1. INTRODUCTION

1.1 Construction of the ‘Autopista del Norte (AP-1)’ (North Motorway) – Overview:
1.1 Construction of the ‘Autopista del Norte (AP-1)’ (North Motorway) – Arbizelai’s bridge:

1.2 Technical data of Arbizelai’s bridge:
- Concept: Circular horizontal alignment of radius 1083 meters
- Total length: 656.73 m
- Six spans of:
  - 37.44 m, 52.64 m, 58.60 m, 65.00 m, 70.40 m, 85.20 m
- 2 piers 31 meters high over the deck
- Pillar’s average height: 35 meters
- Incremental deck launch construction method

1.3 Bridge deck launching
1.3 Bridge deck launching:

Phase 1

Phase 2

1.4 Traditional surveying methods to guide and monitor bridge deck launching:

NOT REAL TIME!!!!!

1.4 Traditional surveying methods to guide and monitor bridge deck launching

2. OBJECTIVES
2 Objectives - Specific requirements for the Arbizelai’s bridge guidance and monitoring system:

- **Real time** 3D guidance of the bridge deck during the incremental launching process.
- **Real time** monitoring of 4 control points (2 on the front, 2 on the rear) of the bridge deck during the incremental launching process. 3D trajectory of these points had to be continuously checked versus the theoretical horizontal and vertical alignments.
- Central pylon’s **Real time** deformation monitoring.
- **Real time** remote access to the system anywhere in the construction site or even from Dragados central office in Madrid.
- User-friendly software interface with data logging and **Real time** alarm system.

**REAL TIME!!!!!**

### 3. DEVELOPMENT

#### 3.1 Previous works

- Satellite tracking and signal multipath tests
- WGS84 to Construction Site Local Coordinate System transformation using static GNSS techniques.
- GNSS reference receiver precise WGS84 coordinates determination
- GNSS antennas offset determination with respect to the deck structure
- Theoretical 3D trajectories calculation for each of the 5 points to be monitored on the deck.
- Radio communications configuration and fine tuning due to the complex orography and safety regulations
- Software installation and configuration
- Remote access configuration
- Initial tests before the start of the launching process
3.2 Hardware

3.2.1 GNSS Receivers:

3.2.2 GNSS Antennas Setups

3.2.3 Radio-Modems

3.2.4 Computers
3.3 Software

3.3.1 Leica GNSS Spider

- GNSS raw observations from all 6 receivers (1 ‘reference’ and 5 ‘rovers’) are sent to the Control Center where Spider software processes them in Real Time.
3.3.1. Leica GNSS Spider:
Spider software computes all 5 baselines between the reference receiver and the other 5 rovers.

3.3.2. Leica GeoMoS:
Using the ‘Virtual Sensor’ functionality of GeoMoS, XYZ coordinates from different points can be combined together using mathematical functions in order to obtain a desired magnitude (for example, orthogonal distance of the pylon to the side of the deck).

Another interesting magnitude computed in Real Time with GeoMoS ‘Virtual Sensors’ during the incremental launching process was the angle of inclination of the pylon.

3.3.2. Leica GeoMoS:
3.3.3 Leica Alignment Monitoring

Offsets of the GNSS antennas have to be calculated with respect to the point of the deck structure from which we already know the theoretical trajectory.
3.3.3. Leica Alignment Monitoring:

Main Screen during launching process:

3.4 Software Integration:

- **3.3.3. Leica Alignment Monitoring:**
  
  Data logging: automatic ASCII file creation (1 file per point and worksession)

- **3.4 Software Integration:**
  
  Spider sends the precise coordinates of all 5 rover receivers to GeoMoS and Alignment Monitoring.

- **GeoMoS:**
  
  GeoMoS monitors the 3D deformation of the central pylon.

- **Alignment Monitoring:**
  
  Checks the 3D position of each point with respect to the theoretical horizontal and vertical trajectory.
4. RESULTS

4. Results - Point 90D (front right): Horizontal Offsets

4. Results - Point 90D (front right): Vertical Offsets
5. FUTURE IMPROVEMENTS

5.1 Alignment Monitoring new features:
- CAD graphical output
- Support for Total Station measurements

5.2 Kalman filtering:
- Blunder prevention

5.3 Use of monitoring GNSS Receivers:
- Leica GMX901 & Leica GMX902GG

5.4 Use of Network RTK instead of Single Station RTK

6. CONCLUSIONS

6. Conclusions:
- Monitoring and guidance system perfectly suitable for its use in any kind of moving structure.
- Need to include a graphical output.
- Other possible applications include:
  - Incrementally launched bridges
  - Barge guidance for pile’s embedding
  - Jump forms
  - Cantilever bridges
Thanks for your attention!
Any questions?