

# Young Researchers Seminar 2009

Torino, Italy, 3 to 5 June 2009

## Calculating a Bridge Assessment Dynamic Ratio Using a Bridge Weigh-In-Motion system

Jason Dowling

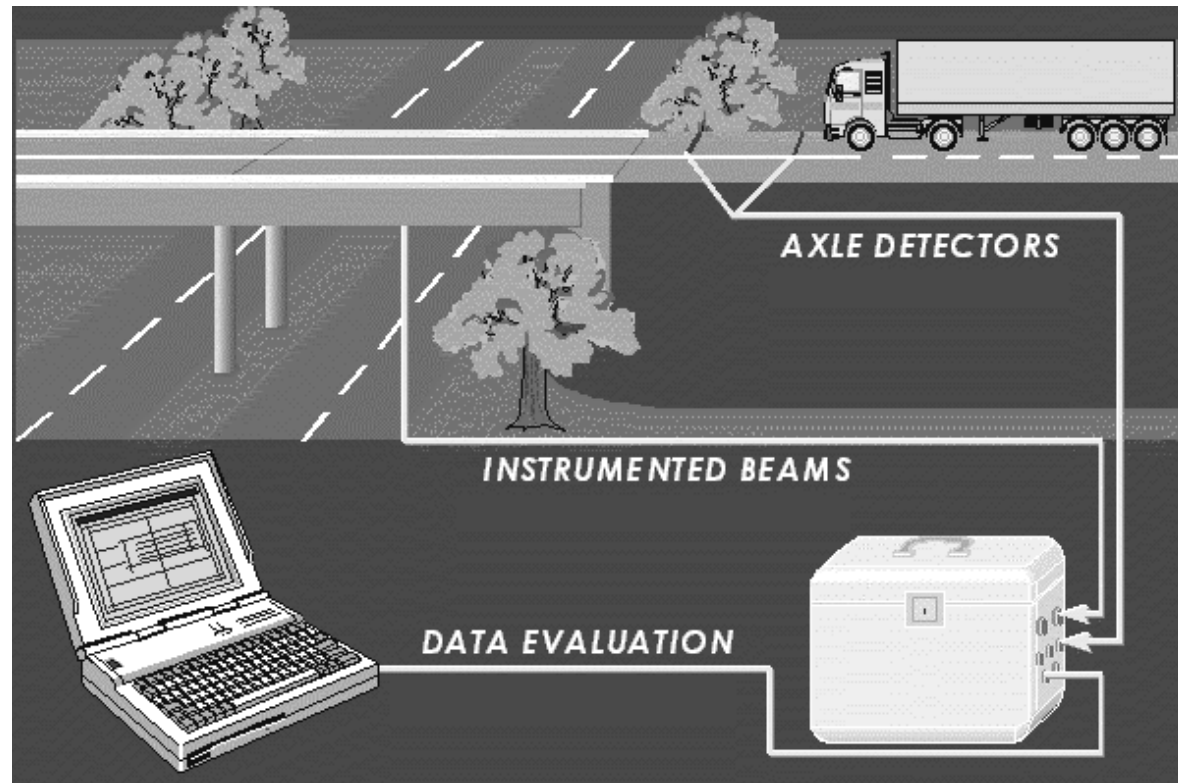


# Overview

1. Bridge Weigh-In-Motion
2. Model Description
3. Assessment Dynamic Ratio
4. Theoretical Simulations - New Algorithm
5. Conclusions

# Bridge Weigh-In-Motion

## Instrumented Bridges....



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# Bridge Weigh-In-Motion

Moses Algorithm (1979)

$$\text{Err} = \sum (M^{\text{th}} - M^{\text{me}})^2$$

$$\frac{\partial \text{Err}}{\partial W_1} = 0$$

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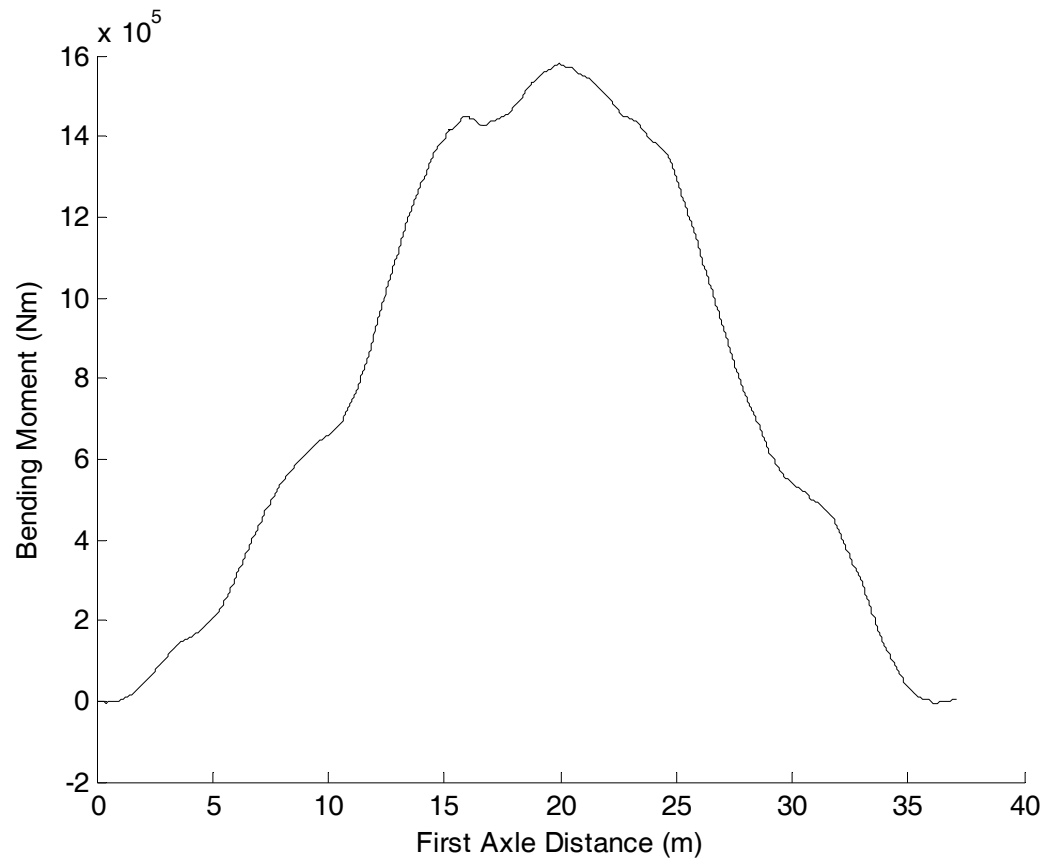
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# Bridge Weigh-In-Motion

Typical 'Measured' Response,  $M^{\text{me}} \dots$



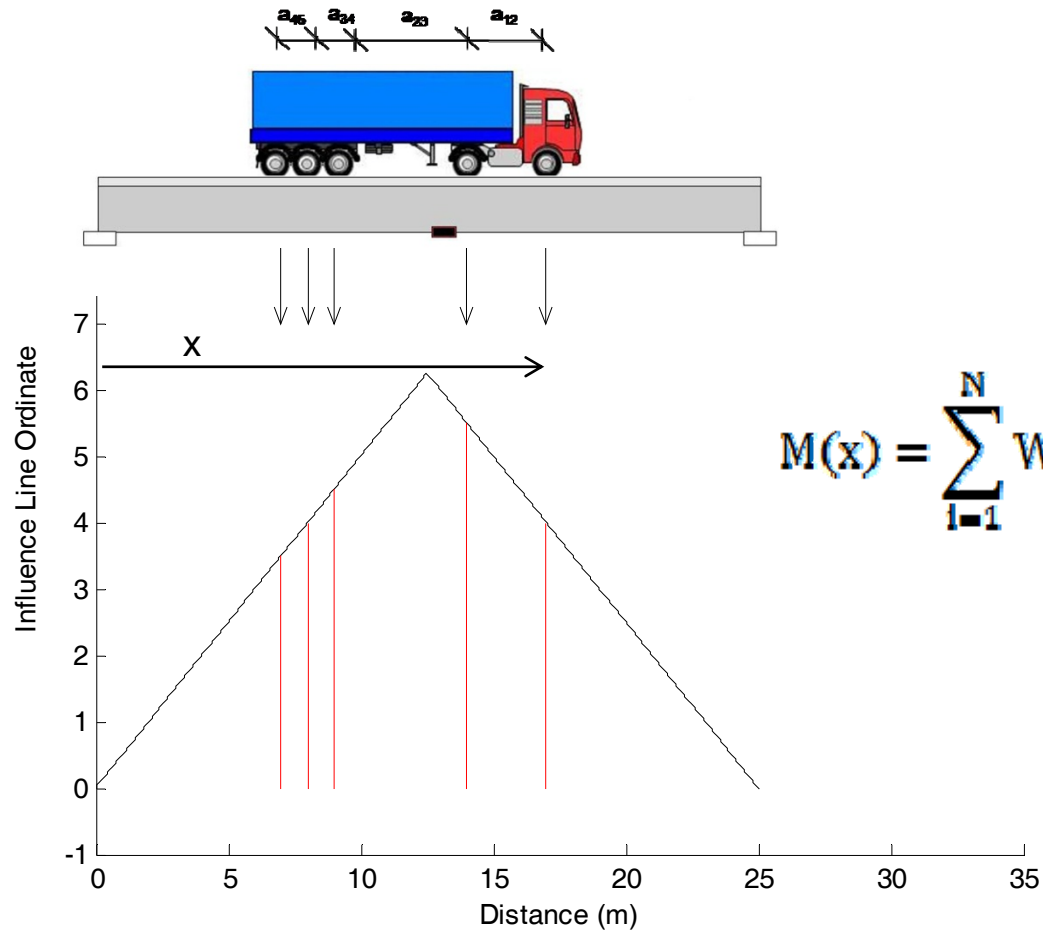
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# Bridge Weigh-In-Motion

M<sup>th</sup>...



$$M(x) = \sum_{i=1}^N W_i I(x - \sum_{i=1}^{N-1} a_{i,i+1})$$

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# Bridge Weigh-In-Motion

Moses Algorithm (1979)

$$\text{Err} = \sum (M^{\text{th}} - M^{\text{me}})^2$$

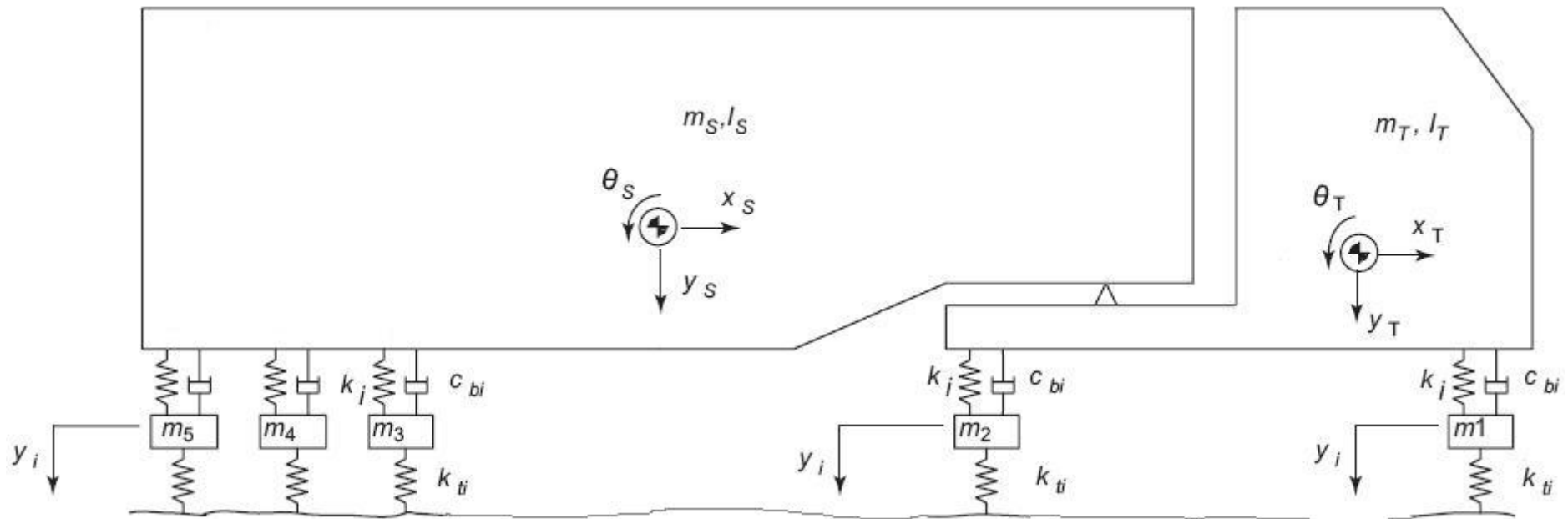
$$\frac{\partial \text{Err}}{\partial W_i} = 0$$

Matrix solution technique:

$$\{W\} = [F]^{-1}\{B\}$$

# Model Description

## Truck Model...



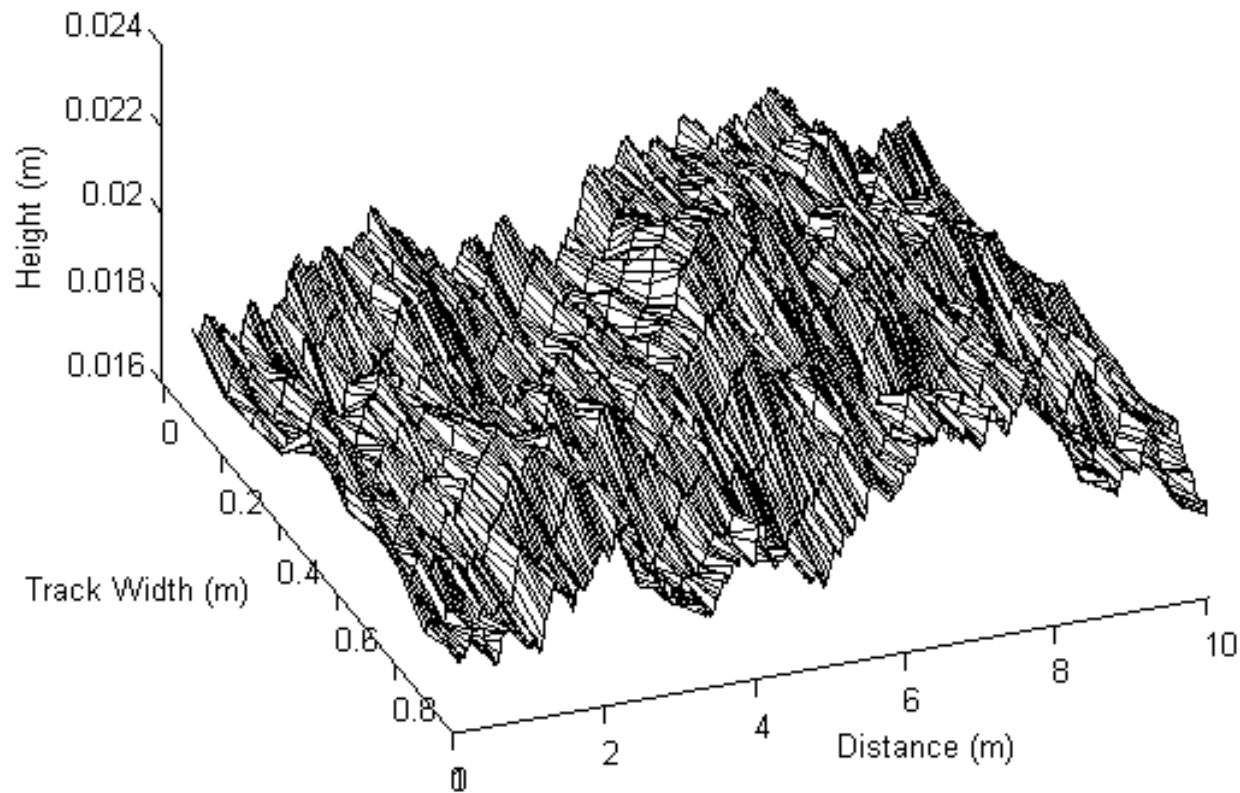
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# Model Description

## Road 'Carpet' Profile



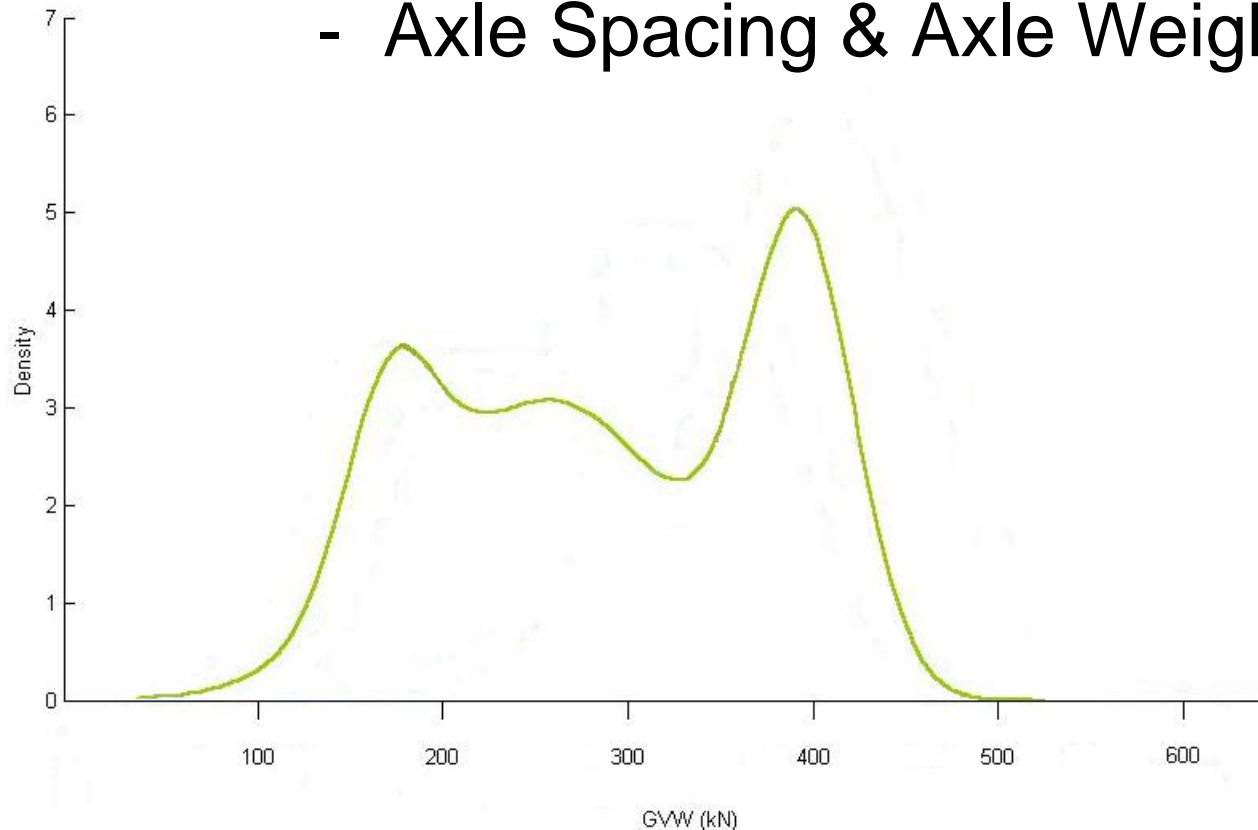
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# Model Description

## Statistical Data - GVW & Velocity - Axle Spacing & Axle Weights



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# Assessment Dynamic Ratio (ADR)

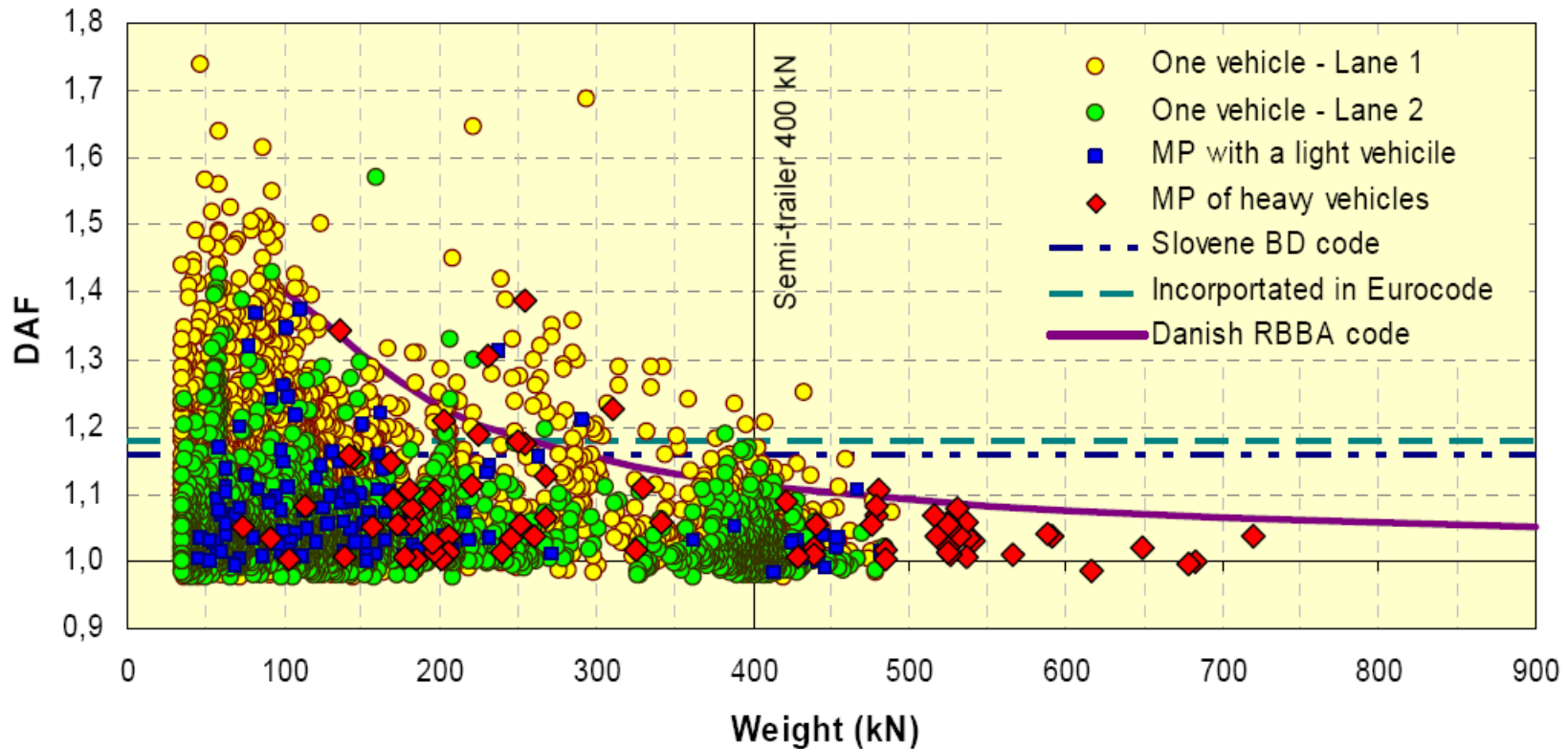
Definition:

$$\text{ADR} = \frac{\text{characteristic } \textit{total} \text{ load effect}}{\text{characteristic } \textit{static} \text{ load effect}}$$

associated with a return period

i.e. not a single event.

# Trends in ADR



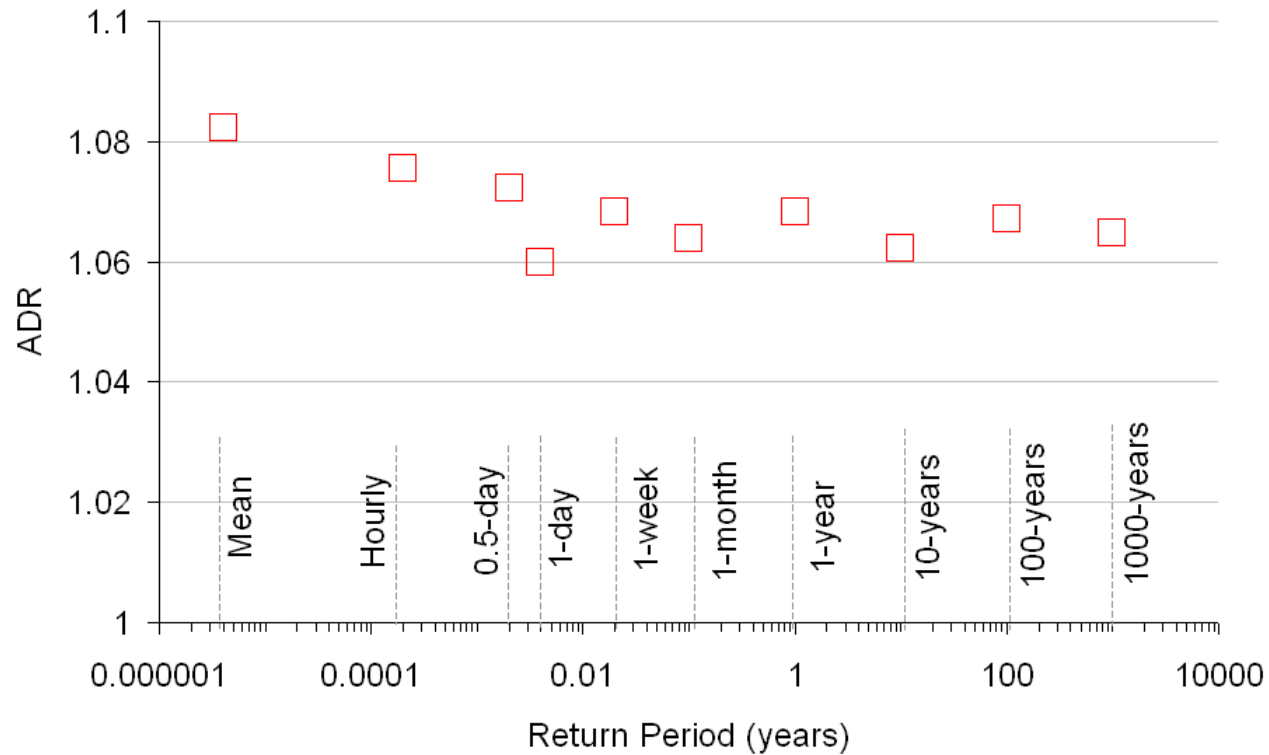
Source: SAMARIS (2006)

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# Trends in ADR



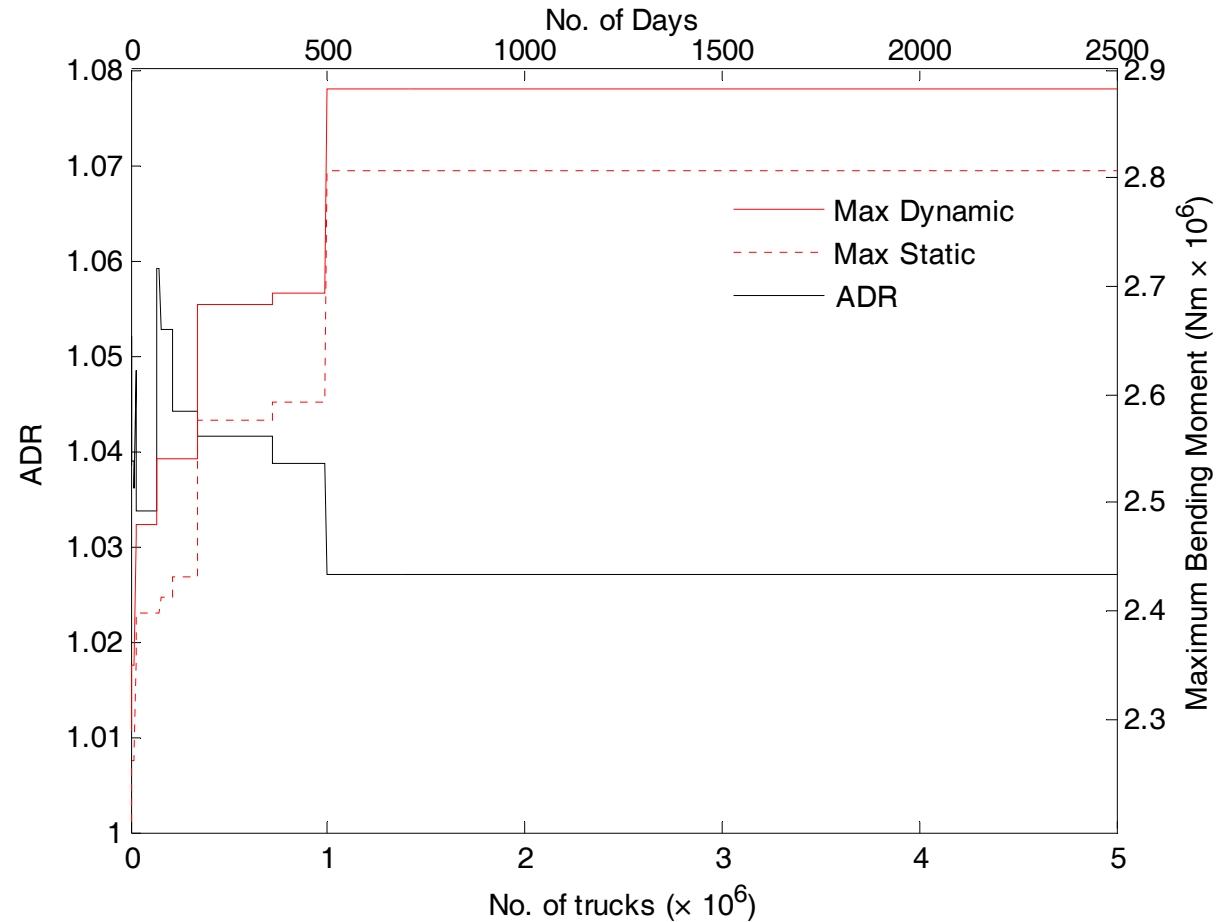
Source: OBrien *et. al* (2009)

# Theoretical Simulations - ADR

10 years...

(500,000  
trucks/year)

25m Bridge  
Class 'A'



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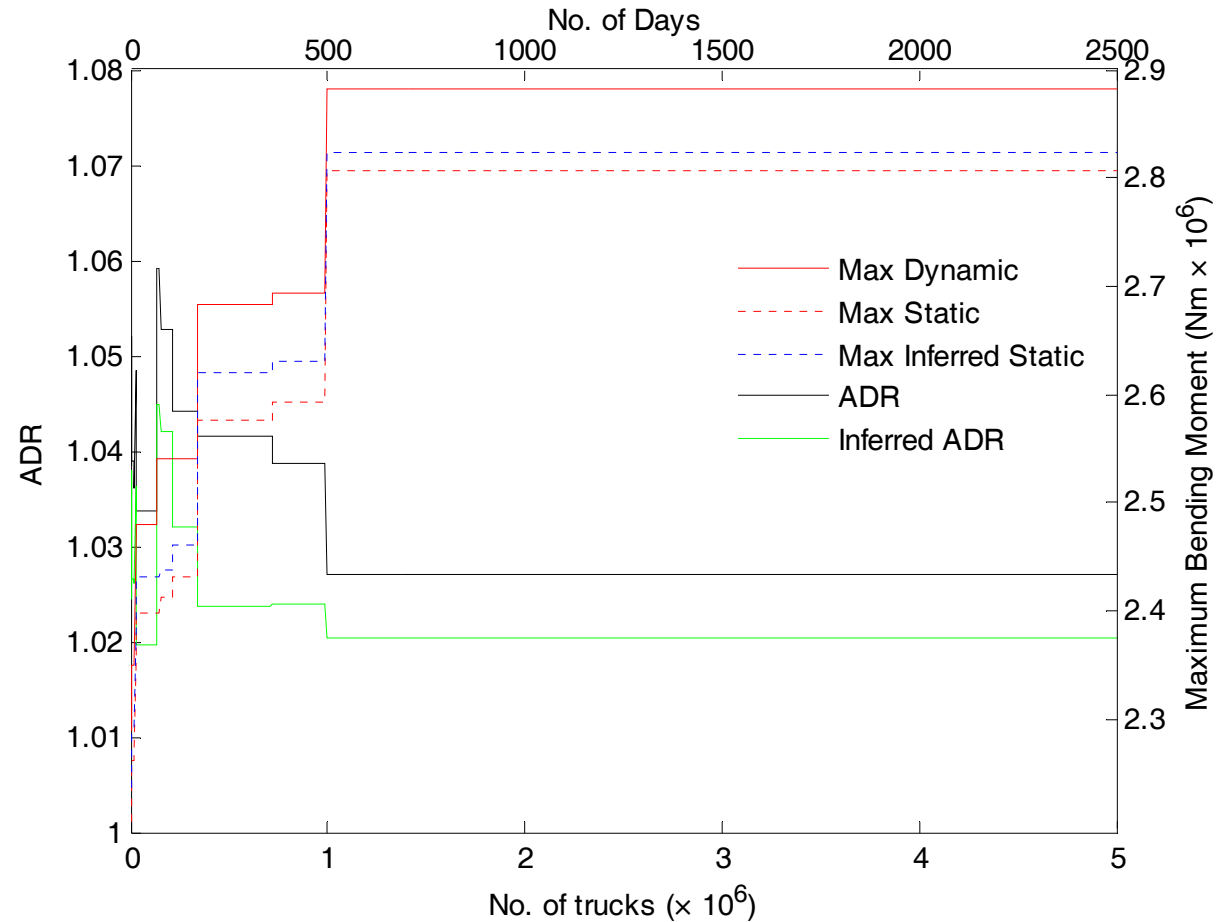


# Theoretical Simulations - ADR

10 years...

(500,000  
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25m Bridge  
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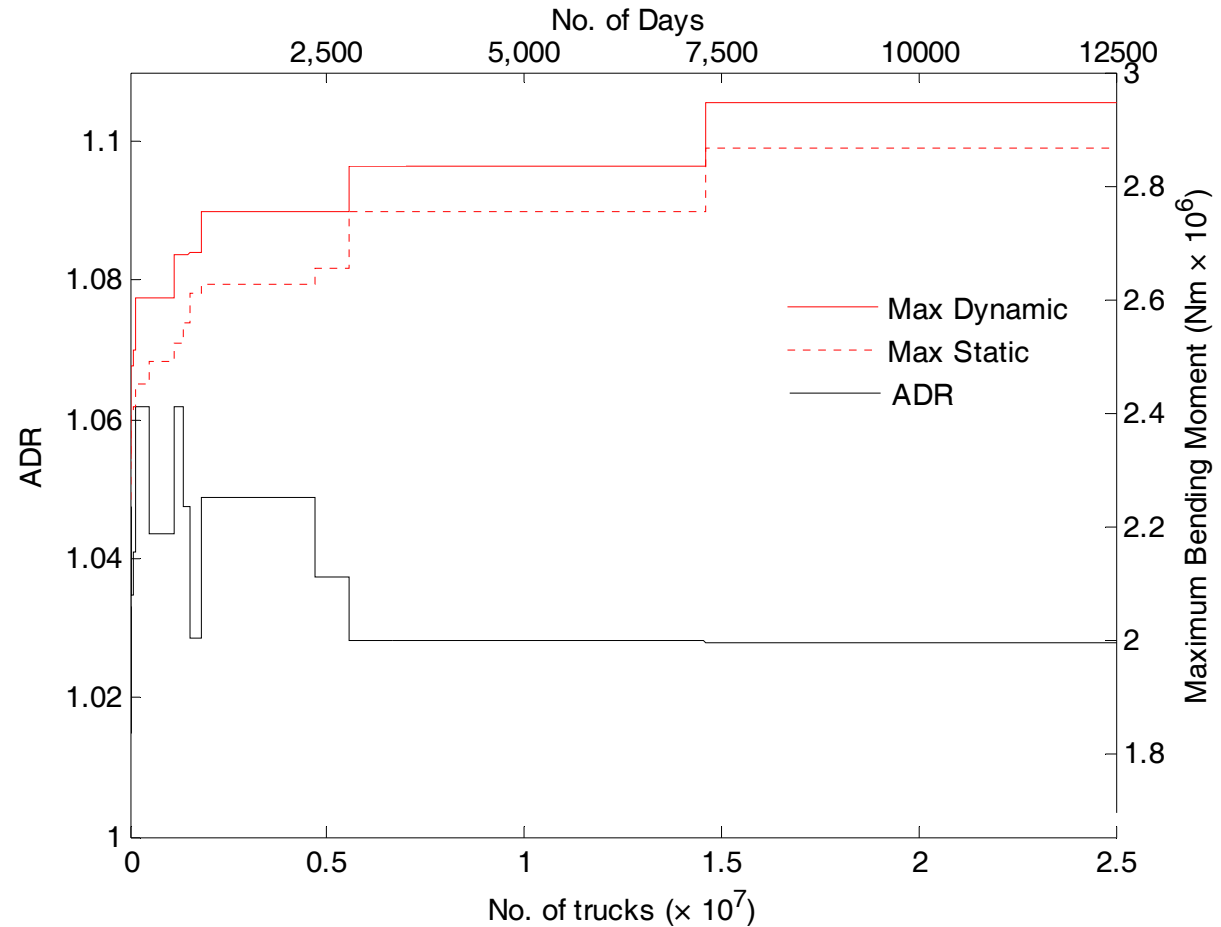
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# Theoretical Simulations - ADR

50 years

25m Bridge  
Class 'A'



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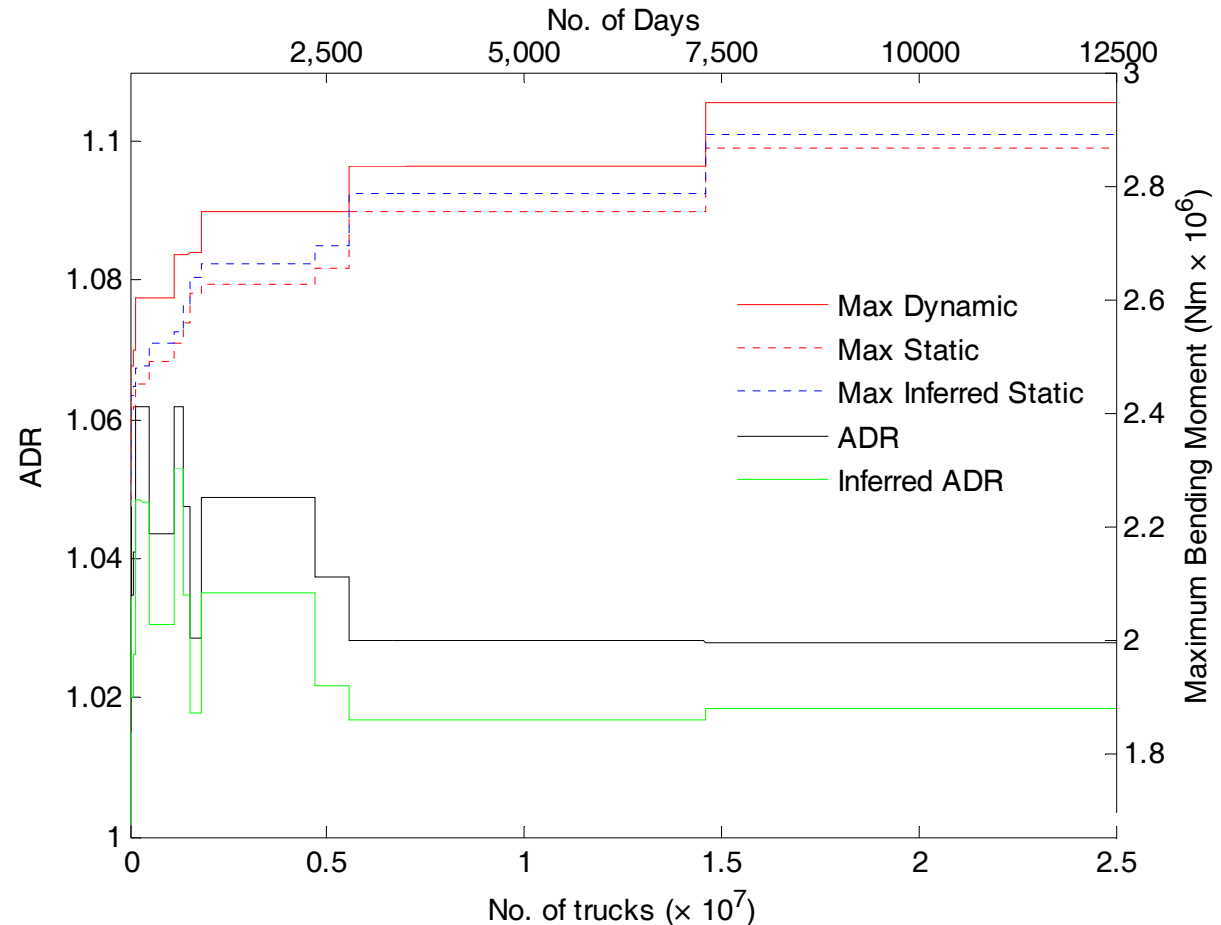
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# Theoretical Simulations - ADR

50 years

25m Bridge  
Class 'A'



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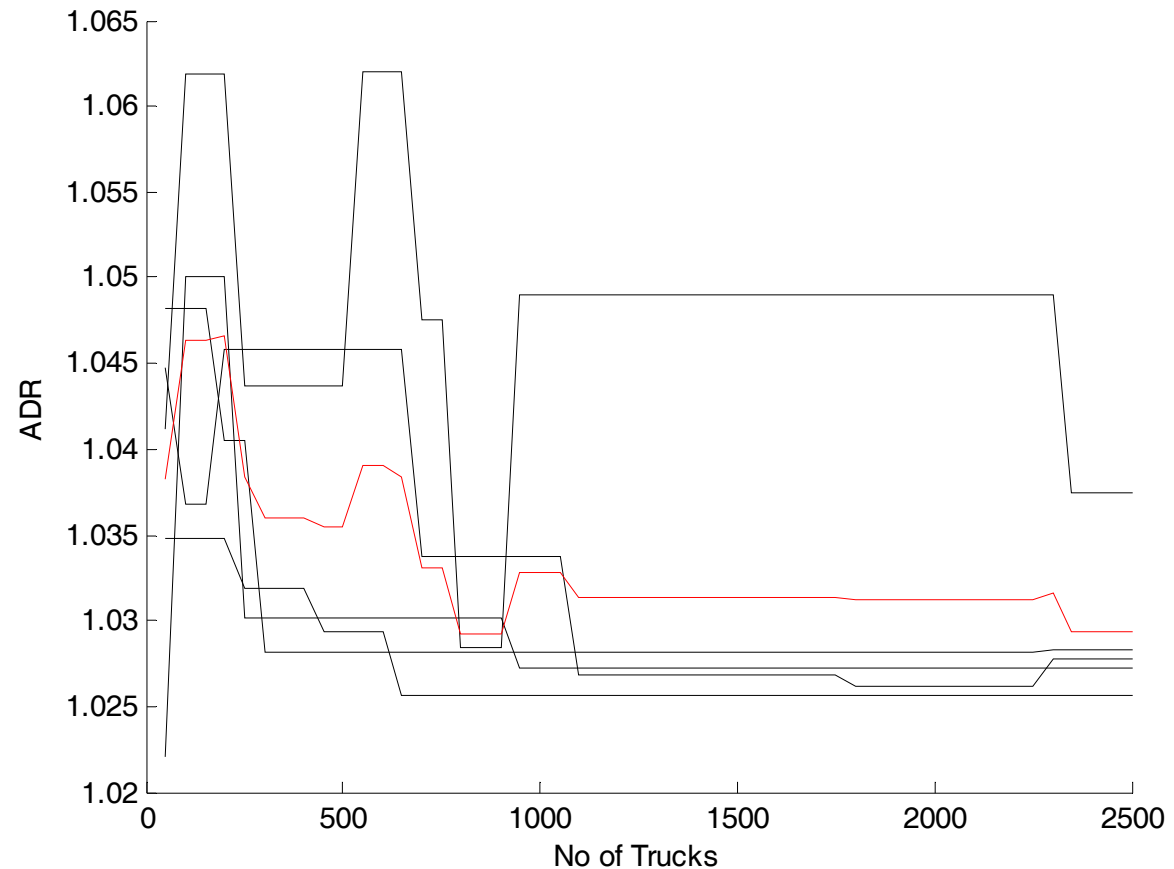
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# Theoretical Simulations - ADR

Simulation  
Variability...

Five 10 year  
simulations



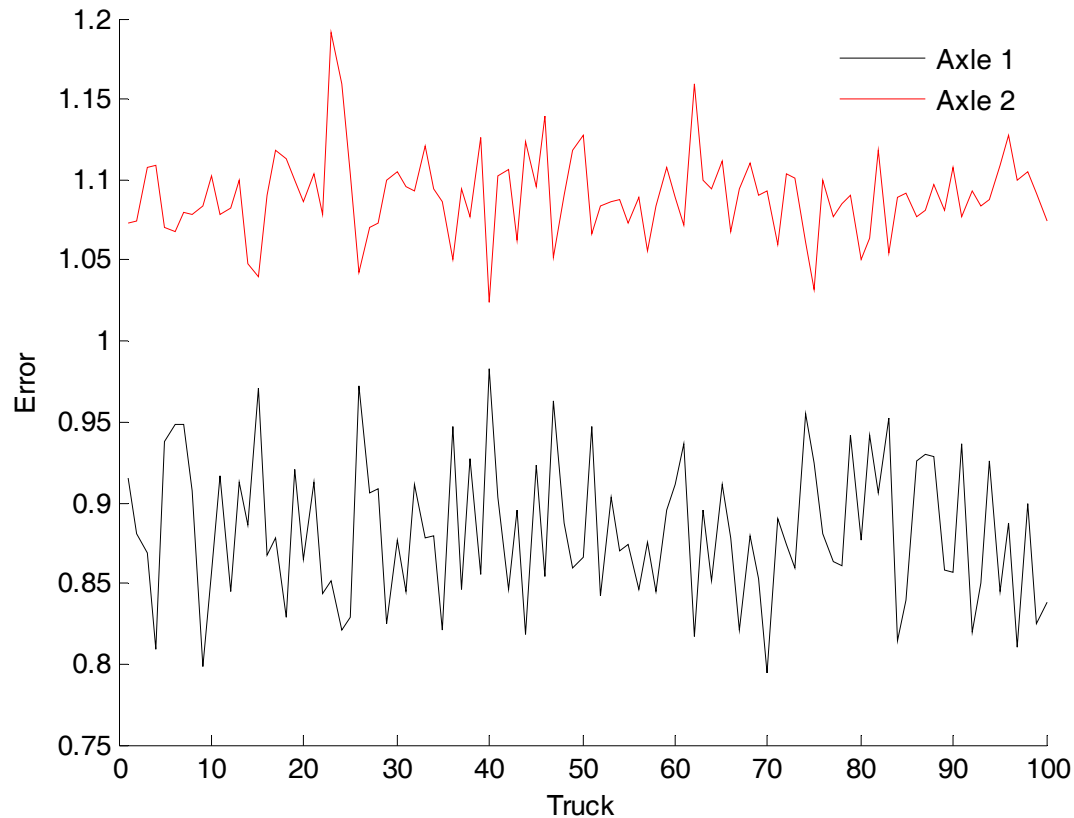
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# Theoretical Simulations - Errors...

Tendency to under-weigh Steer Axle...



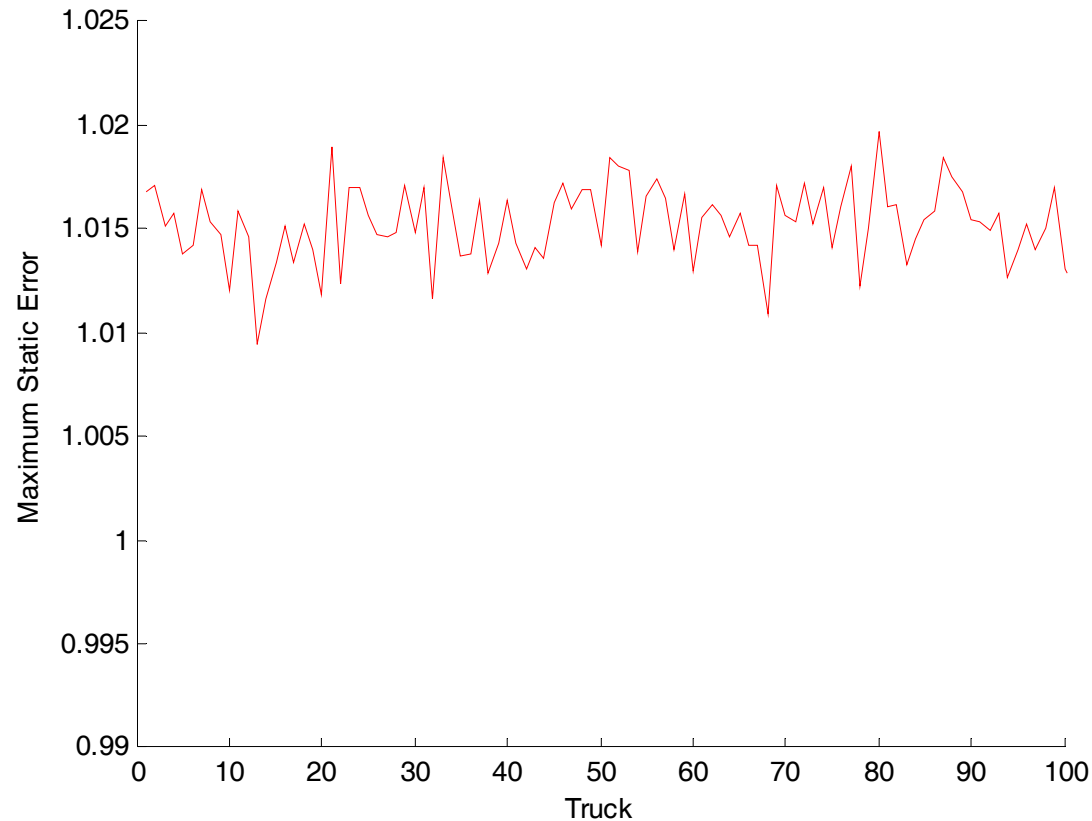
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# Theoretical Simulations - Errors...

## Cause of under-estimation of ADR...



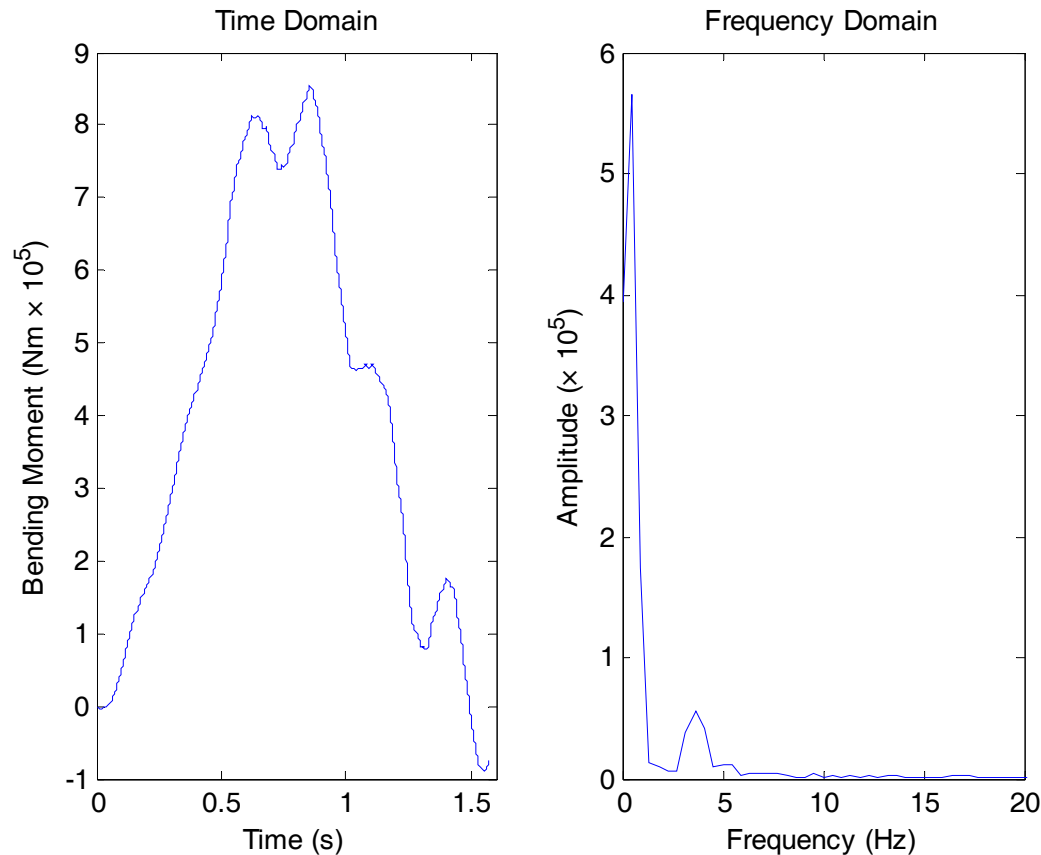
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# Theoretical Simulations - New Algorithm

## Dynamic Response - Time & Freq. Domains



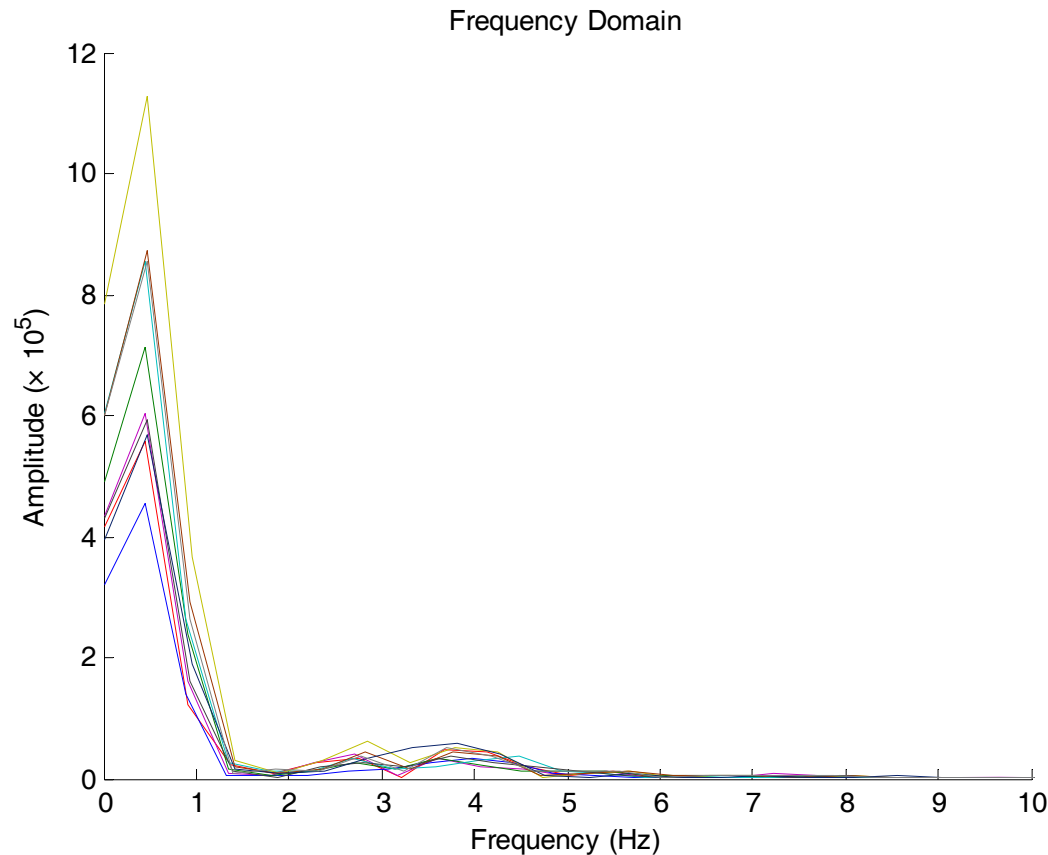
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# Theoretical Simulations - New Algorithm

## 10 Responses represented in the Freq. Domain



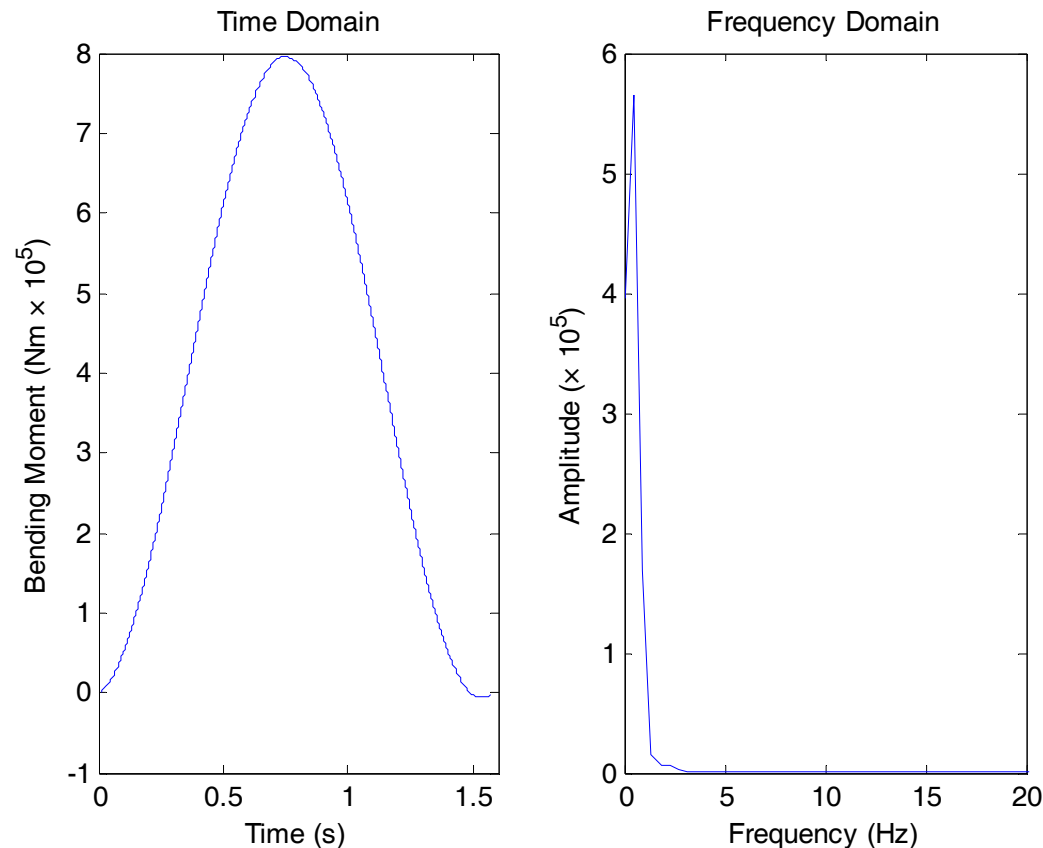
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# Theoretical Simulations - New Algorithm

## Filtered Response - Time & Freq Domains



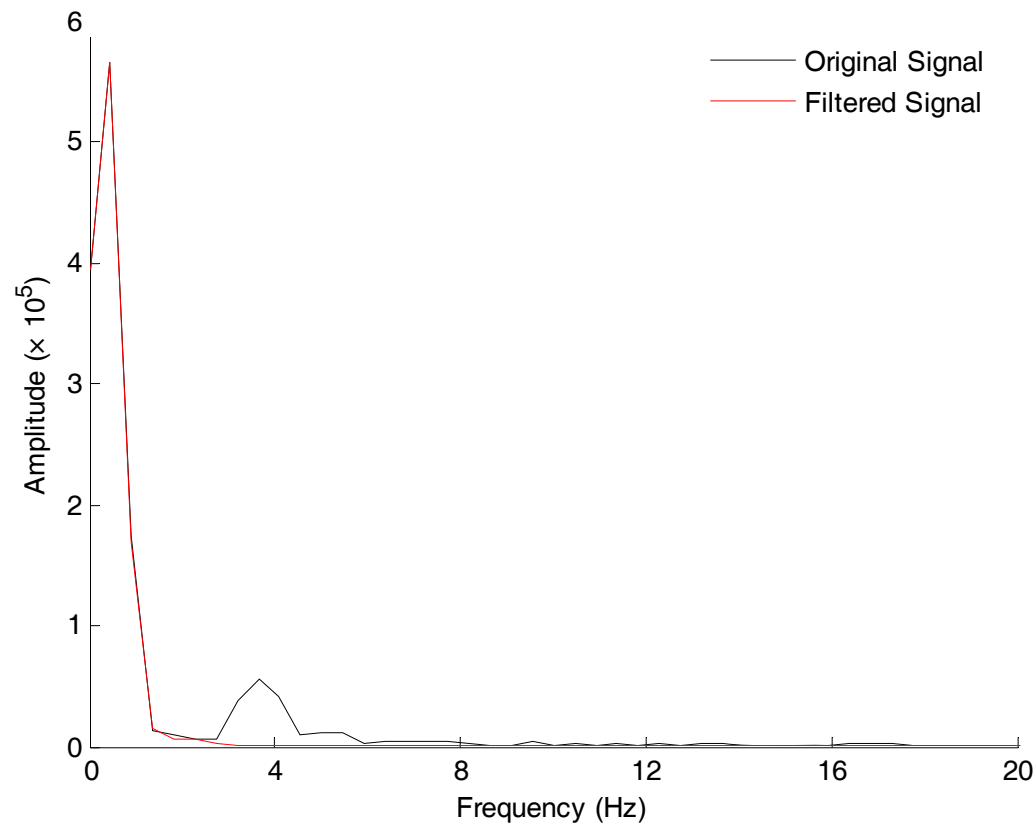
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# Theoretical Simulations - New Algorithm

Incorporating filtering of dynamic signal...



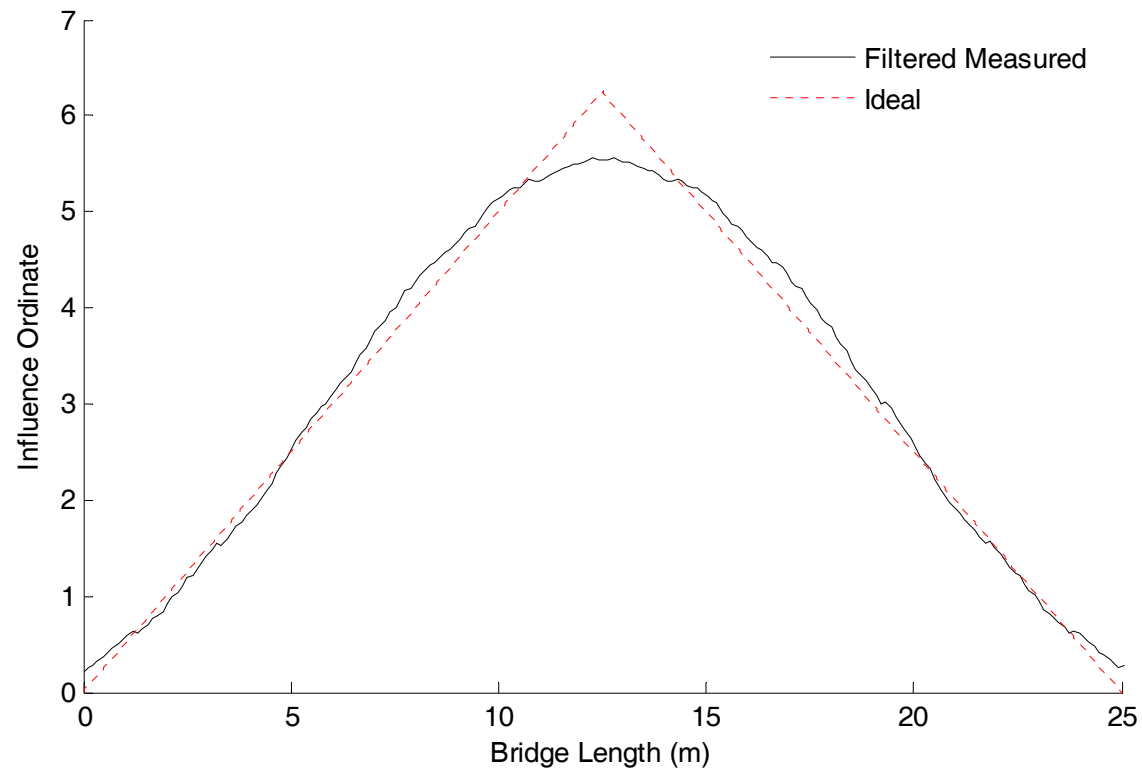
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# Theoretical Simulations - New Algorithm

## 'Measured' Influence Line



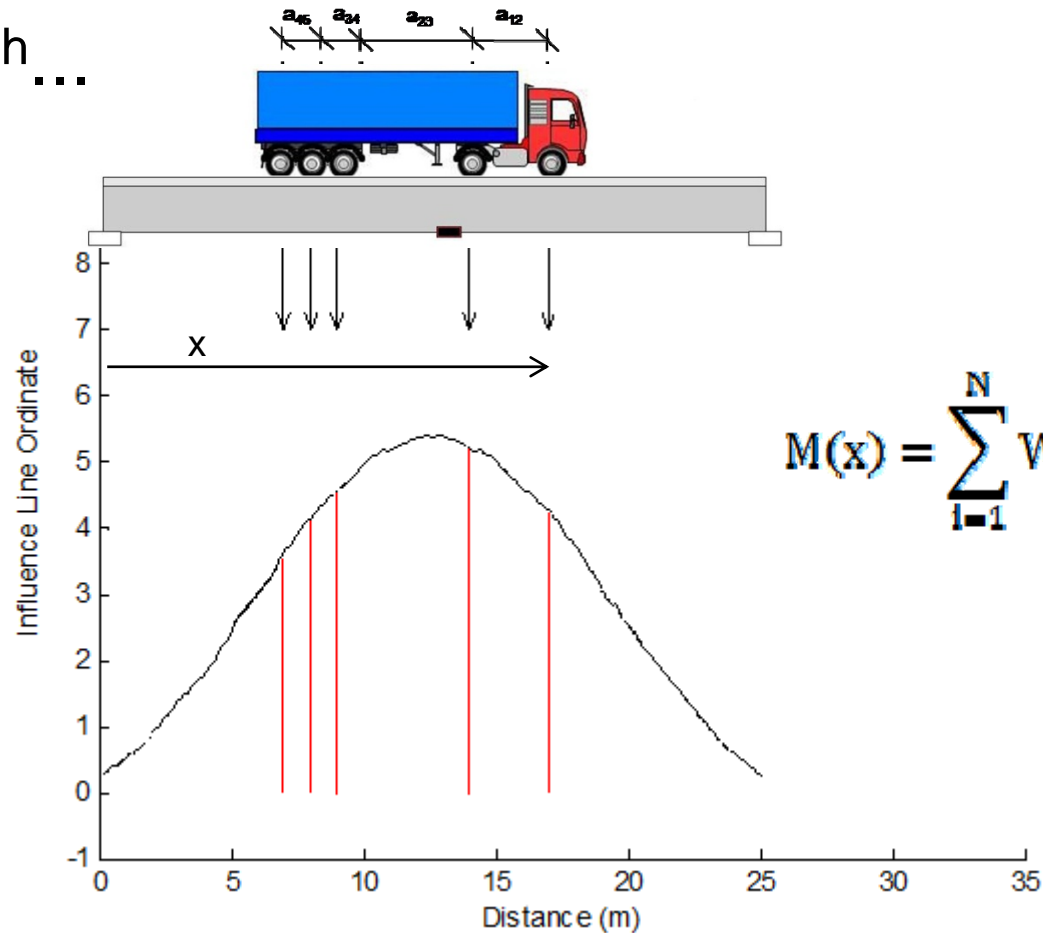
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# Theoretical Simulations - New Algorithm

New  $M^{\text{th}}$ ...



$$M(x) = \sum_{l=1}^N W_l I(x - \sum_{l=1}^{N-1} a_{l,l+1})$$

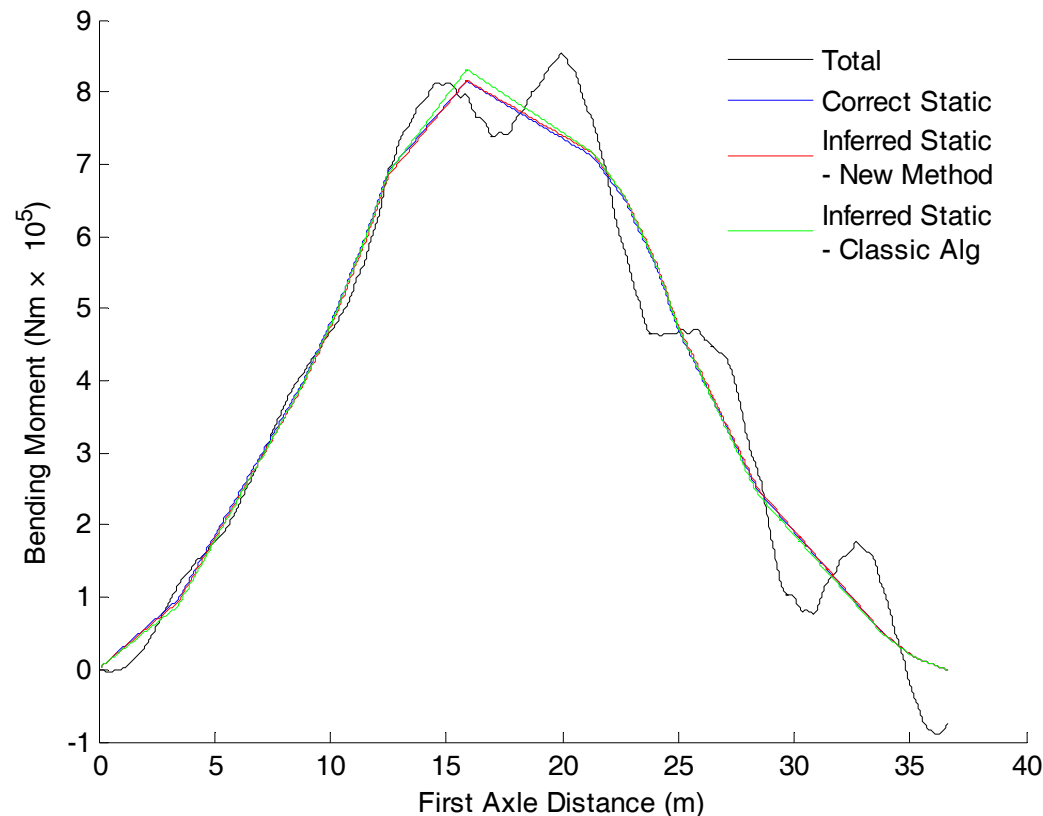
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# Theoretical Simulations - New Algorithm

## Static BM using New Approach



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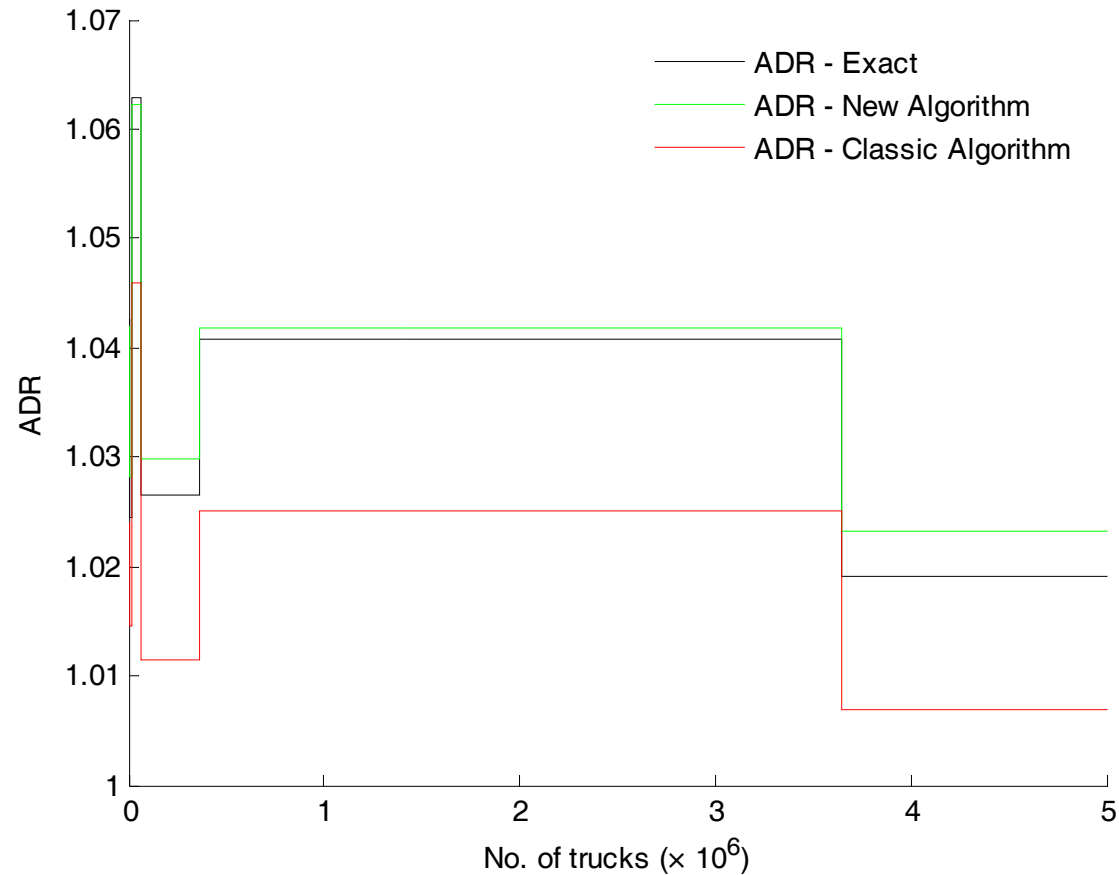
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# Theoretical Simulations - ADR

Example 1:

10 years...



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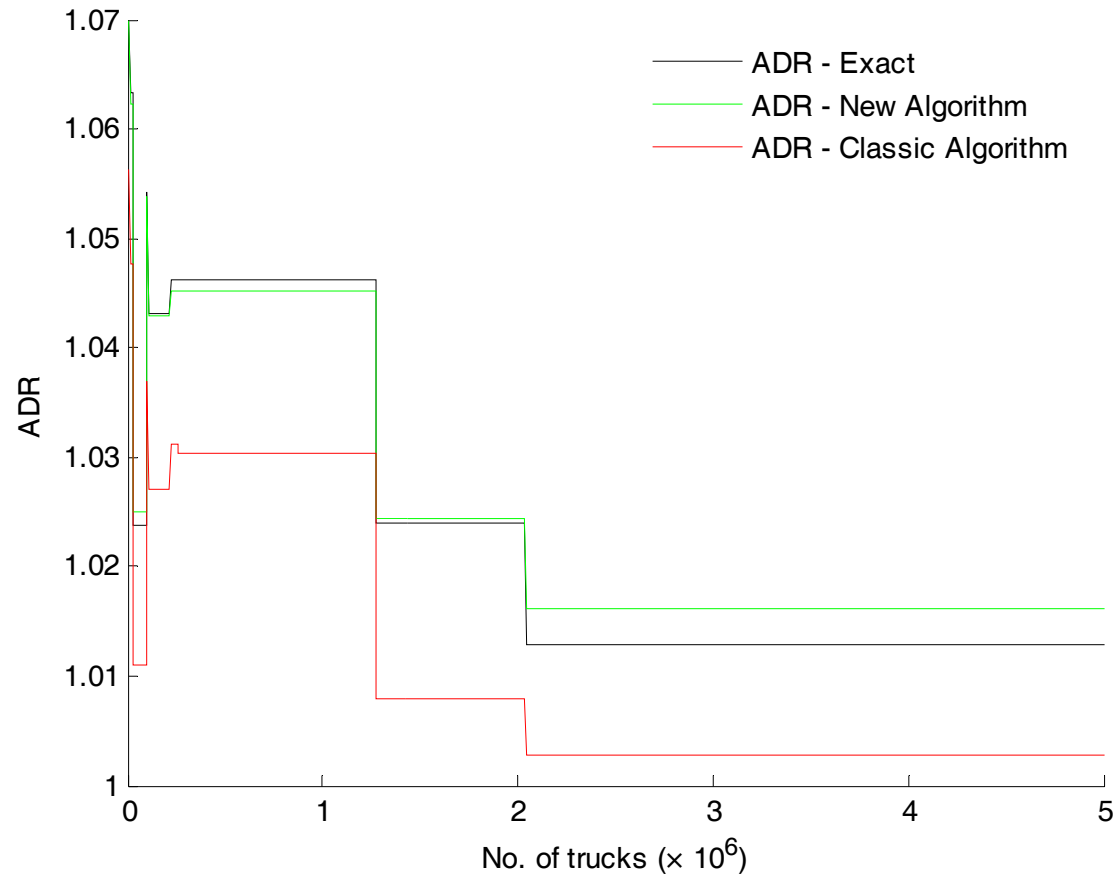
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# Theoretical Simulations - ADR

Example 2:

10 years...



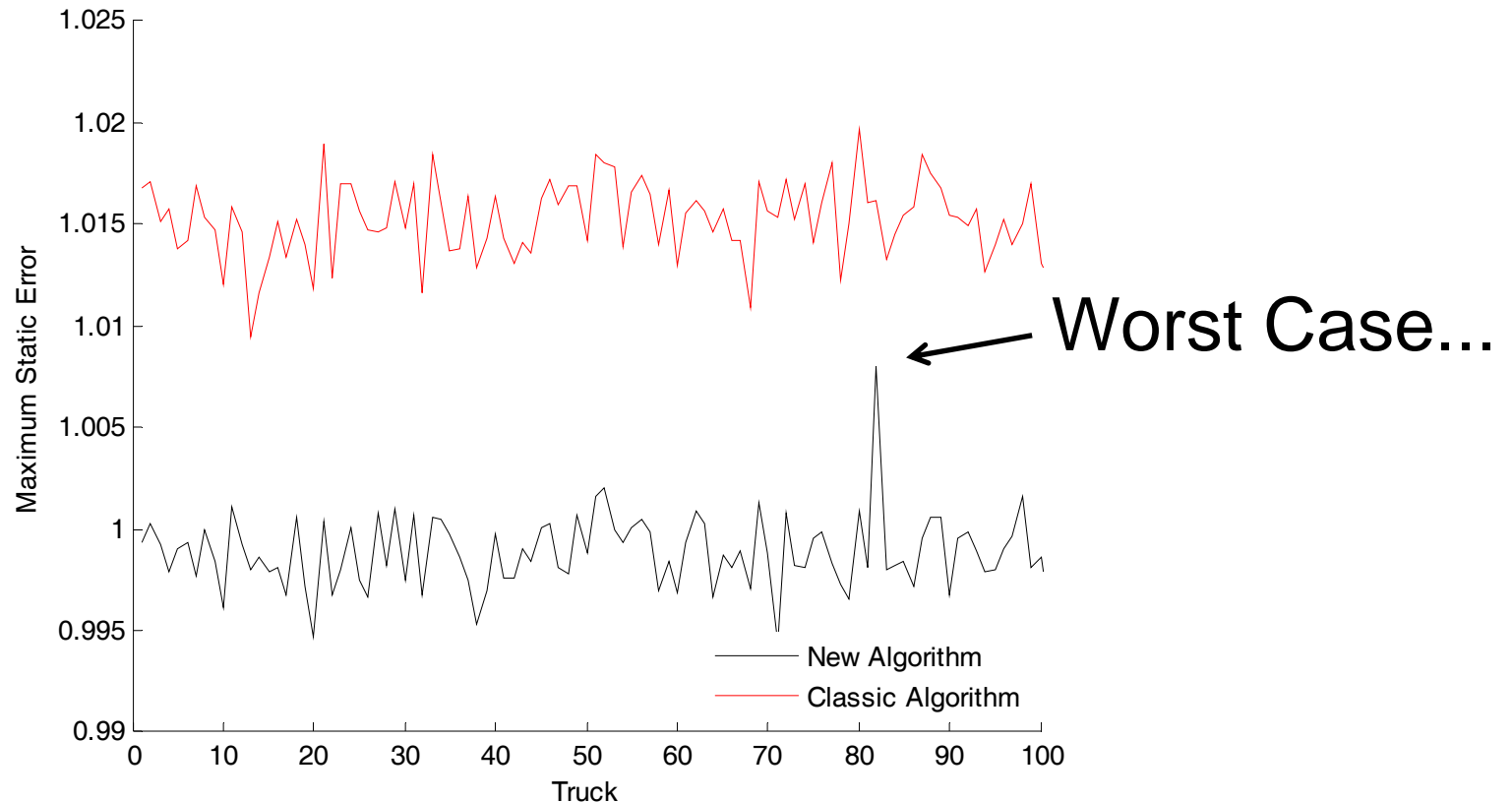
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# Theoretical Simulations - New Algorithm

## Max Static BM Errors using New Approach...



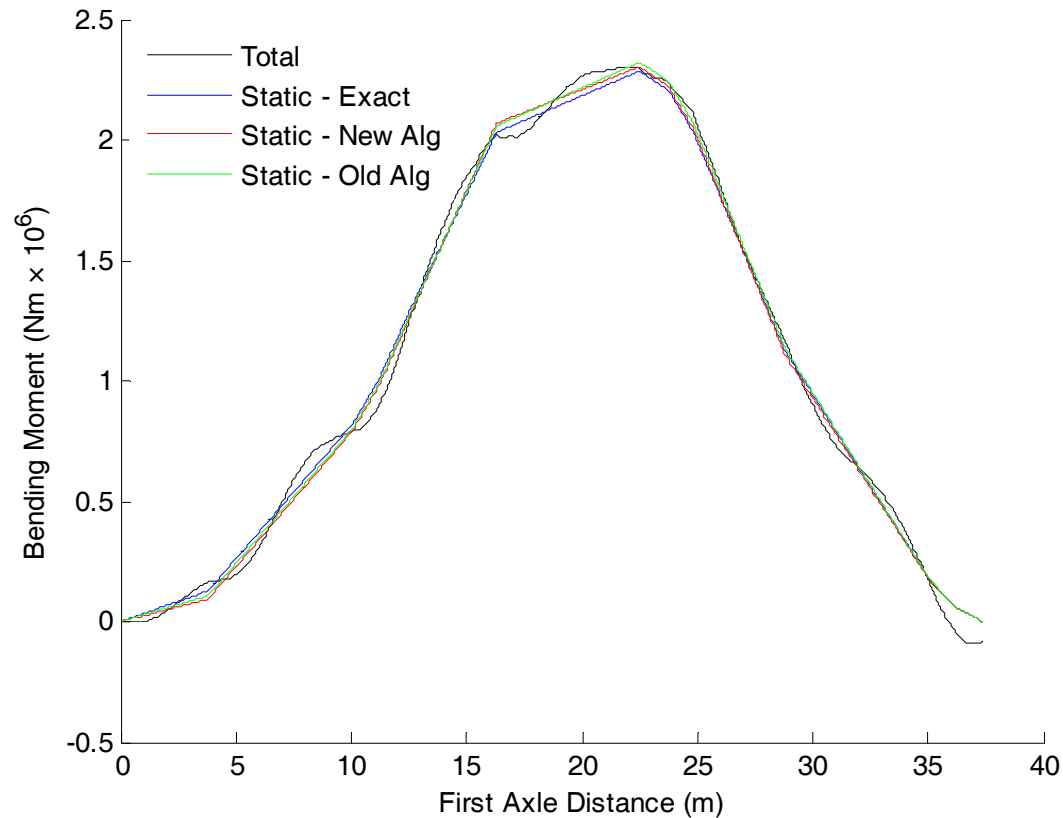
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# Theoretical Simulations - New Algorithm

Worst Case: Max Static BM Error...



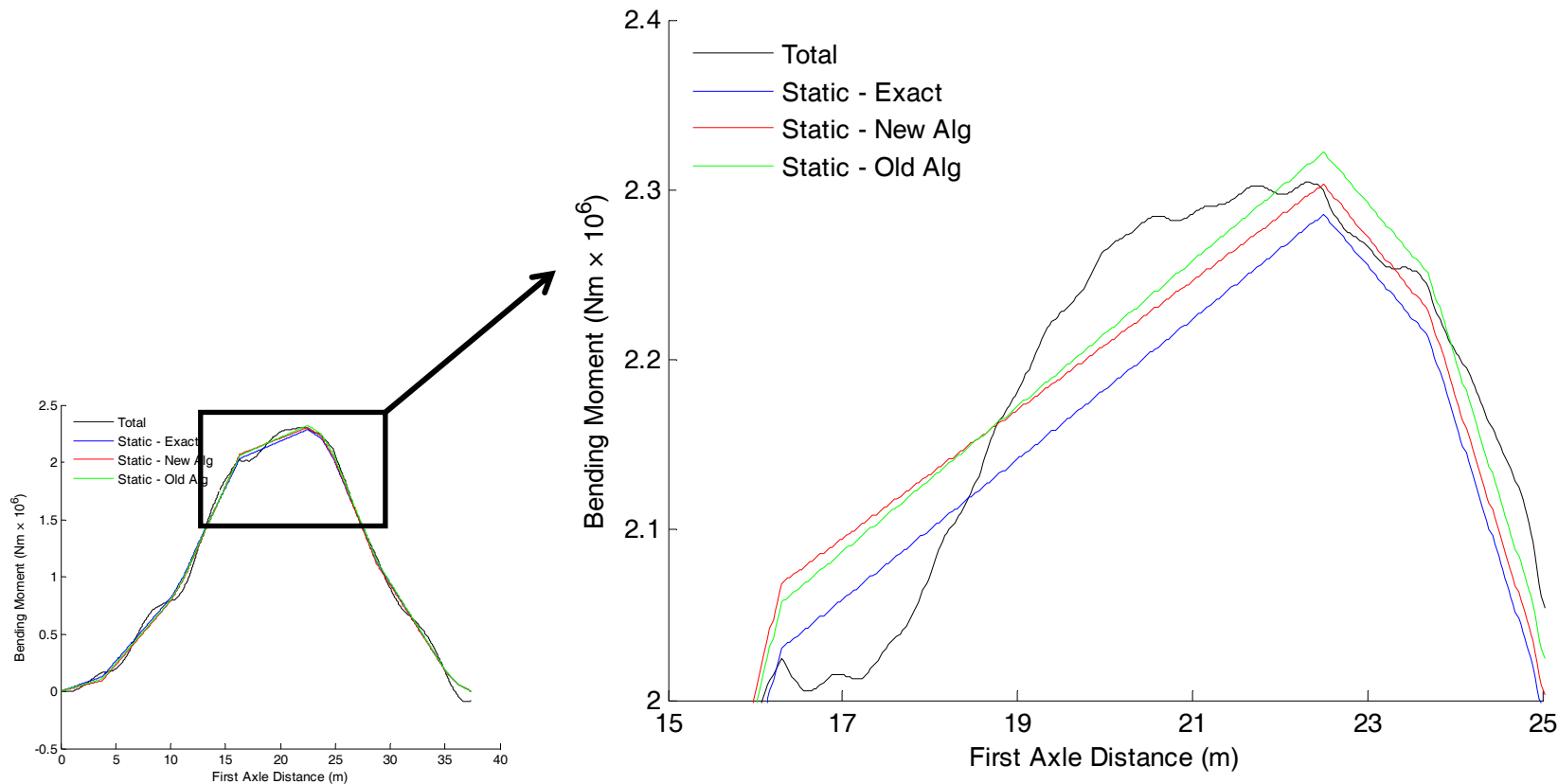
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# Theoretical Simulations - New Algorithm

Worst Case: Max Static BM Error...



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# Conclusions

In Summary:

General ADR trends in keeping with recent findings...

The Classic Moses Algorithm over-estimates Maximum Static Strain...

Incorporating Filtering of the dynamic signal improves predictions...

My Thanks to the 6th European Framework  
Project ARCHES for funding my work.

Thank you for listening.

