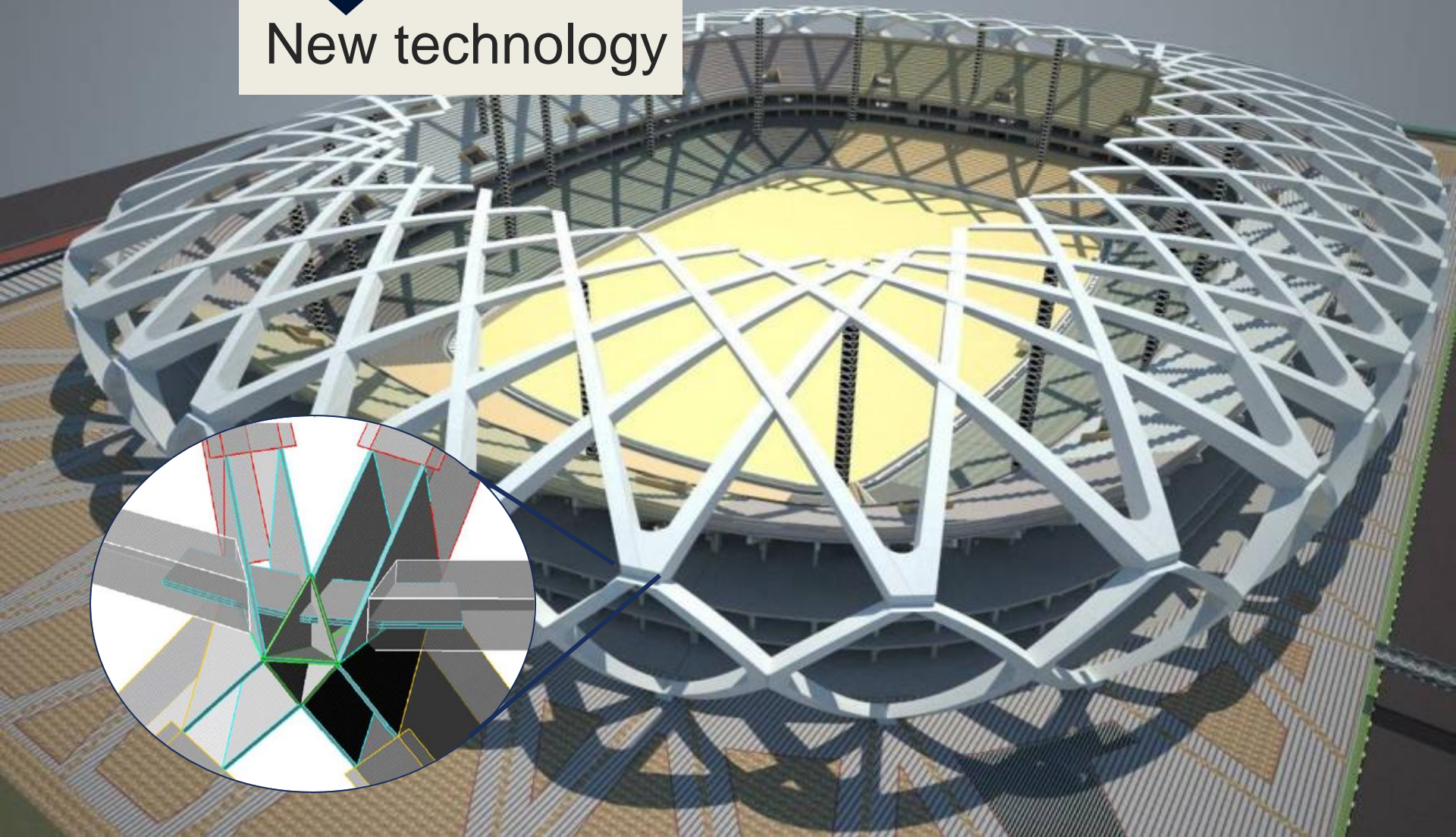
# Challenge no. 4

## Labor skills



## Challenge no. 5

New technology



# Lean construction

- Lean thinking
- Production management-based approach
- Work is structured throughout the process
- Activities that **add value x waste**
- **Necessary** waste x **unnecessary** waste



# Waste

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**Waiting**

**Moving**

**Unnecessary  
processes**

**Unused area**

**Transportation**

**Inventory**

**Overproduction**

**Defects**

**Delays**

# Areas of improvement



**Reinforcing  
steel  
production**



**Precast  
concrete  
fabrication**



**Cast-in-  
place  
concrete**



**Laboratory**

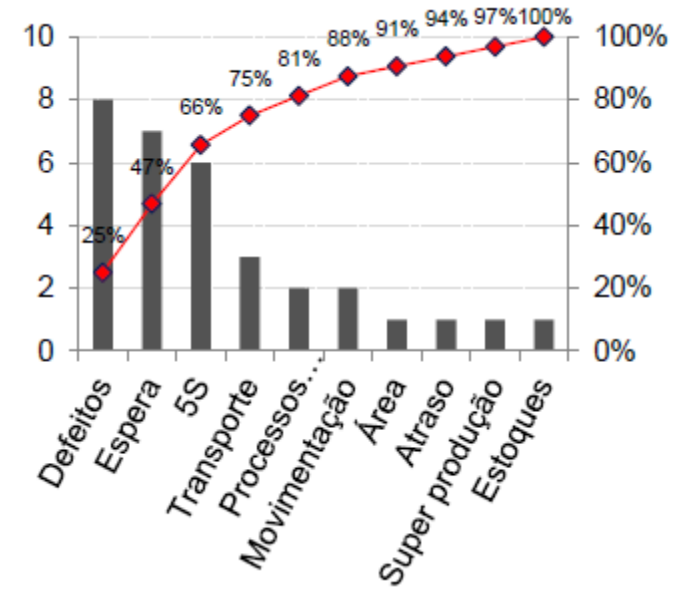
# Lean construction – steps

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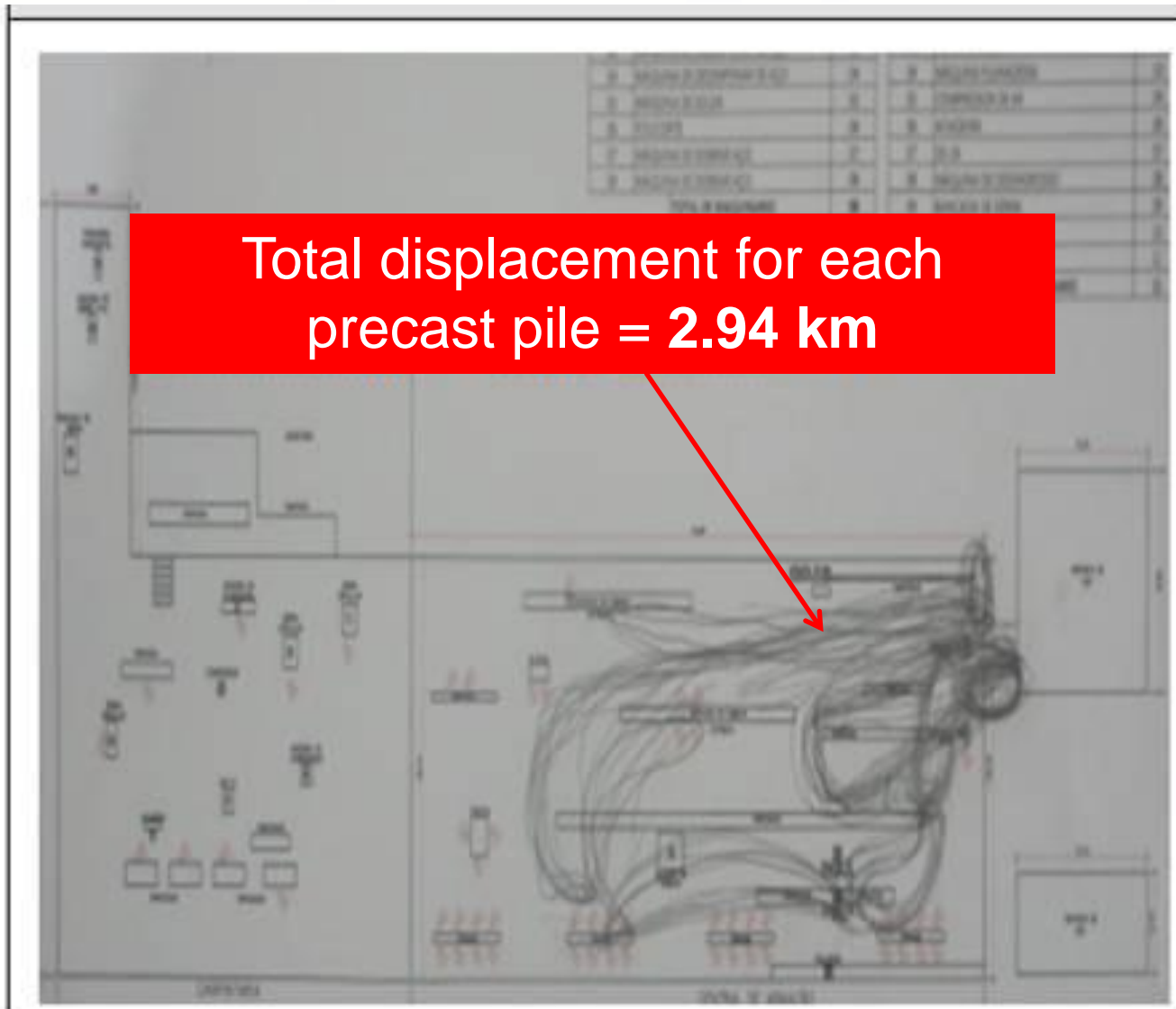
1. Flowchart
2. Qualitative assessment of waste
3. Measurement of displacements
4. Tape-recording and analysis
5. Layout optimization
6. Preparation of operational procedures
7. Mounting of control boards
8. Waste management
9. Visual signs



# Waste assessment



# Measurement of displacements



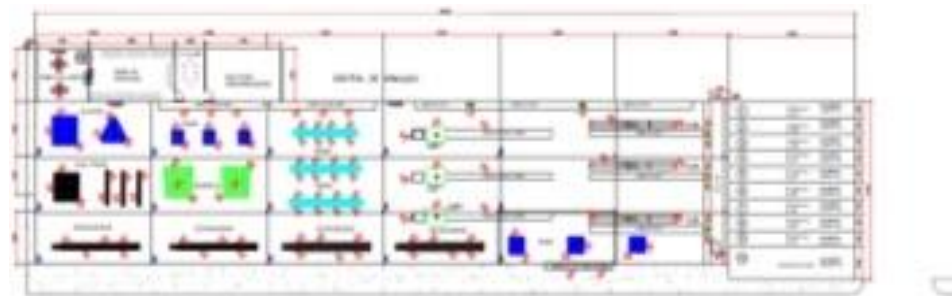
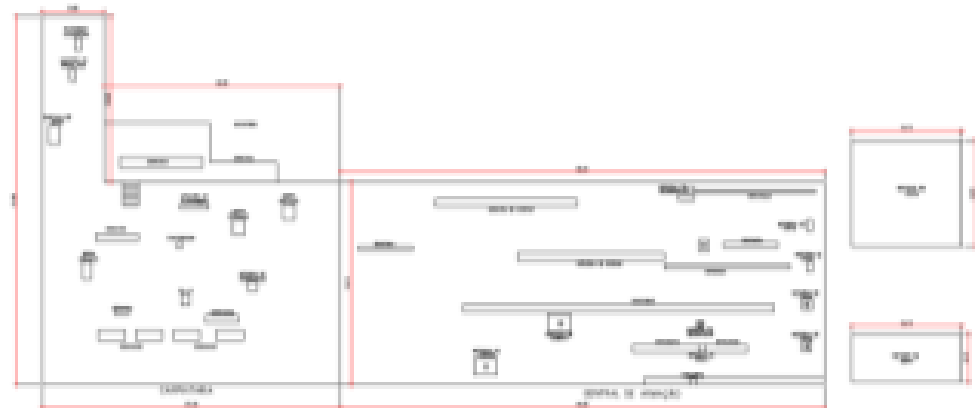
# Recording and Analysis



# Chronoanalysis








# Layout optimization



LAYOUT CENTRAL DE ARMAÇÃO



# Operational procedure

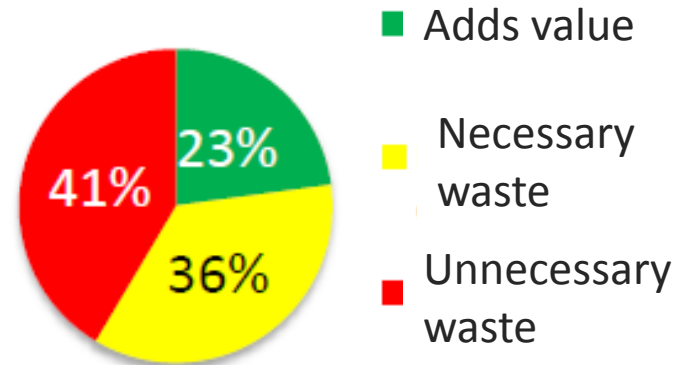
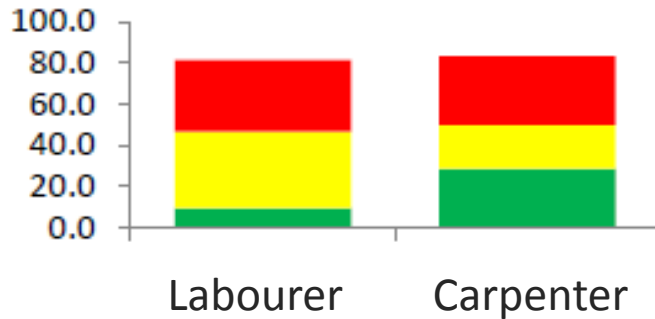
PROCEDIMENTO OPERACIONAL VISUAL							
Elementos:		Forma da Laje in Loco					
E	Processo		Atividade Carpinteiro	Imagem Ilustrativa Atividade Principal	Atividade Ajudante	Imagem Ilustrativa Atividade Secundária	Tempo Atual (Segundos)
	Início	Fim					
1	0:00:00	0:01:30	Verificar ferramentas e colocar guia		Separar e trazer todas as formas necessárias para execução da face da laje		0:01:30
2	0:01:30	0:13:30	Encaixar Formas segundo tamanhos existentes		N.A.		0:12:00
3	0:13:30	0:25:30	Martelar as formas já ajustadas		N.A.		0:12:00
4	0:25:30	0:26:20	N.A.		Recolher formas que restaram e devolver ao carrinho		0:00:50
TEMPO ATUAL TOTAL ( S )							0:26:20

# Control boards

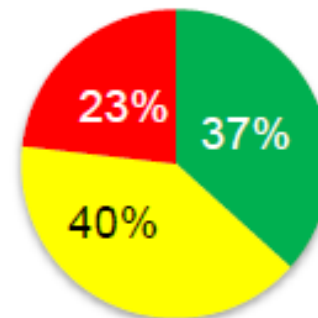
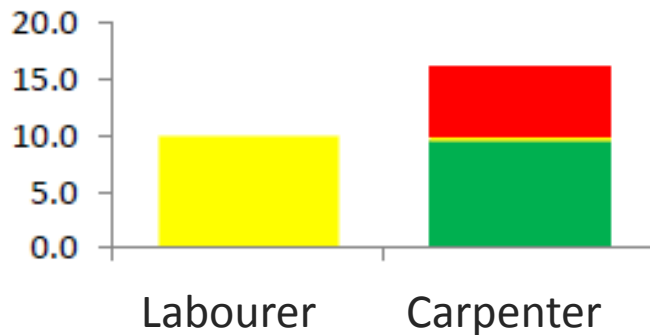


# Waste management

Before



After





# Conclusions

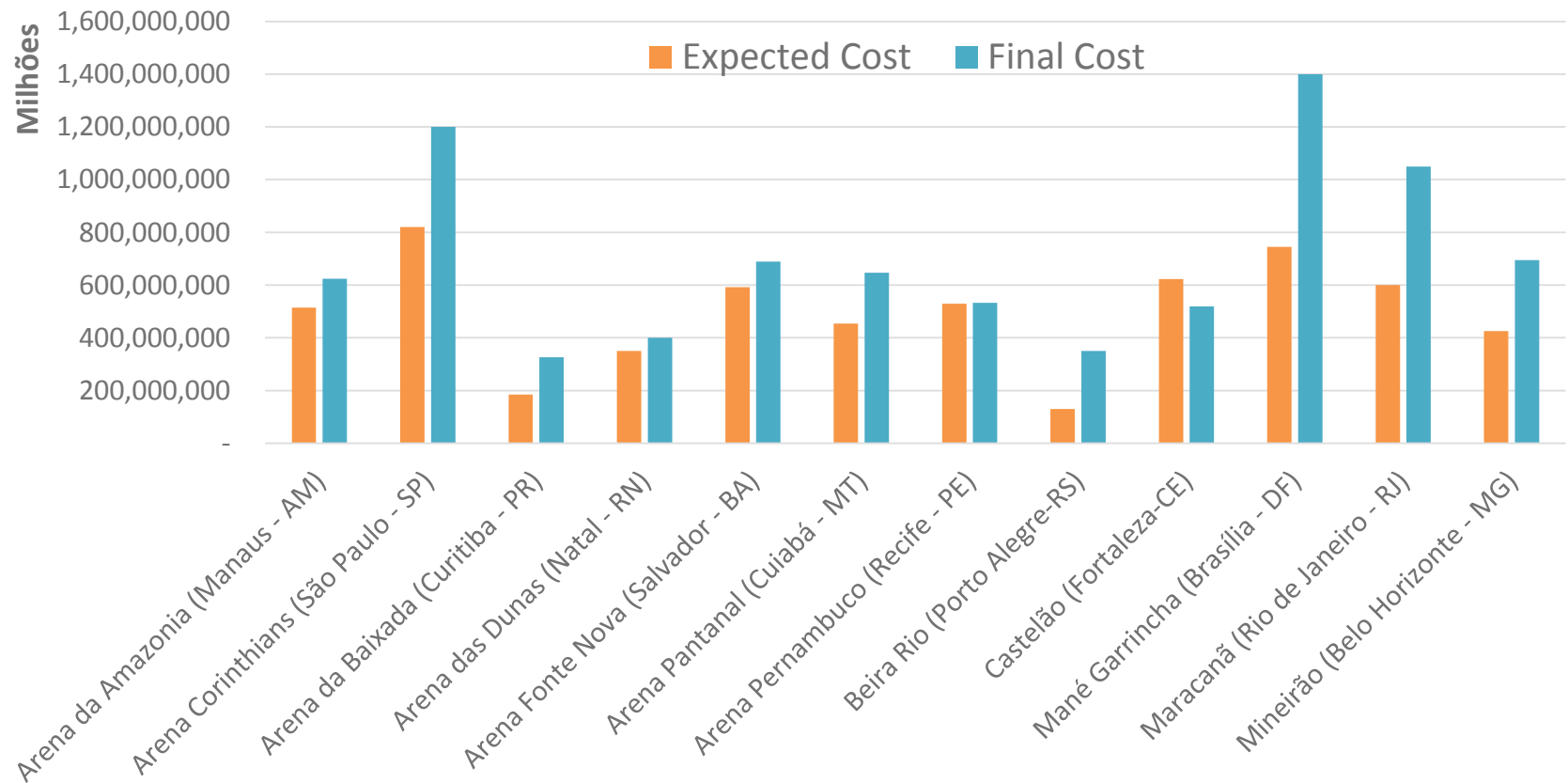


# Conclusions

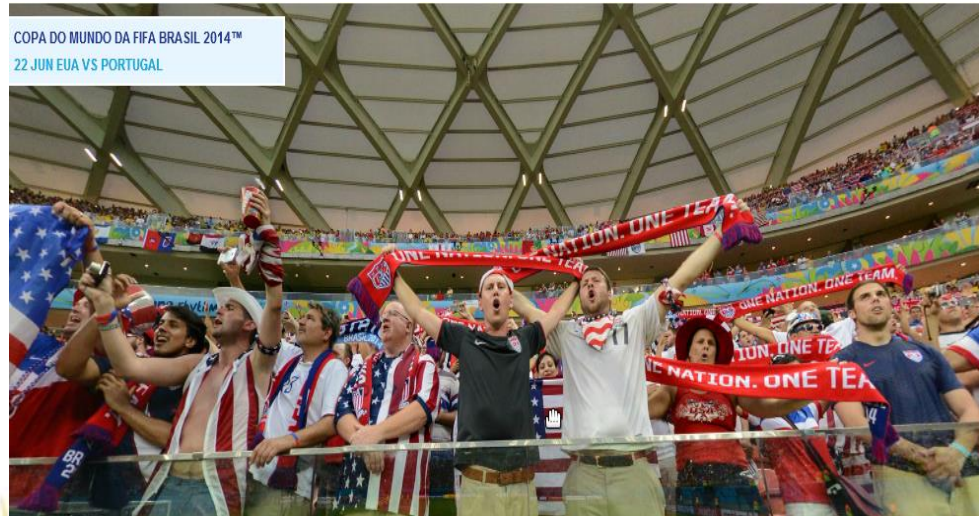
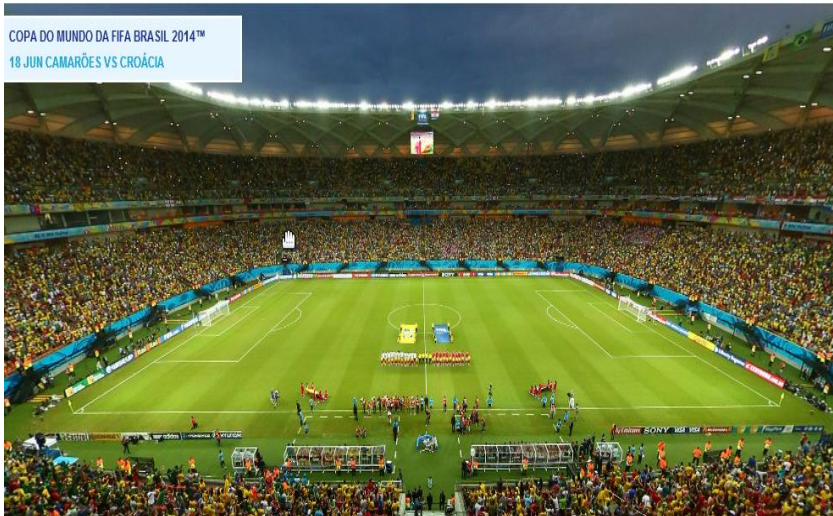
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1. Scope changes represent a major risk for owners and contractors
2. Scope changes are harmful for public works – agencies cannot get funds in due time
3. Projects must be budgeted for time and money contingencies – this is difficult for public agencies
4. Adverse weather, low-skilled labor, shortage of workers, complicated logistics and frequent change orders can only be mastered by an exhaustive process of planning and control
5. Lean construction is suitable for repetitive works

# Cost Overrun in the 12 Stadiums



# FIFA World Cup 2014 Brazil – Manaus



# FIFA World Cup 2014 Brazil – Manaus



Manaus received 120,000 tourists, who left  
£ 325 million in the city



# Matches

**England vs Italy**



**Cameroon vs Croatia**



**USA vs Portugal**

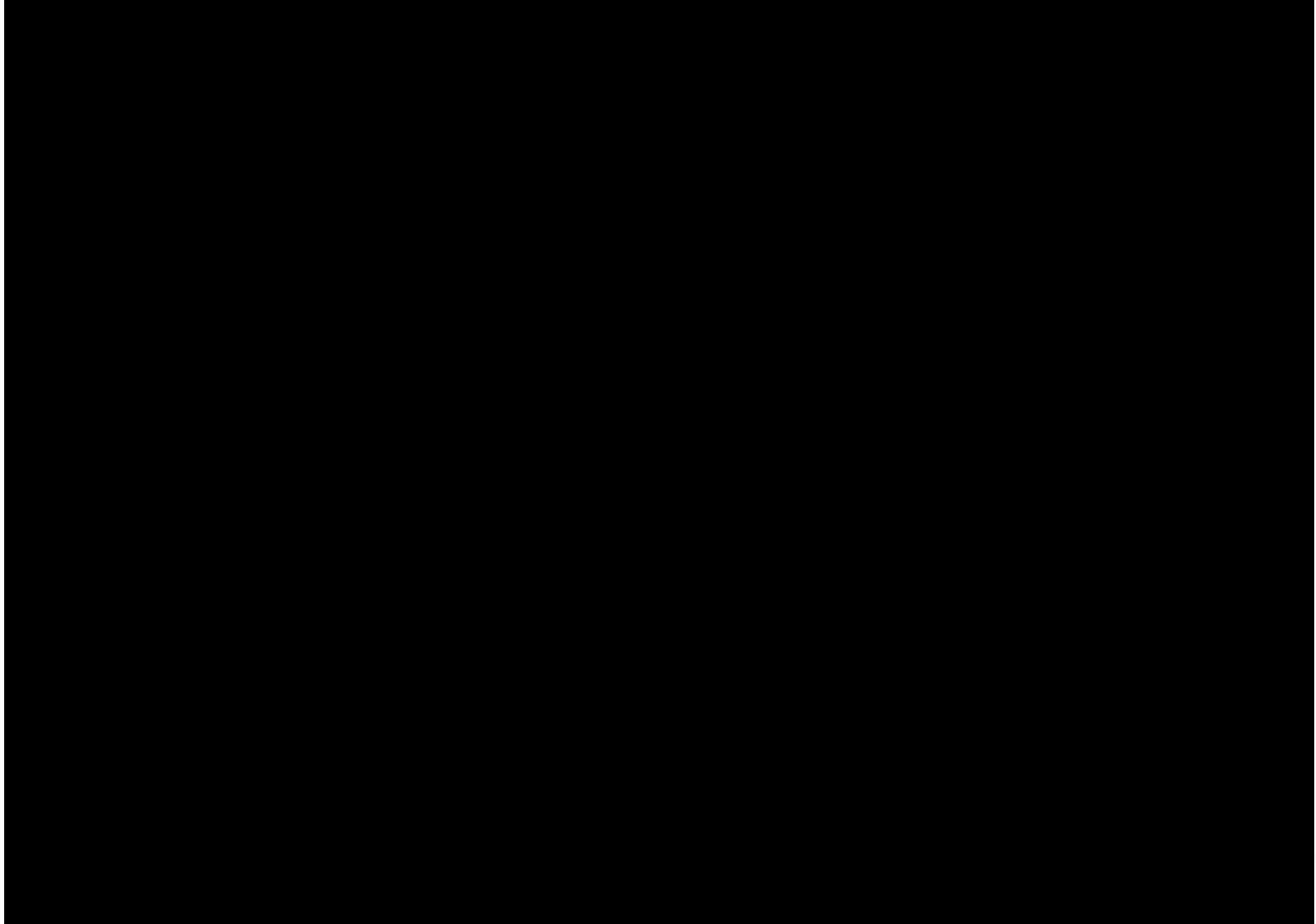


**Honduras vs Switzerland**



# First GOAL – ITALY!!!

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# See you in Russia 2018!

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## Aldo Mattos

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