



HORIZON 2020

**TRUSS**

Training in Reducing Uncertainty  
in Structural Safety

# ESR<sub>10</sub>: John Moughty

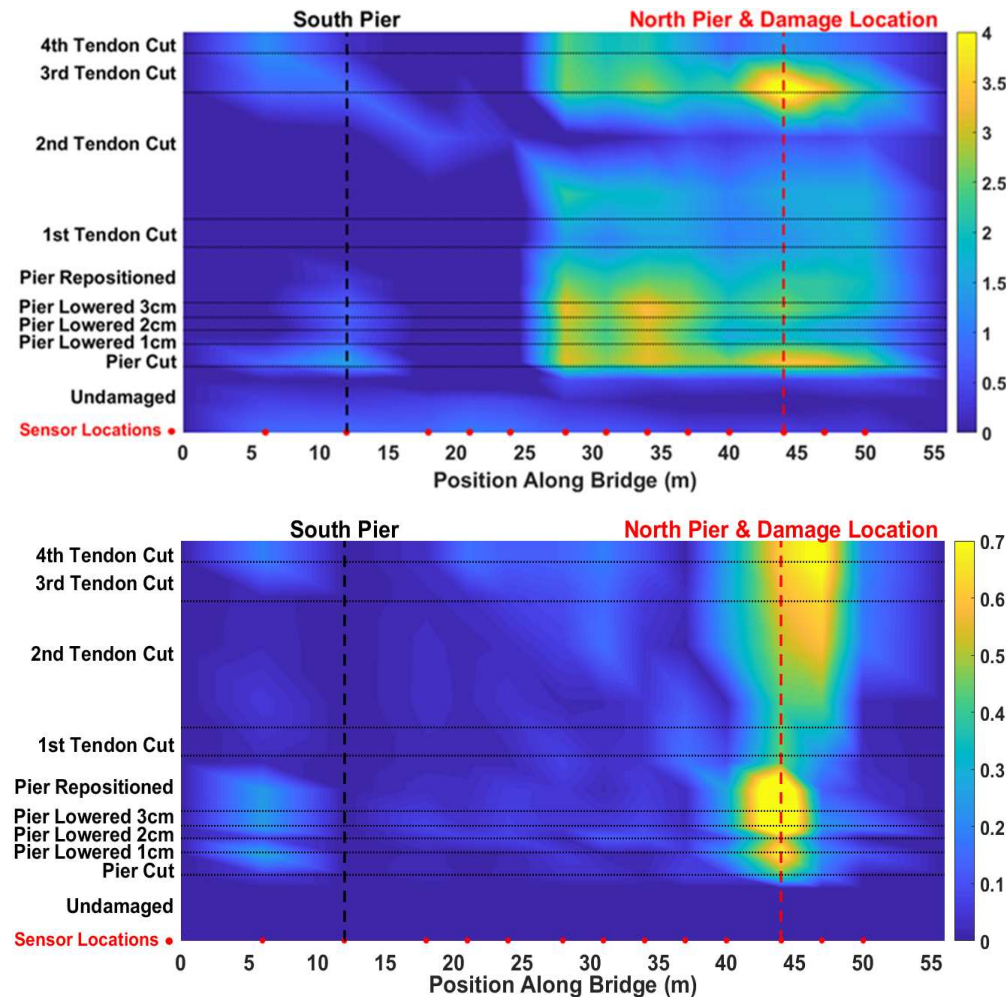


UNIVERSITAT POLITÈCNICA  
DE CATALUNYA  
BARCELONATECH

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Assessment of Bridge Condition and Safety  
Based on Measured Vibration Level

# Developed Numerous Novel Damage-Sensitive VPs



## Mean Cumulative Vibration Intensity

$$MCVI = \frac{CAV^2}{M_f^2} = \frac{\int_0^t \ddot{x}(t)^2 dt}{\left( \sum_{i=m}^n FA_i^2 \cdot (f_i) / \sum_{i=m}^n FA_i^2 \right)^2}$$

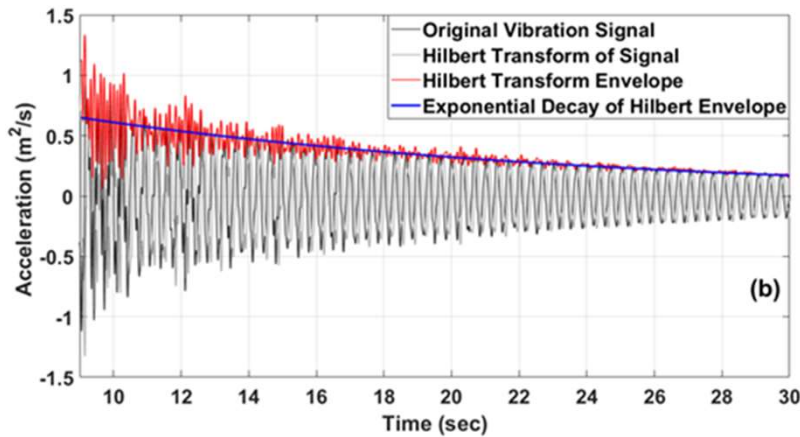
for  $m \leq f_i \leq n$  (in Hz)  
*CAV* = Cumulative Absolute Velocity  
*M<sub>f</sub>* = Mean Frequency

## Distributed Vibration Intensity

$$DVI = \sum_{i=m}^n 10 \log_{10} \left( \frac{\ddot{x}_i^2 \cdot (f_i)}{f_i} / I_s \right)$$

for  $m \leq f_i \leq n$  (in Hz)  
*I<sub>s</sub>* = 10mm<sup>2</sup>/s<sup>3</sup>

# Damage Identification of Non-Stationary Signals - No.1



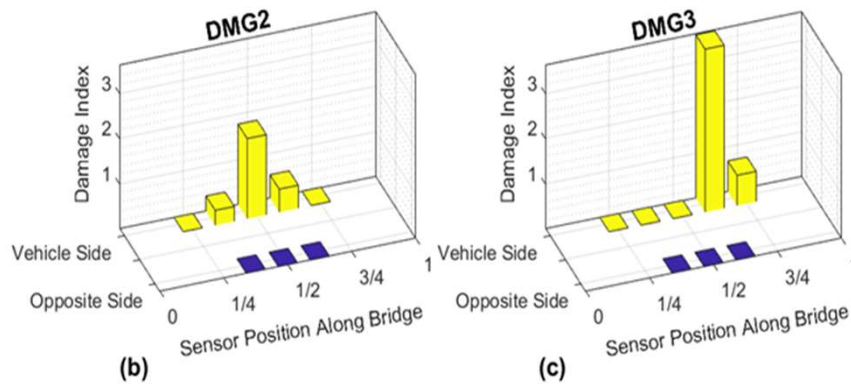
**Hilbert Envelope**

$$H\{x(t)\} = \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{x(\tau)}{t - \tau} d\tau$$

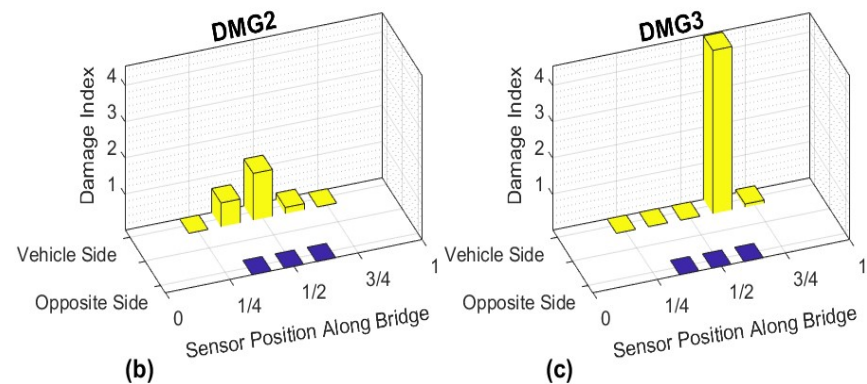
$$z(t) = x(t) + j.H\{x(t)\}$$

$$e(t) = |z(t)|$$

$$y(t) = y_0 e^{at} \quad \text{where: } \begin{array}{l} \text{Decay Intercept (ED}_I\text{)} = y_0 \\ \text{Decay Constant (ED}_C\text{)} = a \end{array}$$

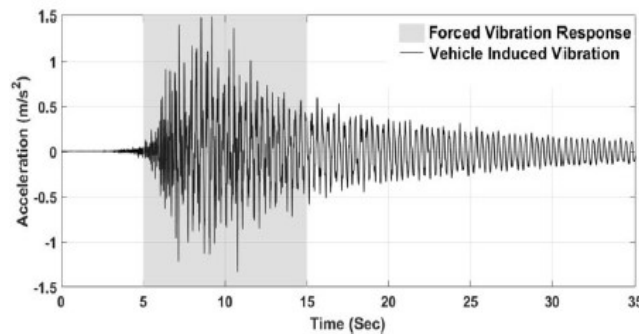


**Hilbert Envelope Intercept**

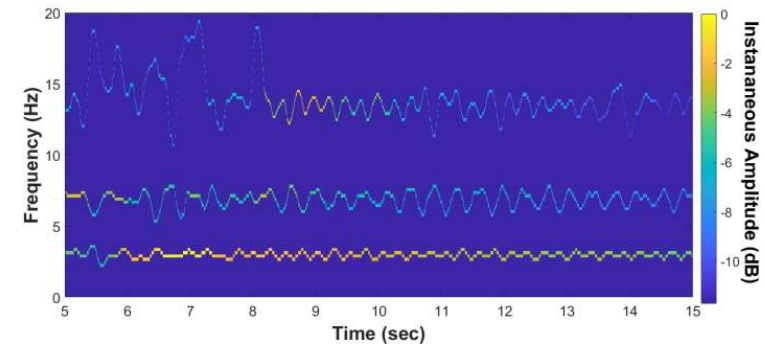


**Hilbert Envelope Decay Constant**

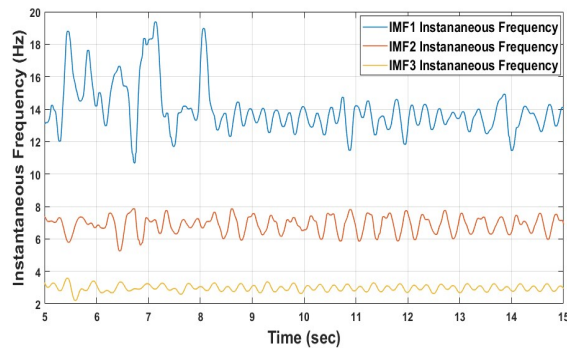
# Damage Identification of Non-Stationary Signals – No.2



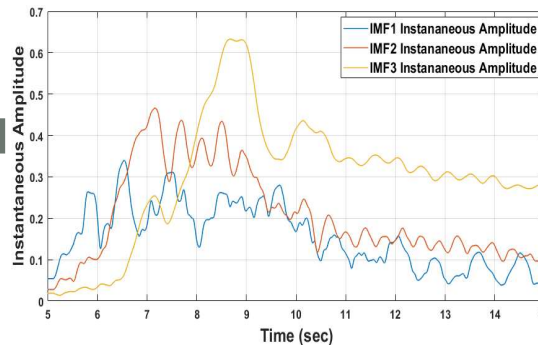
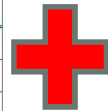
Non-Stationary Data



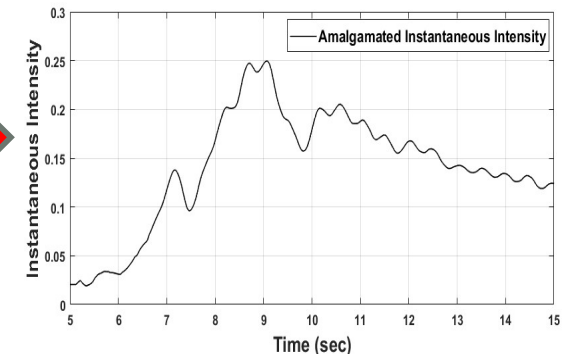
Hilbert Spectrum



Instantaneous  
Frequencies

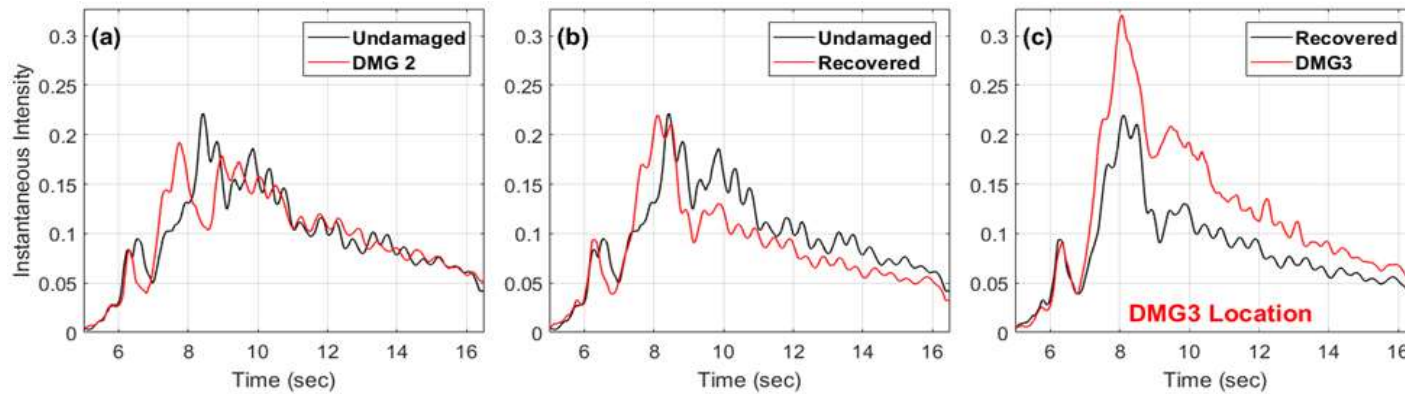


Instantaneous  
Amplitudes

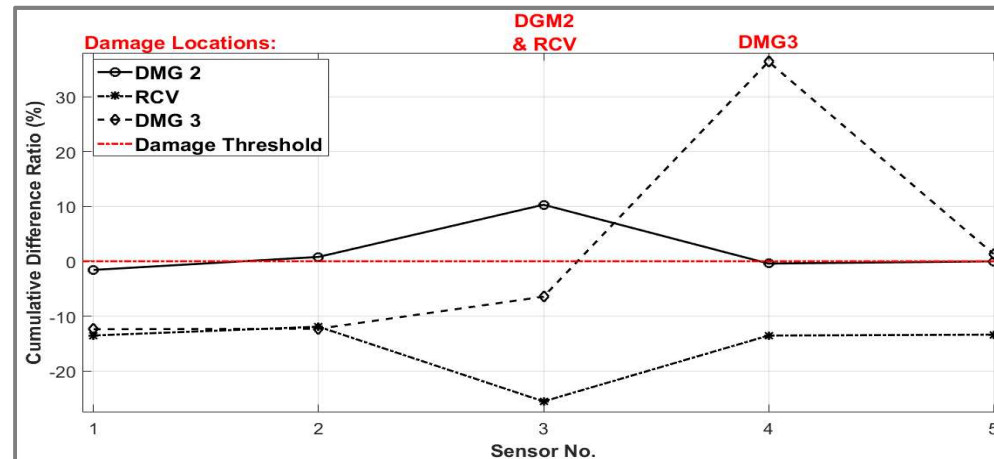


Instantaneous  
Vibration Intensity

# Damage Identification of Non-Stationary Signals – No.2



**Instantaneous Vibration Intensity at Sensor 4 for DMG2, RCV & DMG3**



**IVI Variation at each Sensor for all Damage Scenarios**

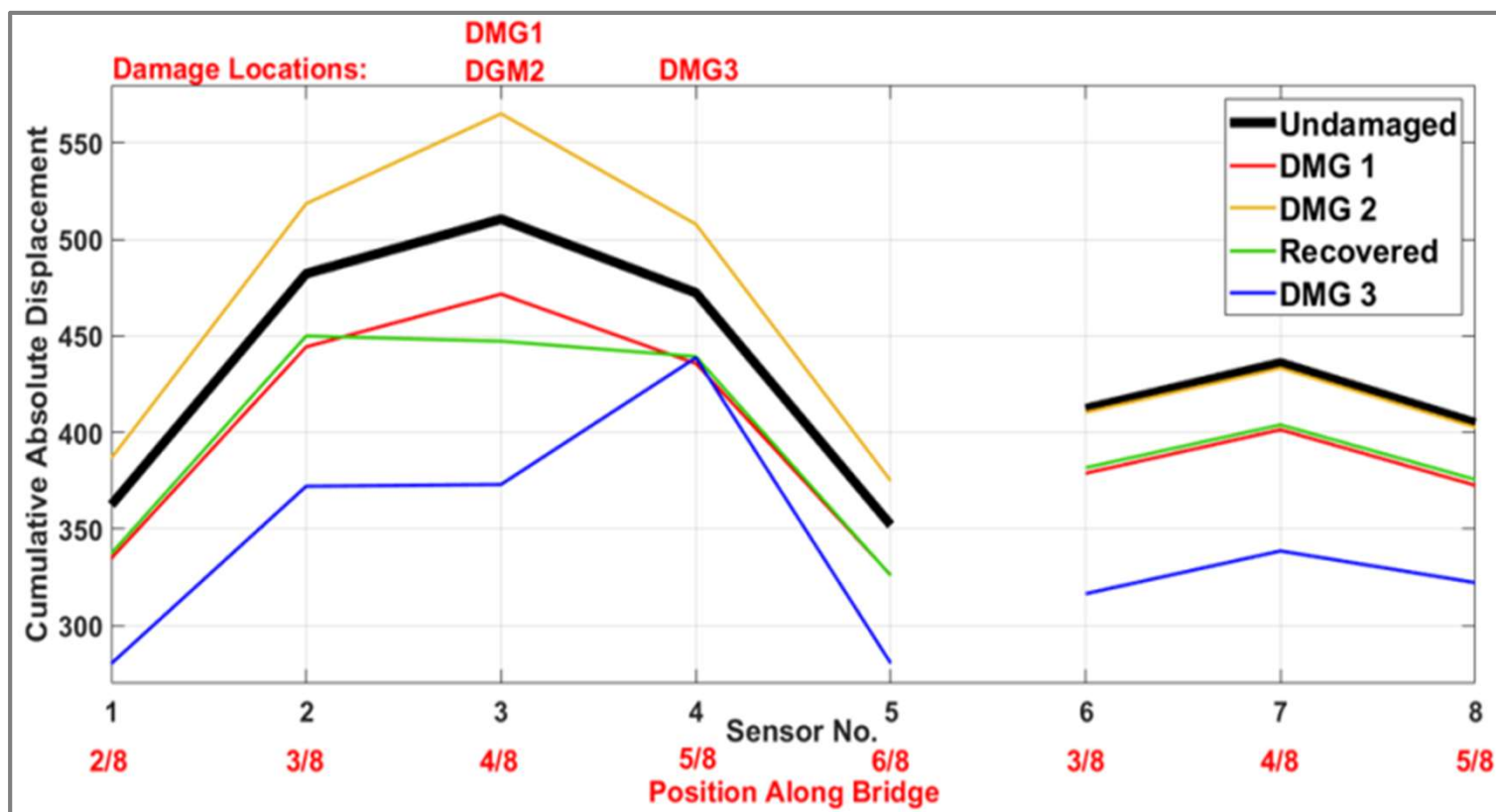


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# Mitigation of vehicle-induced vibration signal variation



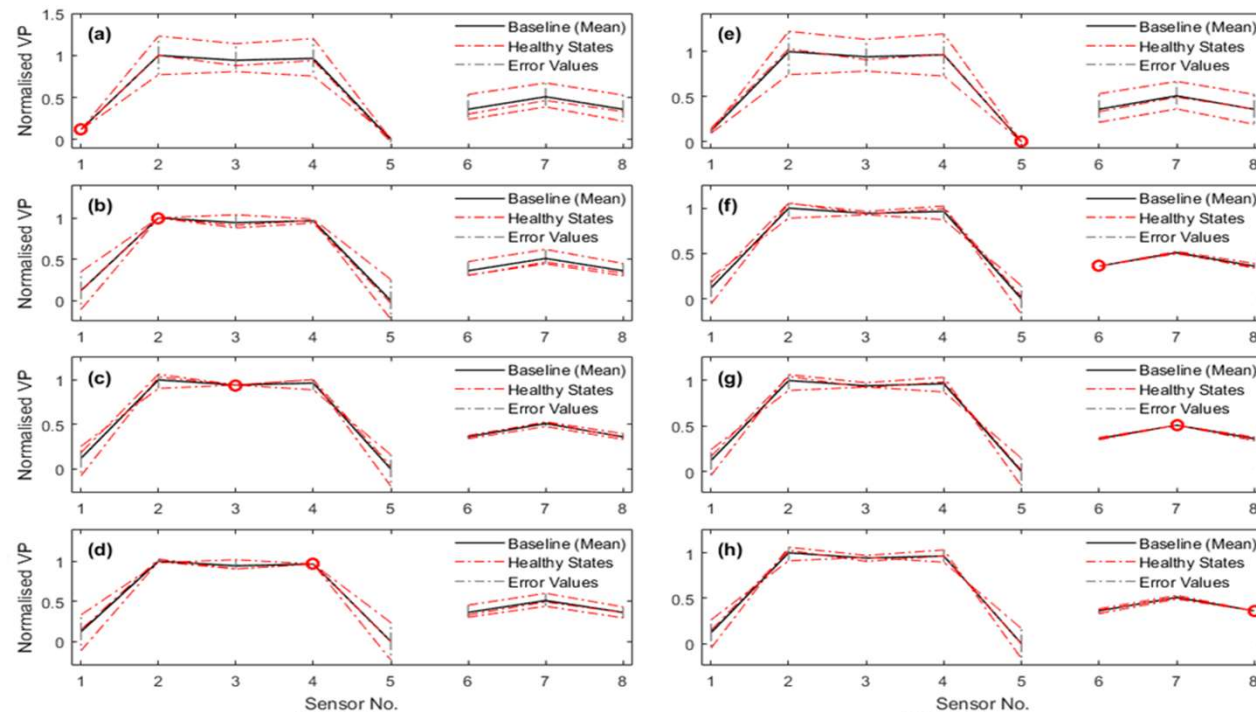


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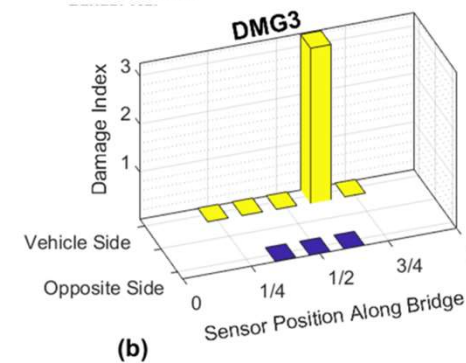
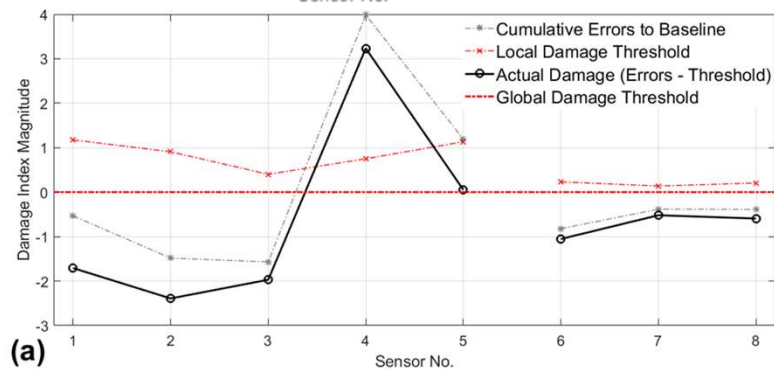
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# Mitigation of vehicle-induced vibration signal variation



**Cumulative  
Errors with  
Threshold**



**Damage  
Plot**



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# Training

Type of Activity	Start date	End date	Title of course/conference/activity and location	No. hours
Language Course	12/10/15	15/12/15	<a href="#">Spanish language course, Merit School, UPC, Barcelona, Spain</a>	50
Course (>1 day)	17/02/16	20/05/16	Machine Learning Course, UPC, Barcelona, Spain	25
Seminar (<=1 day)	11/03/16	11/03/16	Summit on Global Risk in Structural Engineering, IABSE and Finnish Association of Civil Engineers, UPC, Barcelona, Spain	6
Workshop	26/05/16	27/05/16	<a href="#">ISHMII Workshop on Structural Health Monitoring of New and Ageing Infrastructure, Queen's University, Belfast, UK</a>	16
Course (>1 day)	03/07/16	05/07/16	Structural Health Monitoring Using Statistical Pattern Recognition, Los Alamos Dynamics, Bilbao, Spain	20
Conference	05/07/16	08/07/16	<a href="#">8th European Workshop On Structural Health Monitoring EWSHM, Bilbao, Spain</a>	32
Conference	29/08/16	30/08/16	<a href="#">Civil Engineering Research in Ireland 2016 (CERI2016), Galway, Ireland</a>	16
Conference	16/10/16	19/10/16	<a href="#">IALCCE 2016, Delft, The Netherlands</a>	24
Course (>1 day)	15/11/16	30/01/17	Completed two online Matlab courses. One on Machine Learning and the other on Data Processing and Visualization.	30
Language Course	20/11/16	16/12/16	Spanish language course, Don Quijote Language School, Barcelona Spain <a href="http://www.donquijote.org/en/learn-spanish-in-spain/barcelona">http://www.donquijote.org/en/learn-spanish-in-spain/barcelona</a>	30
Secondment (Short Stay < 3 months)	10/10/16	23/12/16	Secondment in COMSA offices in Barcelona	20
Seminar (<=1 day)	05/04/17	05/04/17	Gave presentation to a visiting professor (Al Ghorbanpoor de la University of Wi	2
Conference	18/06/17	22/06/17	<a href="#">ESREL 2017 Porto Roz, Slovenia</a>	24
Conference	12/07/17	14/07/17	<a href="#">EVACES 2017, San Diego, California, USA</a>	16
Conference	22/07/17	23/07/17	<a href="#">ANCRISST 2017, Tokyo, Japan</a>	8
Course (>1 day)	17/07/17	04/08/17	<a href="#">APESS 2017, Yokohama, Japan</a>	120
Conference	10/09/17	13/09/17	<a href="#">EURODYN 2017, Rome, Italy</a>	20
Outreach(open day, talks)	13/11/17	13/11/17	Outreach Activity in UCD (Dublin, Ireland)	2
Outreach(open day, talks)	08/06/17	08/06/17	Outreach Activity In UPC (Barcelona, Spain)	2

# Dissemination - 1

Type of Publicat...	Start date (only if conference)	End date	Title of Publication	Authors (in the same order as published)	Full ref.(name,location or volume, page nos.,year)
Conference publication	05/07/16	08/07/16	Vibration Based Damage Detection Techniques for Small to Medium Span Bridges: A Review and Case Study	Moughty, J.J., Casas, J.R.	8th European Workshop on Structural Health Monitoring, EWHSM, Bilbao
Conference publication	29/08/16	30/08/16	Advancements of Vibration Based Damage Detection Techniques for Small to Medium Span Bridges	Moughty, J.J., Casas, J.R.	Civil Engineering Research in Ireland, CERI 2016, Galway, Ireland
Conference publication	16/10/16	19/10/16	Assessment of vibration intensity as a condition and safety indicator for short-span bridges	Moughty, J.J., Casas, J.R., Rodrigues, R.	IALCCE 2016, Delft, The Netherlands
Conference publication	18/06/17	22/06/17	Evaluation of the Hilbert Huang Transformation of Transient Signals for Bridge Condition Assessment	Moughty, J.J., Casas, J.R.	ESREL 2017, Portoroz, Slovenia
Conference publication	12/07/17	14/07/17	Damage sensitivity evaluation of vibration parameters under ambient excitation	Moughty, J.J., Casas, J.R.	(EVACES 2017), San Diego, California, U.S.A.
Conference publication	10/09/17	13/09/17	Performance Assessment of Vibration Parameters as Damage Indicators for Bridge Structures under Ambient Excitation	Moughty, J.J., Casas, J.R.	(EURODYN 2017), Rome, Italy

## Dissemination - 2

Type of Publicat...	Start date (only if conference)	End date	Title of Publication	Authors (in the same order as published)	Full ref.(name,location or volume, page nos.,year)	Brief description of activity
Journal publication		03/02/17	Bridge Damage Detection Based on Vibration Data: Past and New Developments	Casas, J.R. & Moughty, J.J.	Frontiers in Built Environment, Vol 3 (4), pp 1-12	Journal Paper
Journal publication		13/05/17	A State of the Art Review of Modal Based Damage Detection in Bridges: Development, Challenges and Solutions	Moughty, J.J., Casas, J.R.	Applied Sciences, 2017, 7, 510.	Journal Paper
Conference publication	09/07/18	13/07/18	Development of Vibration-Based Parameters as Damage Sensitive Features for Bridge Structures	Moughty, J.J., Casas, J.R.	(IABMAS, 2018), Melbourne, Australia	Conference Paper
Conference publication	29/08/18	30/08/18	Vibration-Based, Output-Only Damage Identification of Bridge under Vehicle Induced Excitation	Moughty, J.J., Casas, J.R.	(CERI, 2018) Dublin, Ireland	Conference Paper
Conference publication	28/10/18	31/10/18	Noninvasive Empirical Methods of Damage Identification of Bridge Structures using Vibration Data	Moughty, J.J., Casas, J.R.	(IALCCE, 2018) Ghent, Belgium	Conference Paper
Conference publication	28/10/18	31/10/18	Damage Identification of Bridge Structures using the Hilbert-Huang Transform	Moughty, J.J., Casas, J.R.	(IALCCE, 2018) Ghent, Belgium	Conference Paper

# Outreach

- Participated in UPC Doctoral School Open Day
- Participated in Science Week 2017 in Ireland
- Dissemination Research to visiting Professors at UPC

