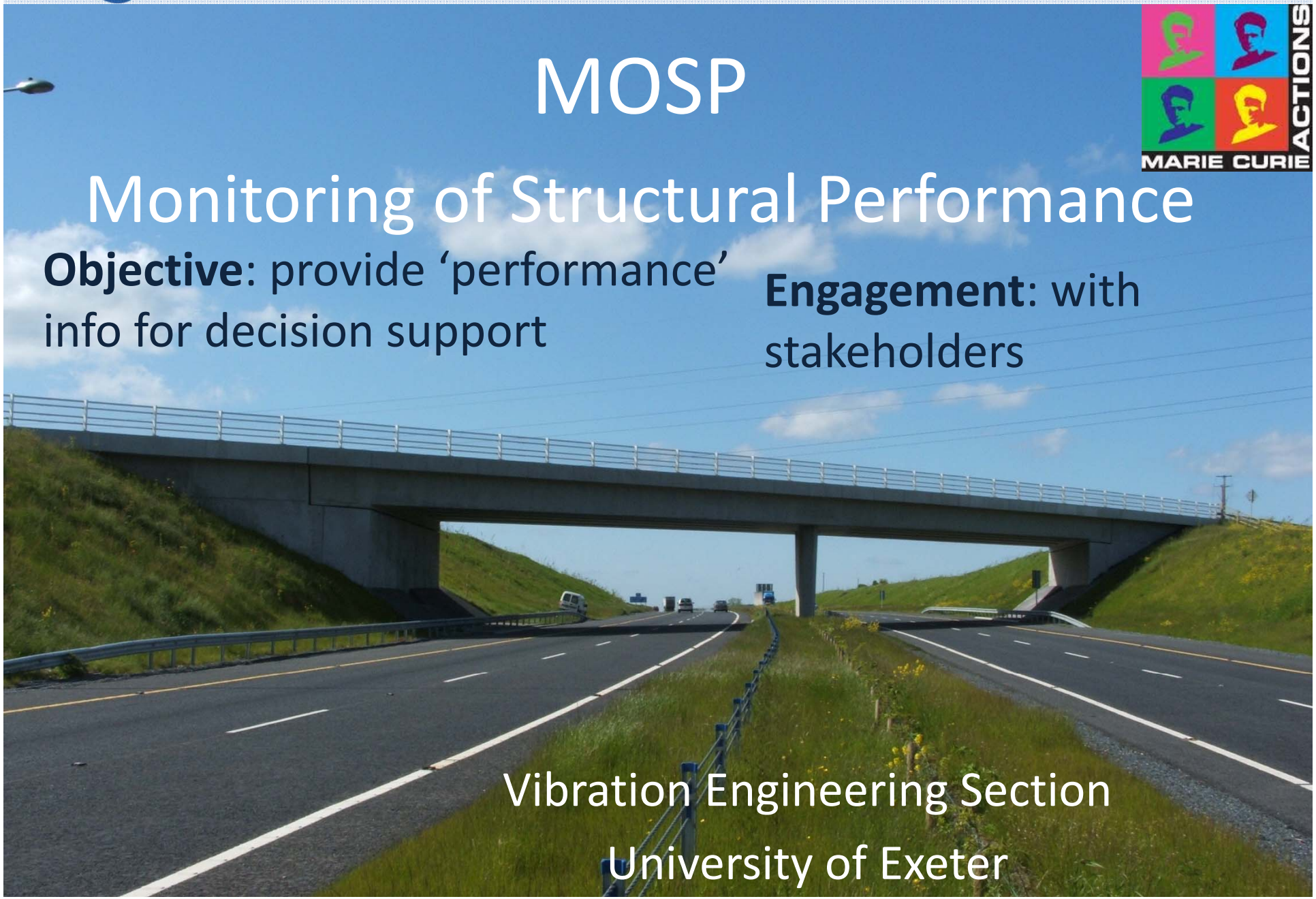


MOSP

Monitoring of Structural Performance

Objective: provide 'performance' info for decision support

Engagement: with stakeholders

Vibration Engineering Section
University of Exeter

Aim of Presentation/Discussion

Get stakeholder input/feedback on what we are trying to do. Particularly:

1. **Survey,** to identify decisions where monitoring data might help

2. Getting some **Data** from instrumented bridges (important)

Content of Presentation

- My Background (1)
- Background to Research Project(4)
- Project Objectives & Constraints (1)
- Condition & Performance (3)
- Survey : type of information sought (5)
- Example of how performance data made a contribution (5)
- Discussion (1)

My Background

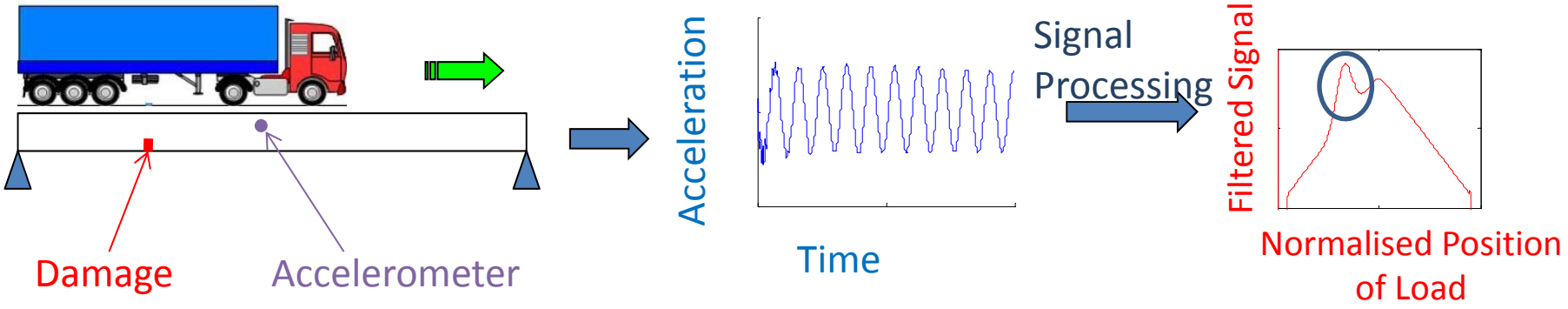
Industry

Bridge Engineer PB PARSONS BRINCKERHOFF 125 YEARS

Inspections & Assessment

OCSC O'CONNOR | SUTTON | CRONIN Multidisciplinary Consulting Engineers

Research (Early)



Difficulties with Bridge Monitoring

Vibration based monitoring proven track record for rotating machinery and some other Mech Eng systems

Similar monitoring technology when applied to bridges has mostly failed to produce practical solutions

Transferring Mech Eng style monitoring to Bridges has not worked well for a number of reasons

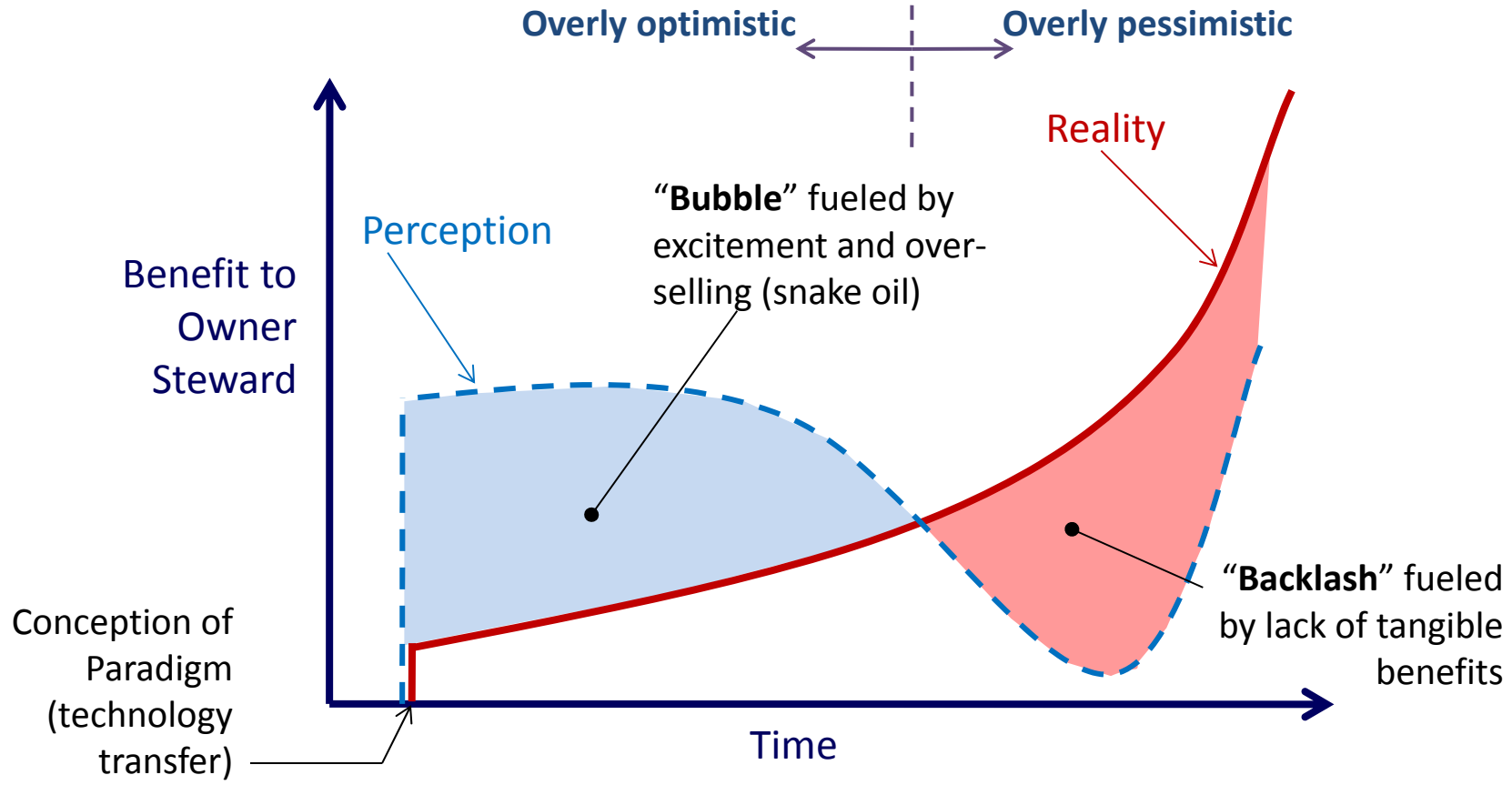
Rotating Machinery Vs Bridges

	Rotating machinery	Bridges
1	Simple/consistent dynamic signatures under normal conditions	Wide variation in dynamic signature under normal conditions (e.g. due to temperature or traffic)
2	Anomalies easy to detect (relatively)	May take years to learn 'normal' patterns well enough to identify anomalies
3	Mass produced and type tested so very good base line data available	Bridges are unique, pre service testing is very limited and accurate numerical modelling is difficult, so base line data is rare
4	Service life typically 10-20 years	Service life for bridges is much longer and due to limited field observations long term effects are not well understood

Conclusions & Ideas

- **Conclusion**: Mech Eng Healthy/Broken approach not really applicable to bridges
- **Idea**: Use Civil Eng approach: Measure useful information to which Engineering Judgement can be applied (complement visual information)
- **Question**: What would be useful to measure?
- **Budgets**: constrained, anything new must add value

The snake-oil effect in civil SHM



By courtesy of Franklin Moon, Drexel University

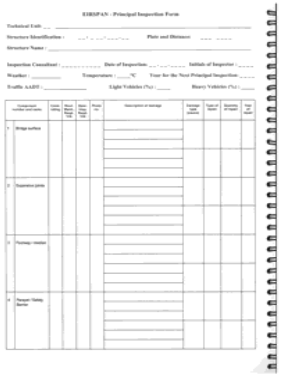
Project Objectives & Constraints

- **Objective**: provide bridge managers with information/knowledge that is useful for decision support (Engineering judgement)
- **Ambition**: is to bring together client 'needs' with emerging technology
- **Aware**: technology may not meet these 'needs'.

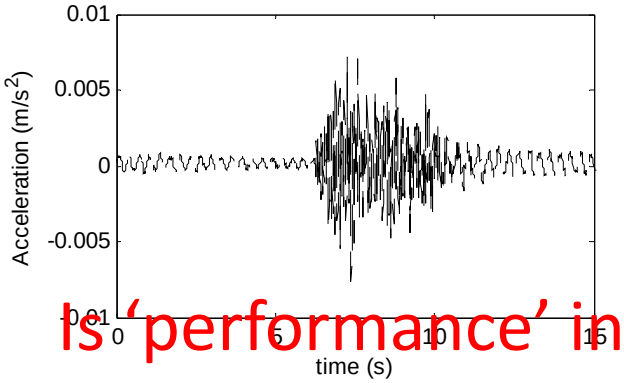
- **Not**: permanent installation (sensors running 24/7)

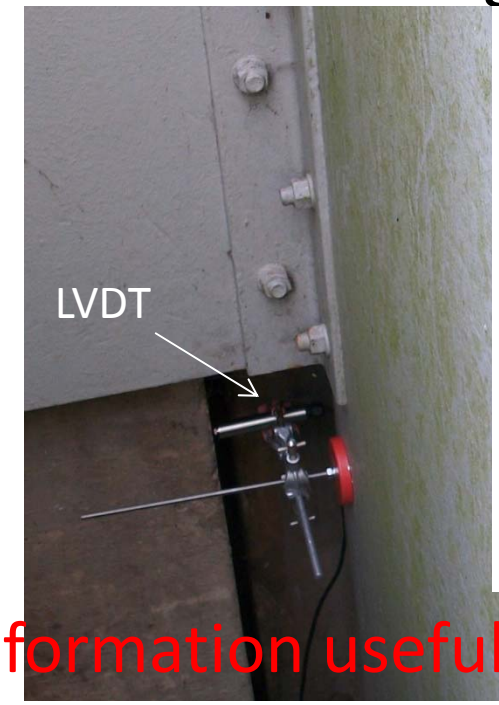
Condition & Performance (1/3)

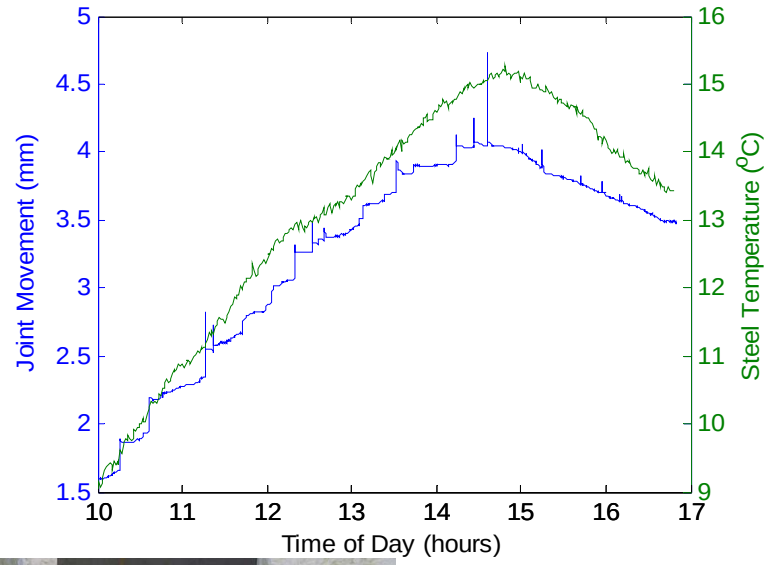
- **'Condition'**: monitored using visual inspections



- **'Performance'**: monitored using limited sensors





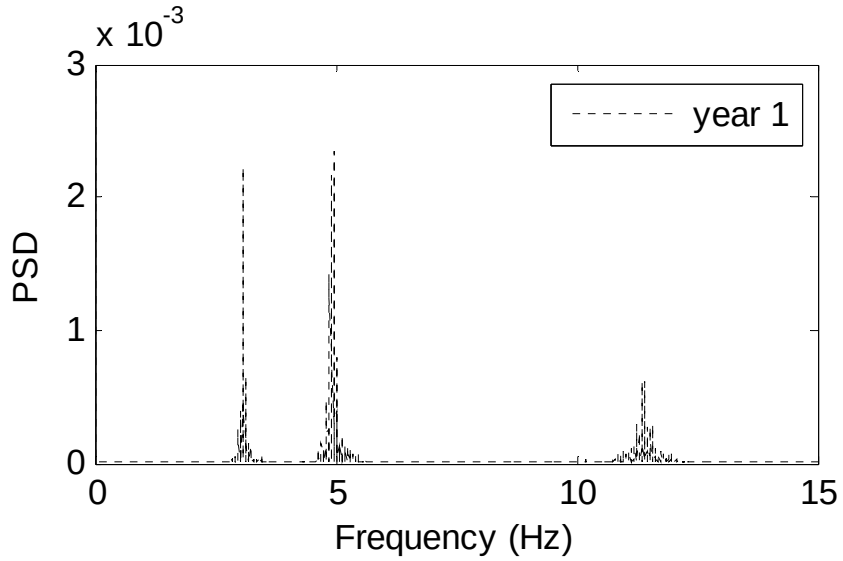


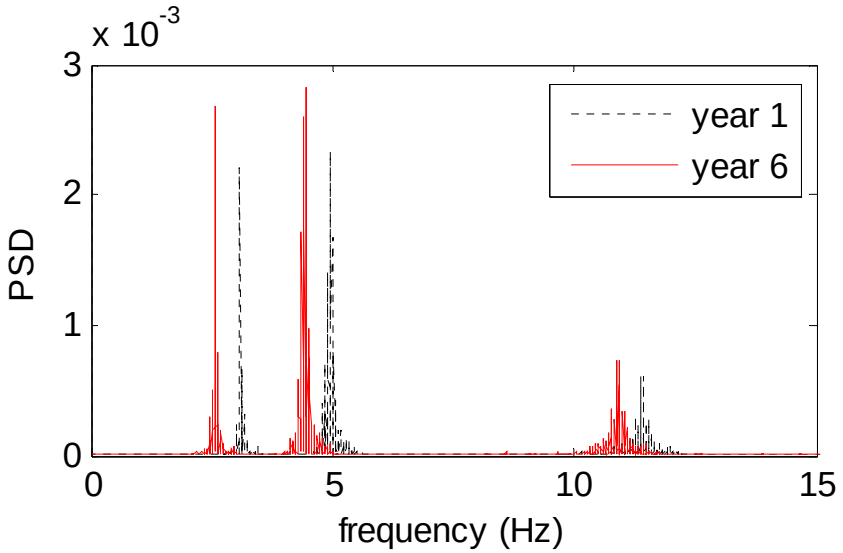
Is 'performance' information useful for decision support?

Condition & Performance (2/3)

- **Current**: (condition based) system is effective, so any new performance info must be complementary, perhaps rapid deployment sensors during a PI.

  If behaviour is changing with time, so what?





Constraint: Shortage of information on how bridges behave in service

Need for Data

- Little or no longitudinal studies on ‘regular’ bridges, expensive, some performance data difficult to interpret.
- Use data from bridges already instrumented (cost effective)
- Despite uniqueness of each bridge, learn a lot about variations/trends across the year, (normal/abnormal)
- Processing: extracting trends from data (excel sheets - GUI)
- Trade **processing** for **data**
- No silver bullet (healthy/damaged). **Individually**: allow easier application of Eng Judgement (value), **Collectively** : start to bring power

Survey

- **Survey**: Want to identify measurable parameters ('performance' aka behaviour) to complement those we can see ('condition').

What would bridge managers find most useful to know?

- **Constraints**: It may be that some of these 'useful' parameters can't be measured.
- Survey is to identify client 'needs' that could potentially be met by emerging technology.
- The next few slides describe the type of information sought by the survey (but we welcome suggestions!)

Type of Information sought in Survey

A. What maintenance/management decisions do you make about your bridges that relate to its **load carrying capacity**?
B. For the decisions listed in A what information do you currently use to make the decision? (*check list*)
C. For the decisions listed in A what 'new' information would assist you in making the decision? (*check list*)

Type of Information sought in Survey

D. Does scour occur on your bridges?(*rarely-often*)

E. How is scour identified? (*check list*)

F. When compared with other bridge management decisions scour is an issue where sensor data would be beneficial? (*strongly disagree – strongly agree*)

Type of Information sought in Survey

G. When a sudden even occurs that potentially effects the safety of the bridge, what decisions are you faced with? (*check list*)

H. For the decisions listed above what information do you currently use to make the decision? (check list)

I. Is there any 'new' information you would like to have available to you to assist you in making the decision?

Aim of Survey

- Match capabilities with requirements
- Highlight real problems to research community, and thereby focus research efforts
- Be no more than 10 minutes!

Next: Example of performance data being used

Pioneer Bridge Upgrading (Singapore)

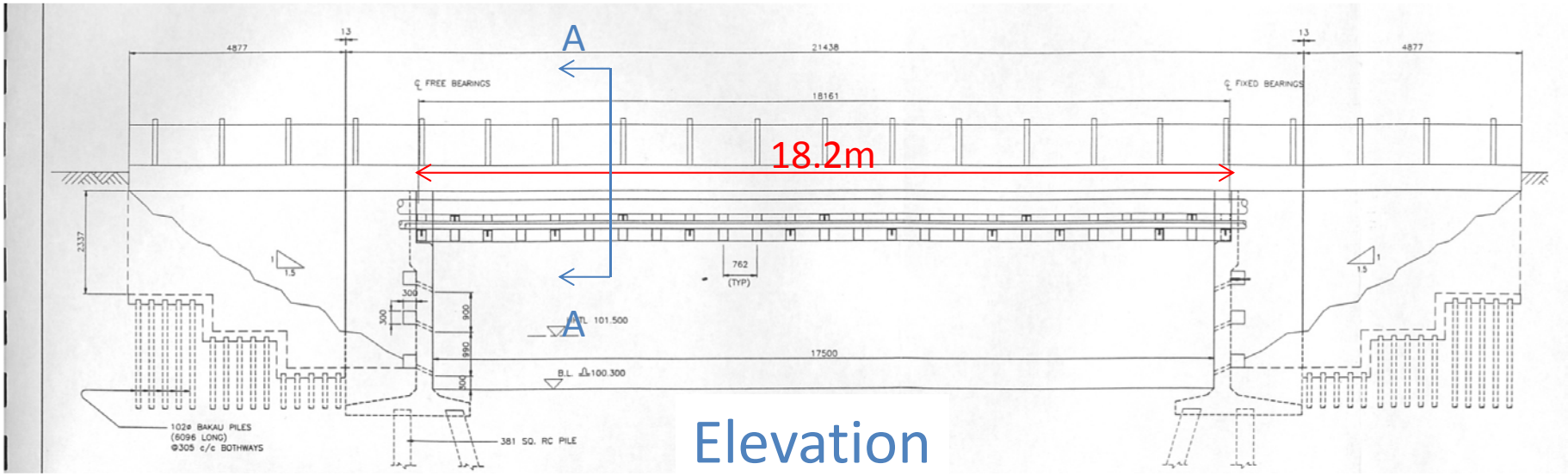
- built in 1968
- span 18.2 m
- width 18.8 m
- Inverted T beams & Diaphragms
- carries abnormal loads from port

➢Deck in good condition but assessment (2001) indicated insufficient for abnormal loads and bearings poor

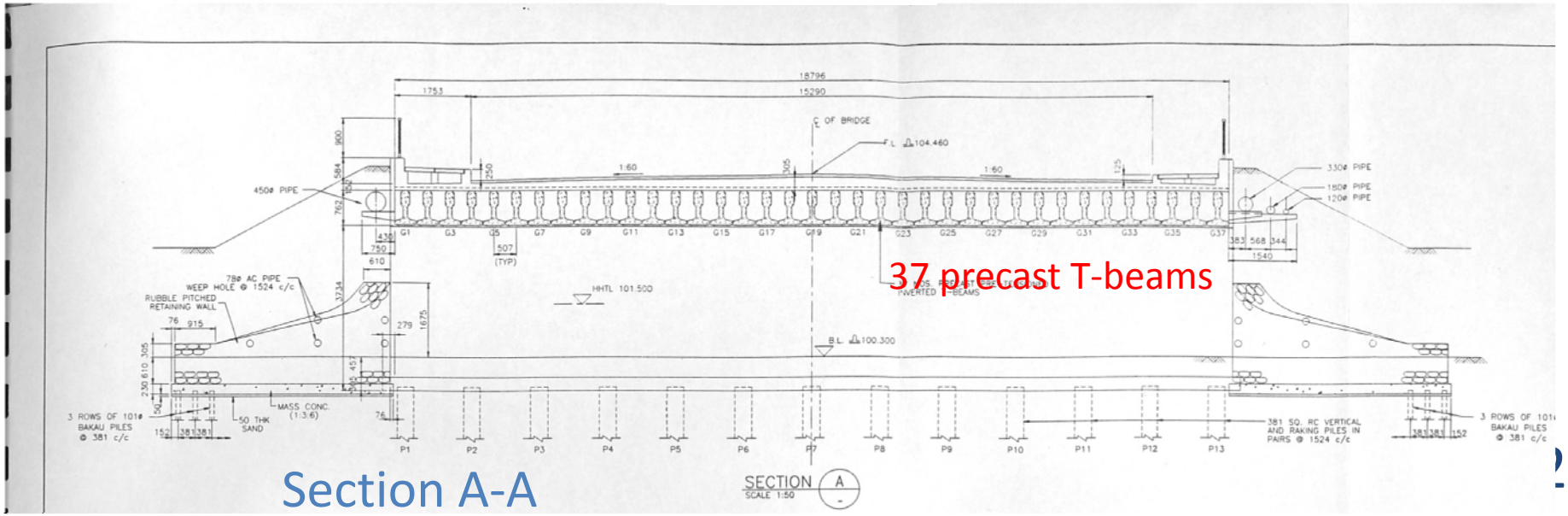
➢Decided to strengthen the bridge deck by restraining end rotation

➢To check stiffness change they monitored it

Bridge Drawings



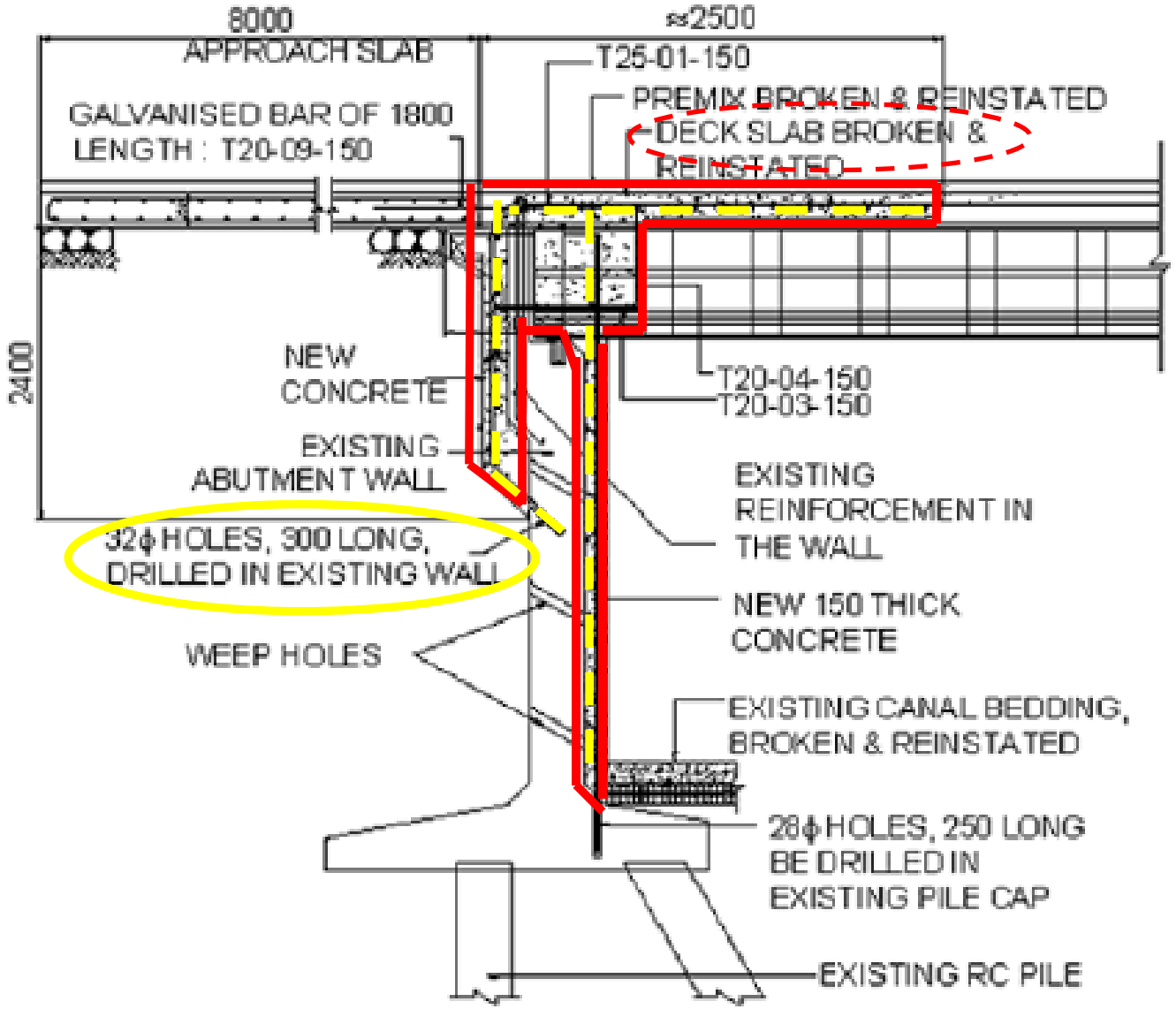
Elevation



37 precast T-beams

Section A-A

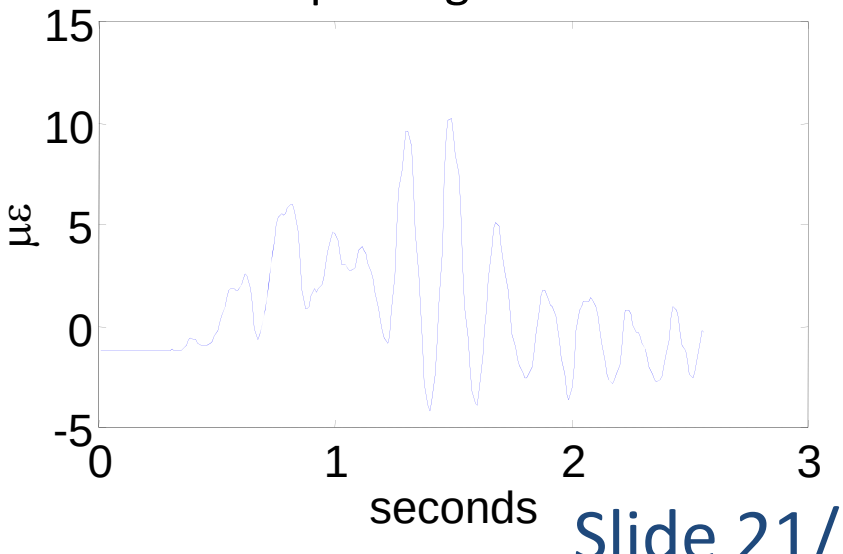
Pioneer Bridge Upgrade work



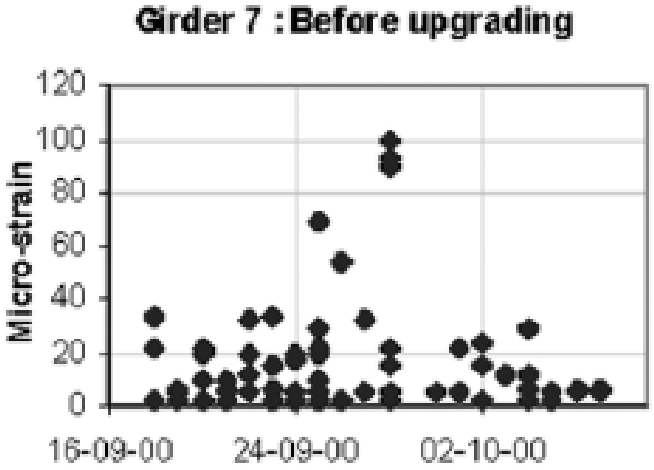
Monitoring bridge performance under live loads

- Instrumentation: 4 strain gauges mounted on Girders 7, 15, 24 and 33
- Duration: 4 weeks for both pre and post upgrade
- Recording: response due to heavy vehicles exceeding preset threshold

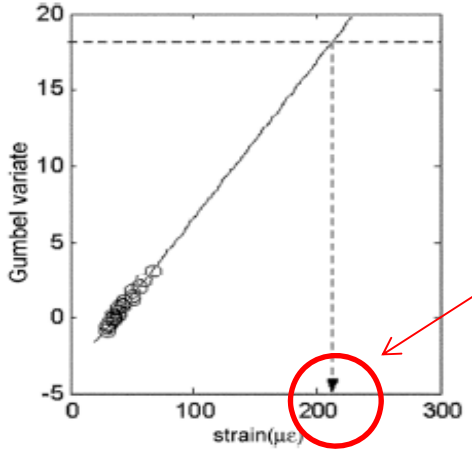
example of dynamic strain due to passing vehicle



Maximum daily strains and projected 120 year strains, B&A upgrade

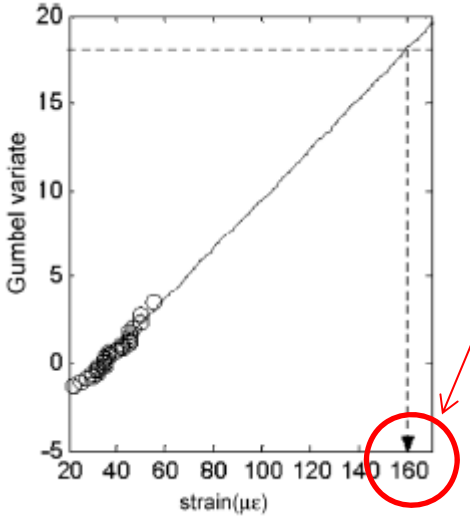


120 year strain Lane 1 Before upgrade



Before upgrade
≈**200**

120 year strain Lane 1 before upgrade



After upgrade
≈**160**

We would welcome

1. Feedback on concept of survey and any support with implementation

E.g. if you could sense or measure one parameter on your bridges what would it be?

Or what is costing you money/disruption? (focus efforts)

2. Discussion on performance monitoring, and some data sharing

Adding physical info to existing evidence to which we apply Eng Judgement