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CONTROL OF THE SIX DEGREES OF FREEDOM OF A FLOATING BODY USING VIDEO IMAGING TECHNIQUES:
MONITORING THE OPERATION OF FLOATING GATE OPENING AND CLOSING AT CAMPAMENTO'S DRY DOCK (ALGECIRAS BAY, SPAIN)

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POLITÉCNICA
Puerto Bahía de Algeciras
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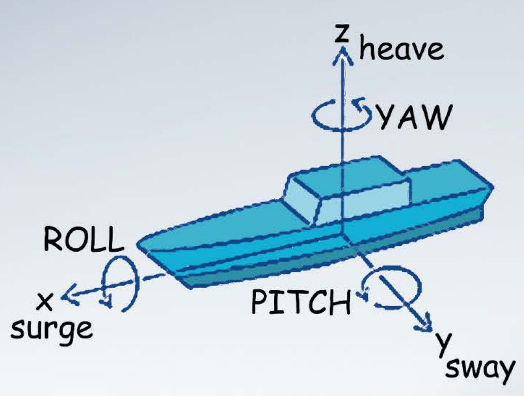
MOTIVATION

Floating bodies oscillate and move under the action of forcing agents, such as waves, wind or actions of use and exploitation. The study of the response of these floaters is critical to the analysis of the operating thresholds of activities such as ship loading and unloading, berthing and mooring, transportation, anchoring of structures or the opening and closing of locks. This paper proposes video-imagery techniques as a low-cost non-intrusive tool for the physical environment and port activities monitoring, using the surveillance and control infrastructure already existing at ports (ZEUS_Port Project)

THE SIX DEGREES OF FREEDOM OF A FLOATING BODY



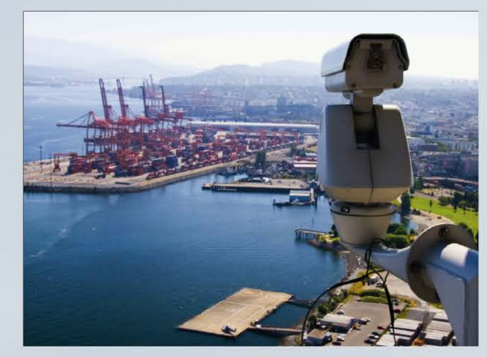
REGISTRATION OF MOTION INSTRUMENTATION COMPARISON

FIELD

INSTRUMENT	INTRUSION	ACCURACY	DIFFICULTY OF USE	ROBUSTNESS	€
GPS-RTK					
GIROSCOPE					

LABORATORY

INSTRUMENT	INTRUSION	ACCURACY	DIFFICULTY OF USE	ROBUSTNESS	€
WIRE					
LÁSER					
GIROSCOPE					
OPTICAL MOTION CAPTURE SYSTEMS					



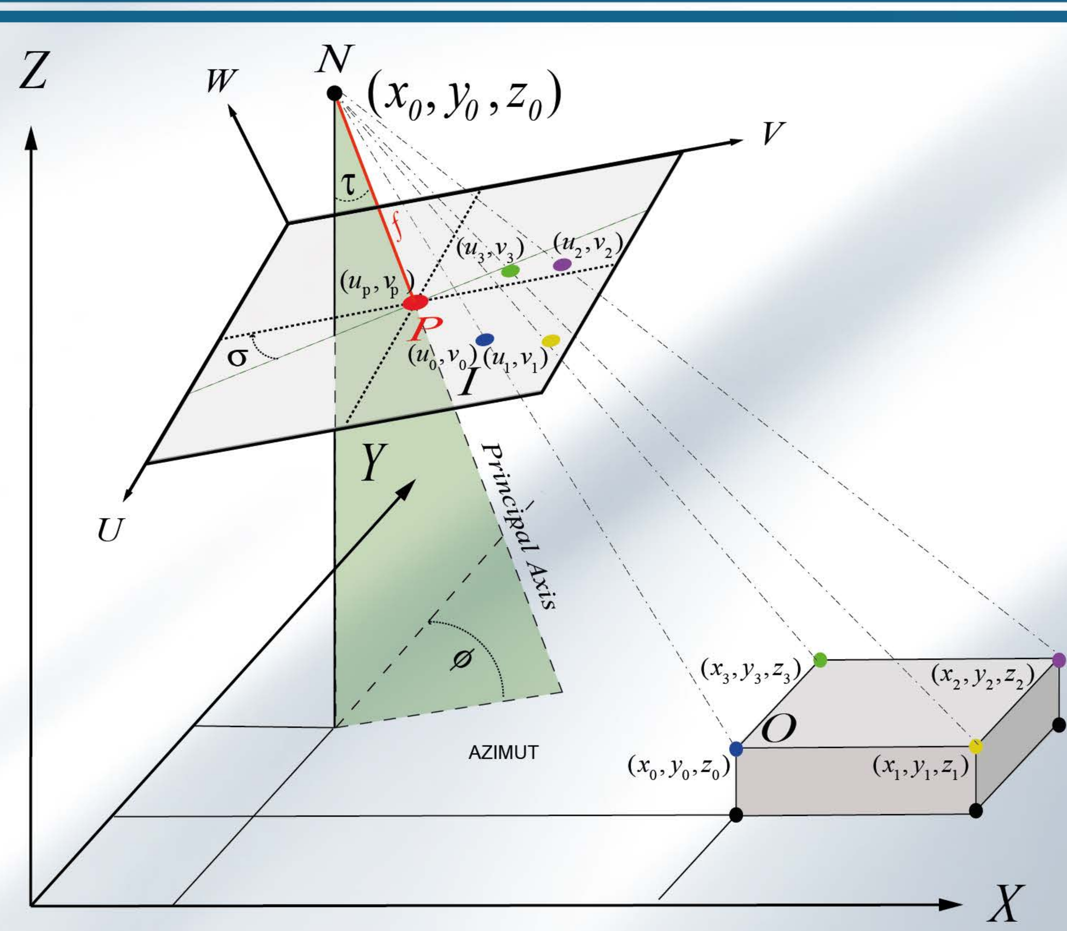
INTRUSION	
ACCURACY	UNDER STUDY
DIFFICULTY OF USE	
ROBUSTNESS	UNDER STUDY

VIDEO IMAGERY TECHNIQUES ARE APPLICABLE IN LABORATORY AND FIELD

DIGITAL VIDEO IMAGERY TECHNICS

ZEUS PROJECT

OBTAINING THE POSITION OF AN OBJECT KNOWN ITS GEOMETRY. CONCEPTS



IMPLICIT PARAMETERS

$$A = \lambda V^{-1} B^{-1} F M T$$

$$V = \begin{pmatrix} 1 & 0 & -u_0 \\ 0 & 1 & -v_0 \\ 0 & 0 & 1 \end{pmatrix} \quad B = \begin{pmatrix} 1+b_1 & b_2 & 0 \\ & 1-b_1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad F = \begin{pmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$\lambda \rightarrow$ Scale Factor

$M \rightarrow$ Rotation Matrix

$T \rightarrow$ Translation Matrix

$V \rightarrow$ Matrix with information about (u_0, v_0)

$B \rightarrow$ Matrix with information about distortion (b_1, b_2)

$F \rightarrow$ Matrix with information about focal distance, f

EXTRINSIC PARAMETERS

$$\phi = \sin^{-1}\left[\frac{C_{31}}{(C_{11}^2 + C_{21}^2 + C_{31}^2)^{\frac{1}{2}}}\right] \quad \omega = \sin^{-1}\left[\frac{-C_{32}\sec\phi}{(C_{12}^2 + C_{22}^2 + C_{32}^2)^{\frac{1}{2}}}\right] \quad \kappa = \sin^{-1}\left[\frac{-C_{21}\sec\phi}{(C_{11}^2 + C_{21}^2 + C_{31}^2)^{\frac{1}{2}}}\right]$$

CAMERA POSITION

$$\begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} = \frac{-1}{\lambda} \mathbf{R}^T \mathbf{K}^{-1} \begin{bmatrix} L_3 \\ L_6 \\ 1 \end{bmatrix}$$

where:

$$\lambda = ({C^2}_{11} + {C^2}_{21} + {C^2}_{31})^{\frac{1}{2}} = ({C^2}_{12} + {C^2}_{22} + {C^2}_{32})^{\frac{1}{2}}$$

If Xi e Yi coplanar: Colineal Model

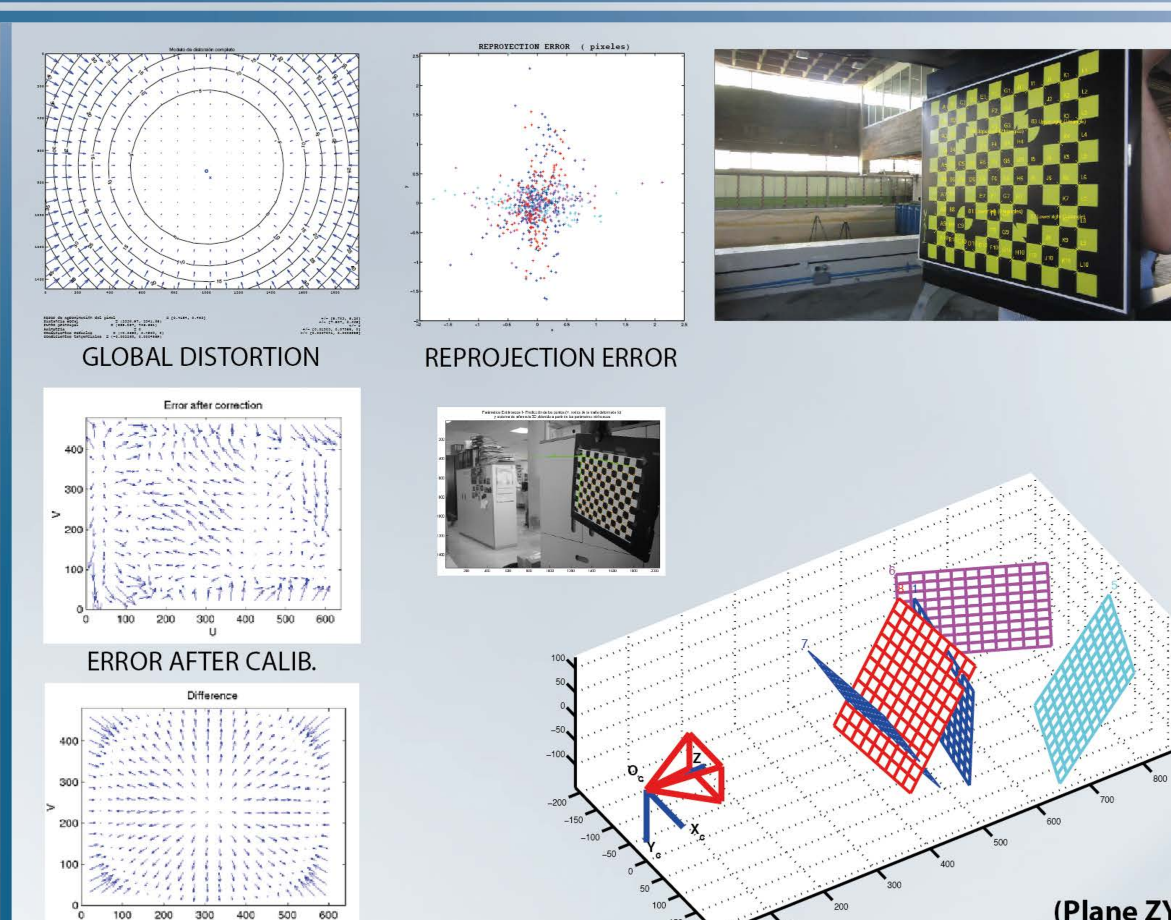
$$\begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} = \frac{-1}{\lambda} \mathbf{R}^T \mathbf{K}^{-1} \begin{bmatrix} L_3 \\ L_6 \\ 1 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ Z_{ref} \end{bmatrix}$$

The basis of the solution of the 3D geometric problem is to know the camera extrinsic and implicit parameters as well as to determine the geometry of the observed element.

Assuming that the observation point does not vary, the relative displacements between frames will be due to positional changes in the rigid solid.

Time domain facilitates the camera frame rate, a value which will be known for constant sampling rates, or which shall be measured in the event that the passage of time is variable

CAMERA CALIBRATION



GLOBAL DISTORTION
REPROJECTION ERROR
ERROR AFTER CALIB.
DISTANCES
(Plane ZY)
EXTRINSIC PAREMETERS ZY

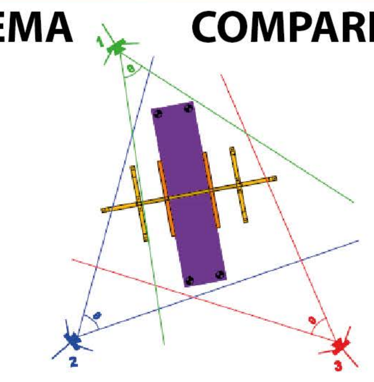
VALIDATION OF THE VIDEO IMAGERY TECHNIQUE: LABORATORY TEST

INSTRUMENTATION

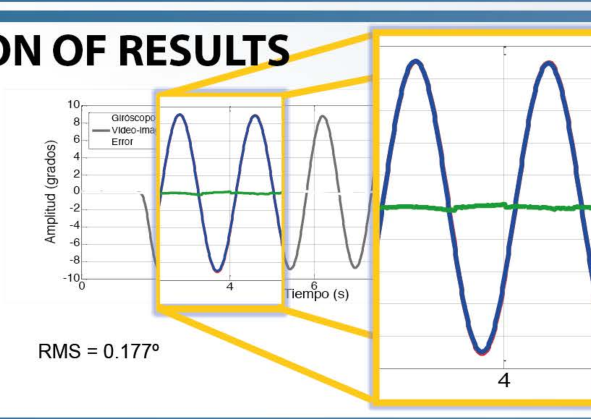
AHRS. Gyro-enhanced Attitude and Heading Reference System.
-MTi Xsens

VIDEO CAMERA
-CASIO EX-F100
30 fps/f10mm/HD

ACQUISITION SCHEMA



COMPARISON OF RESULTS



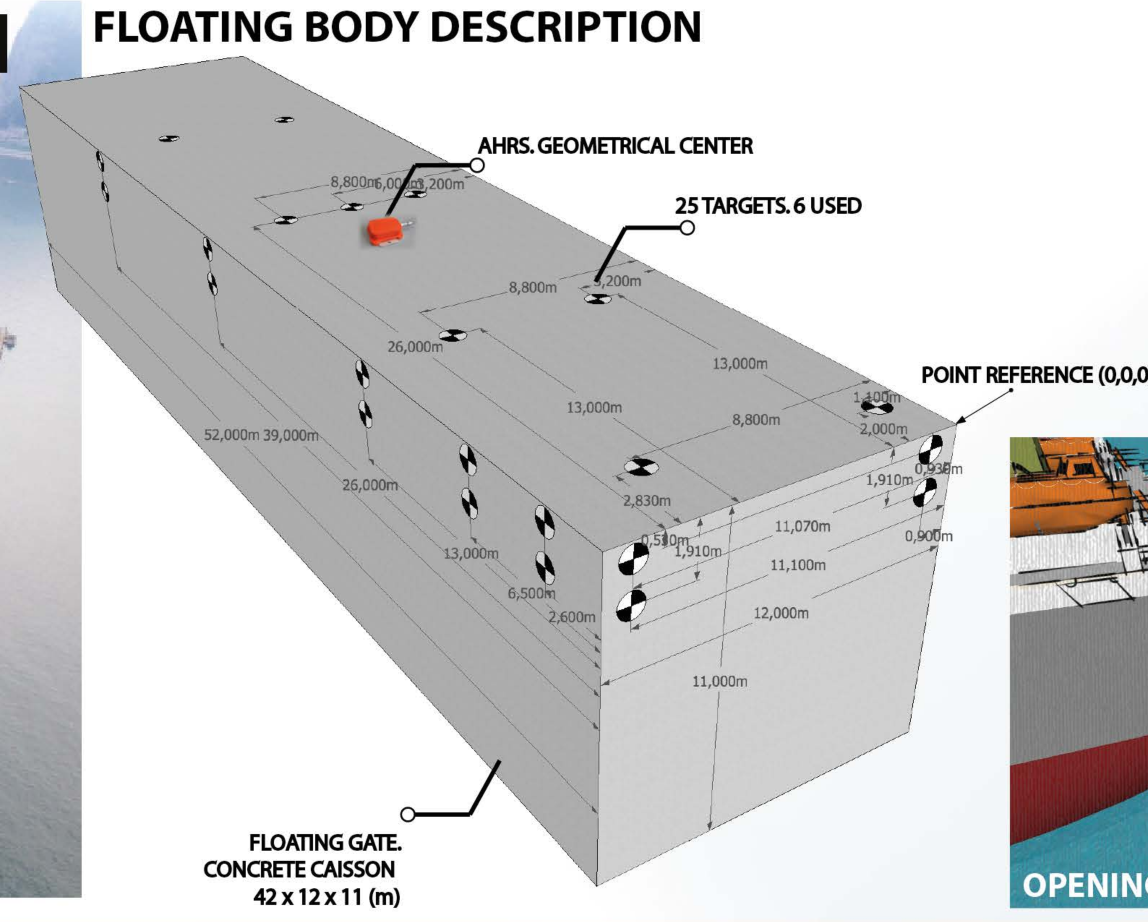
VALIDATION CONCLUSIONS

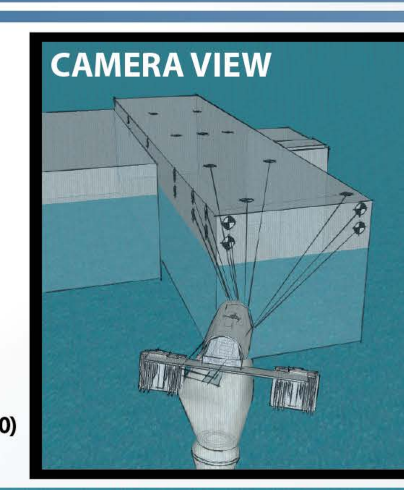
In this phase of work the following conclusions were obtained:

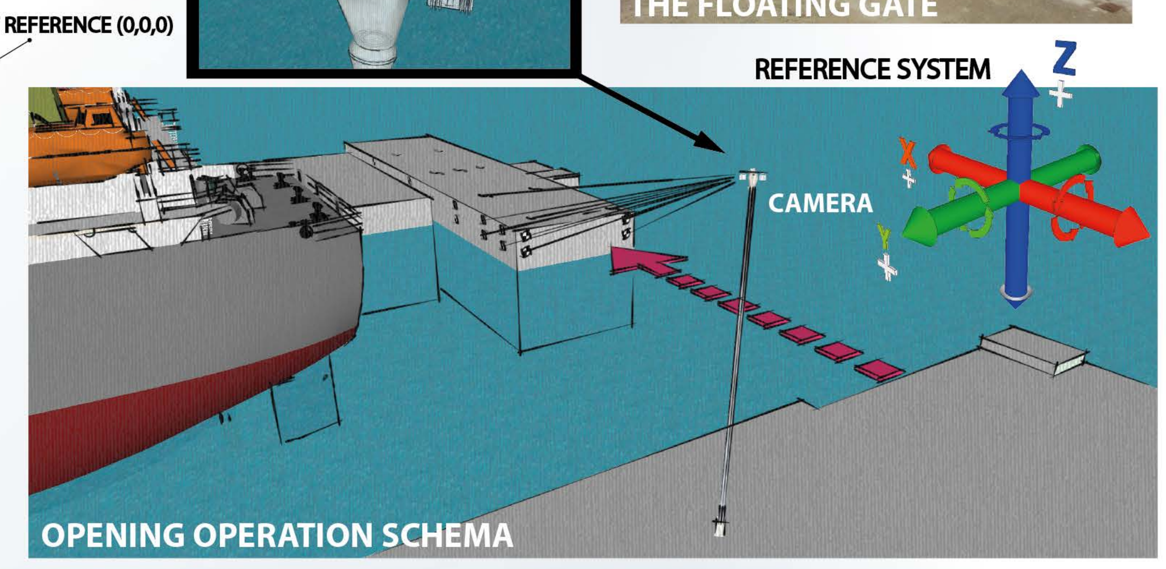
1. The technique is accurate and functional in field and laboratory.
2. The correct detection of the control points is the key to the accuracy of the method, and depends on the image resolution.
3. For monitoring in nature conditions f5-10 fps are recommended, and in laboratory, it depends on the scale but values between 25-50 fps give good results.
4. Adequate illumination intensities in the laboratory allow high speed shots and avoid trails that hinder the detection of the solid.

PRACTICAL APPLICATION: THE OPERATION OF FLOATING GATE AT CAMPAMENTO'S DRY DOCK

FLOATING BODY DESCRIPTION

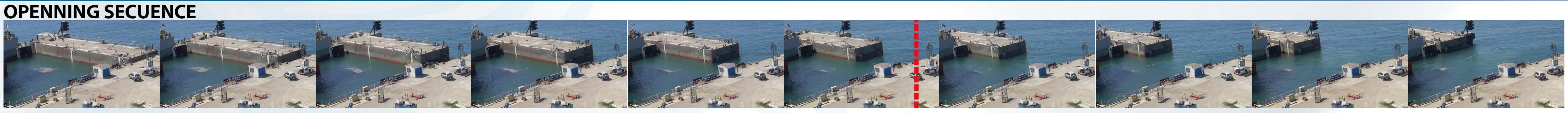




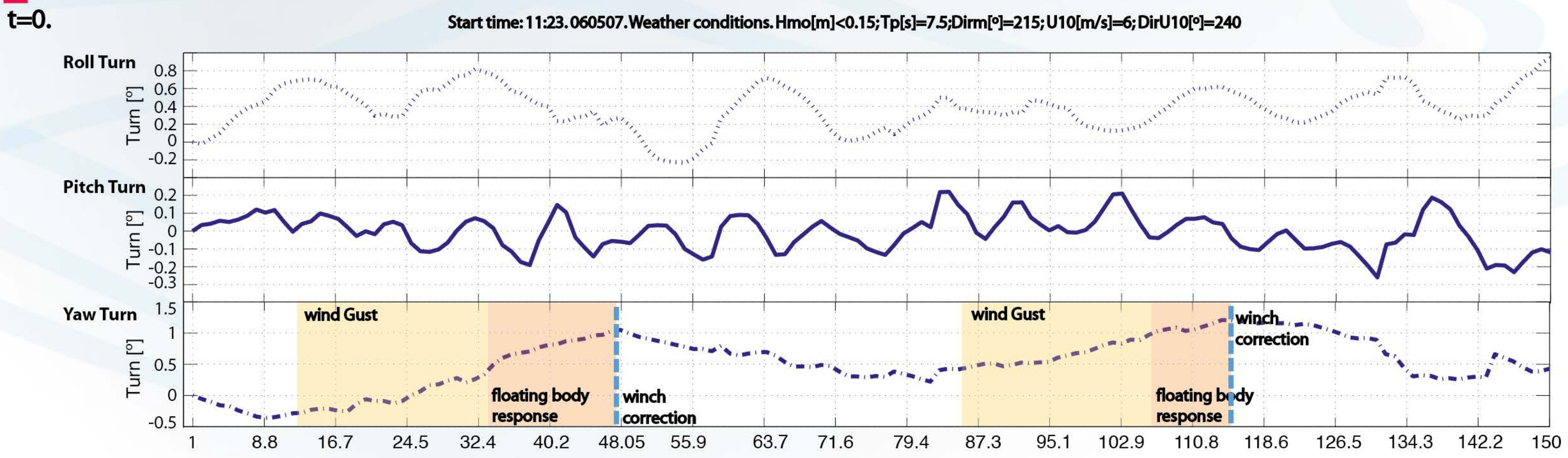


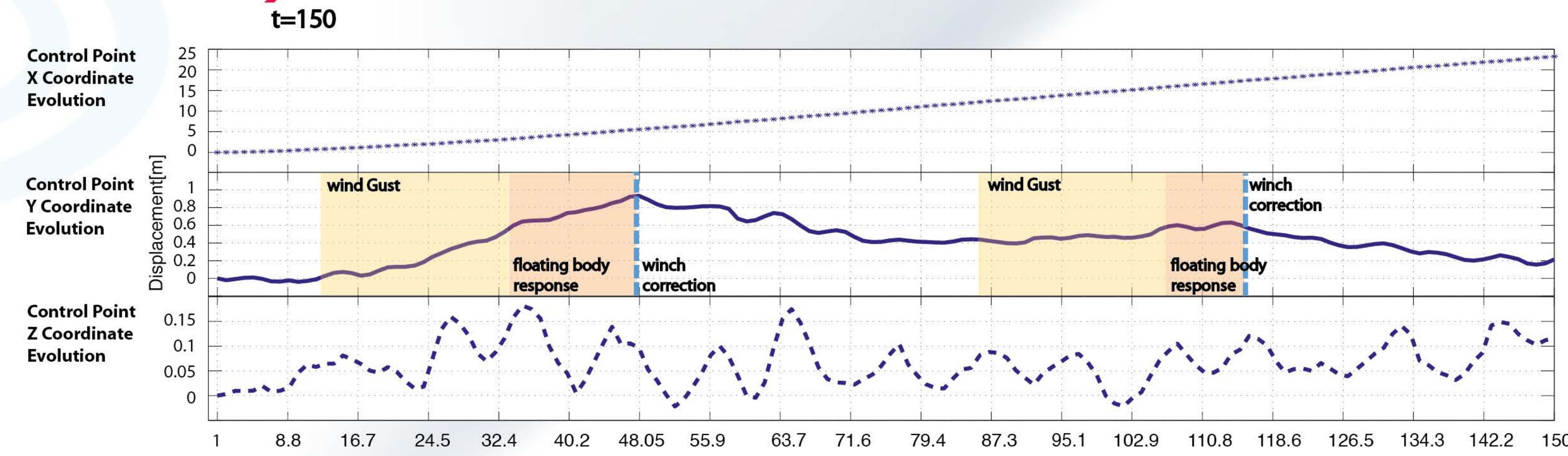
RESULTS

OPENNING SECUENCE



Start time: 11:23. 060507. Weather conditions. Hmo[m]<0.15; Tp[s]=7.5; Dirm[º]=215; U10[m/s]=6; DirU10[º]=240





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