



## **How Reliable Are Your Products**

Chris Stone



# Agenda

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Reliability – It's not just about statistics

Product Life Cycle – Know your enemy

In service stresses – proving the design

Testing

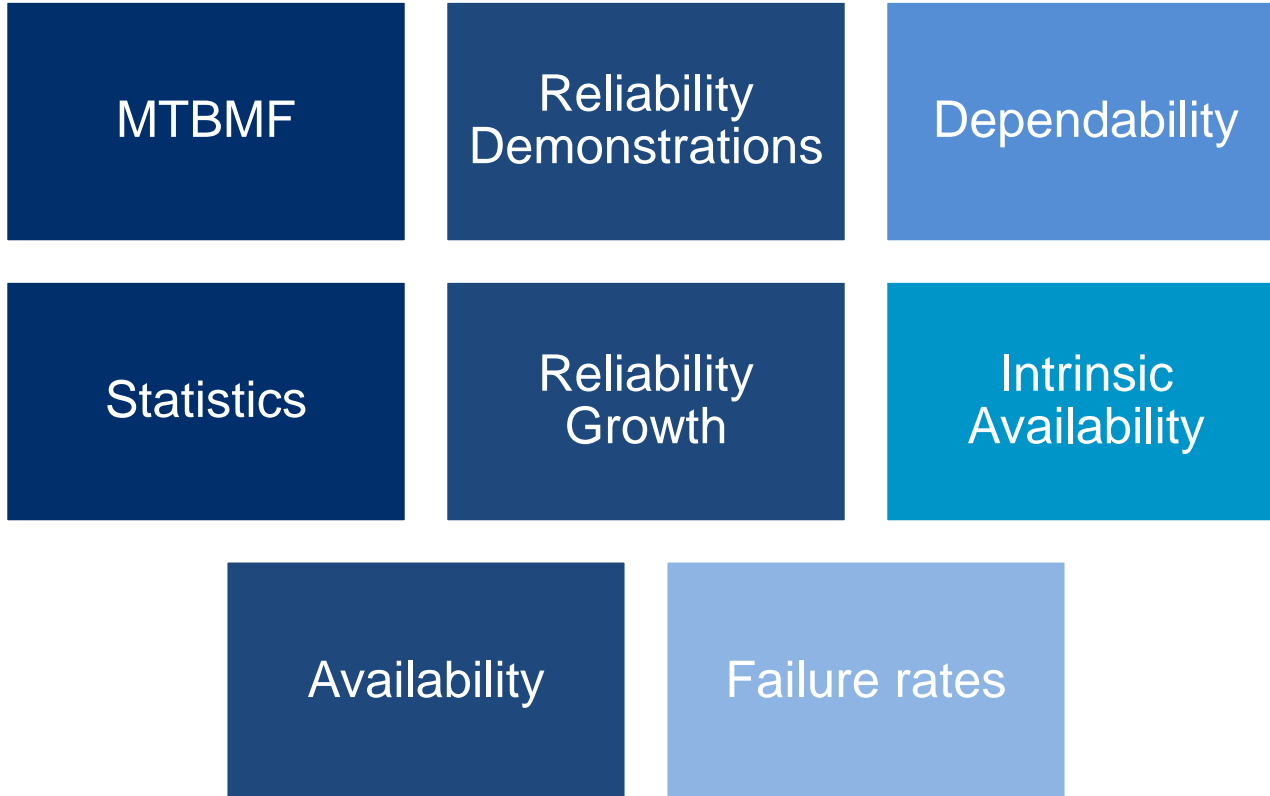
Summary

# Agenda

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Reliability – It's not just about statistics

# Reliability – what does it all mean?



# Eurostar sleeper carriage

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# Reliability

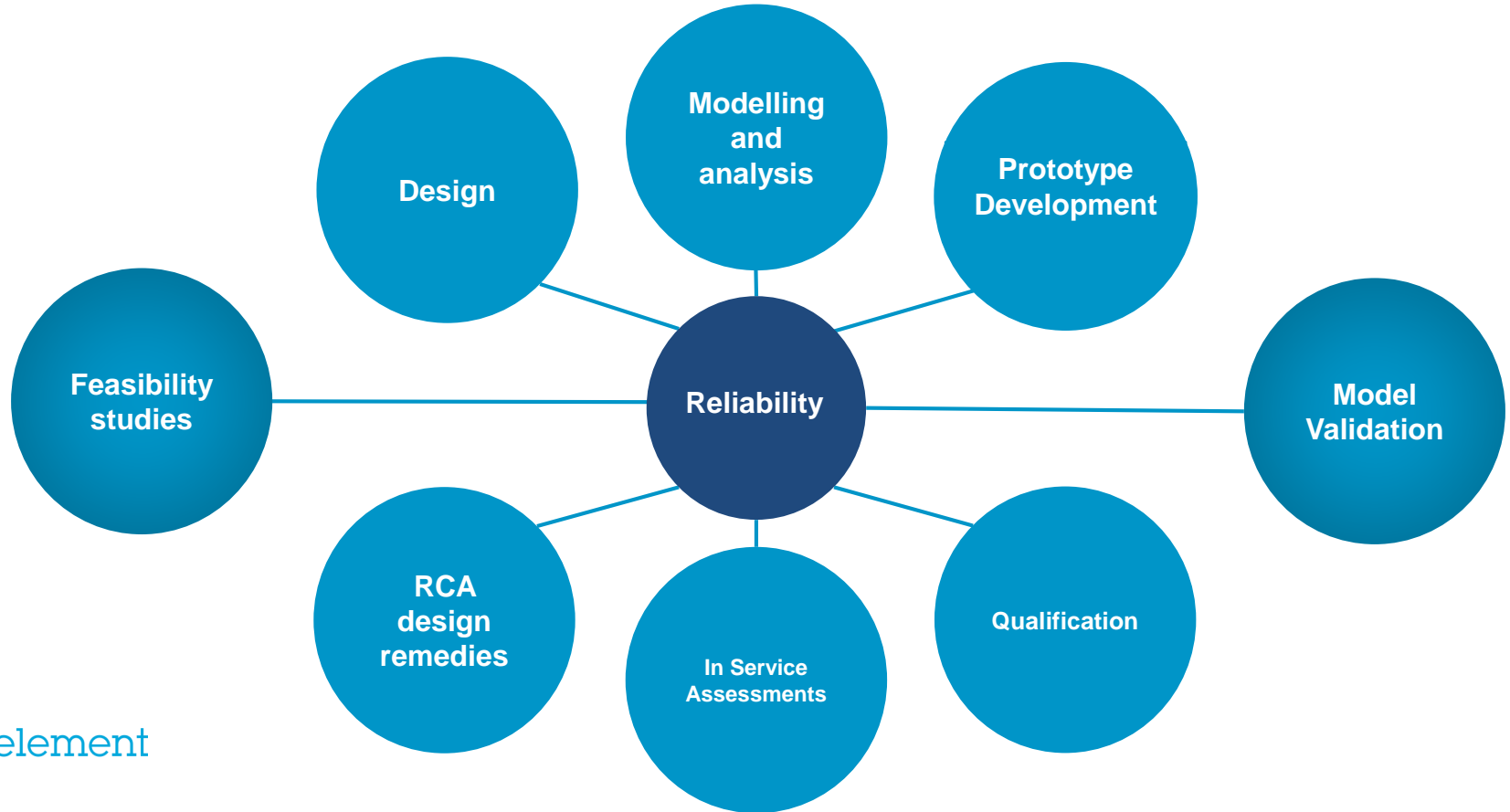
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“It’s about using the appropriate engineering tools to understand and combat the combination of stresses that your product will see during its life”



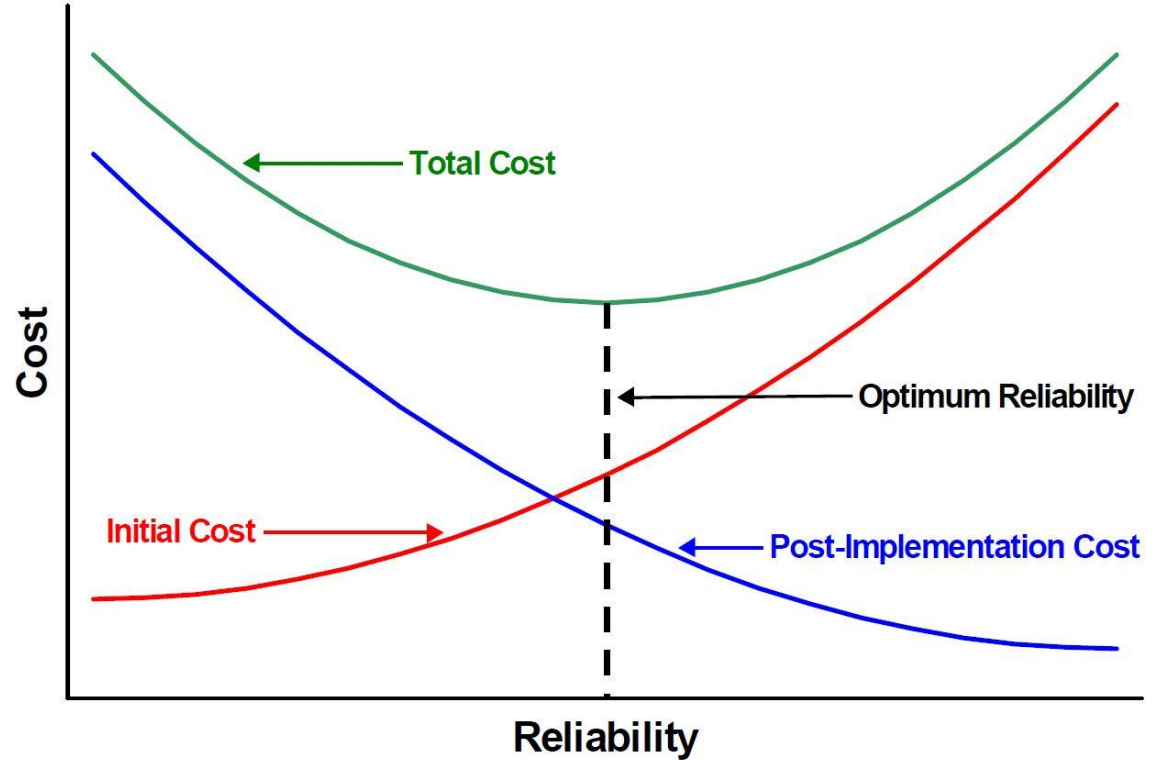
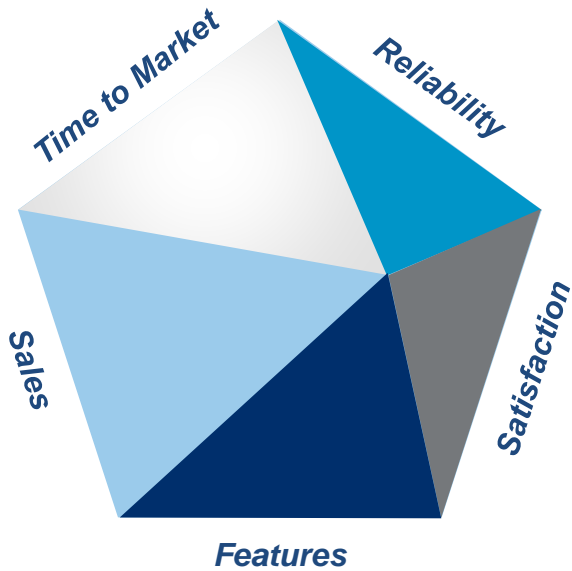
# Reliability

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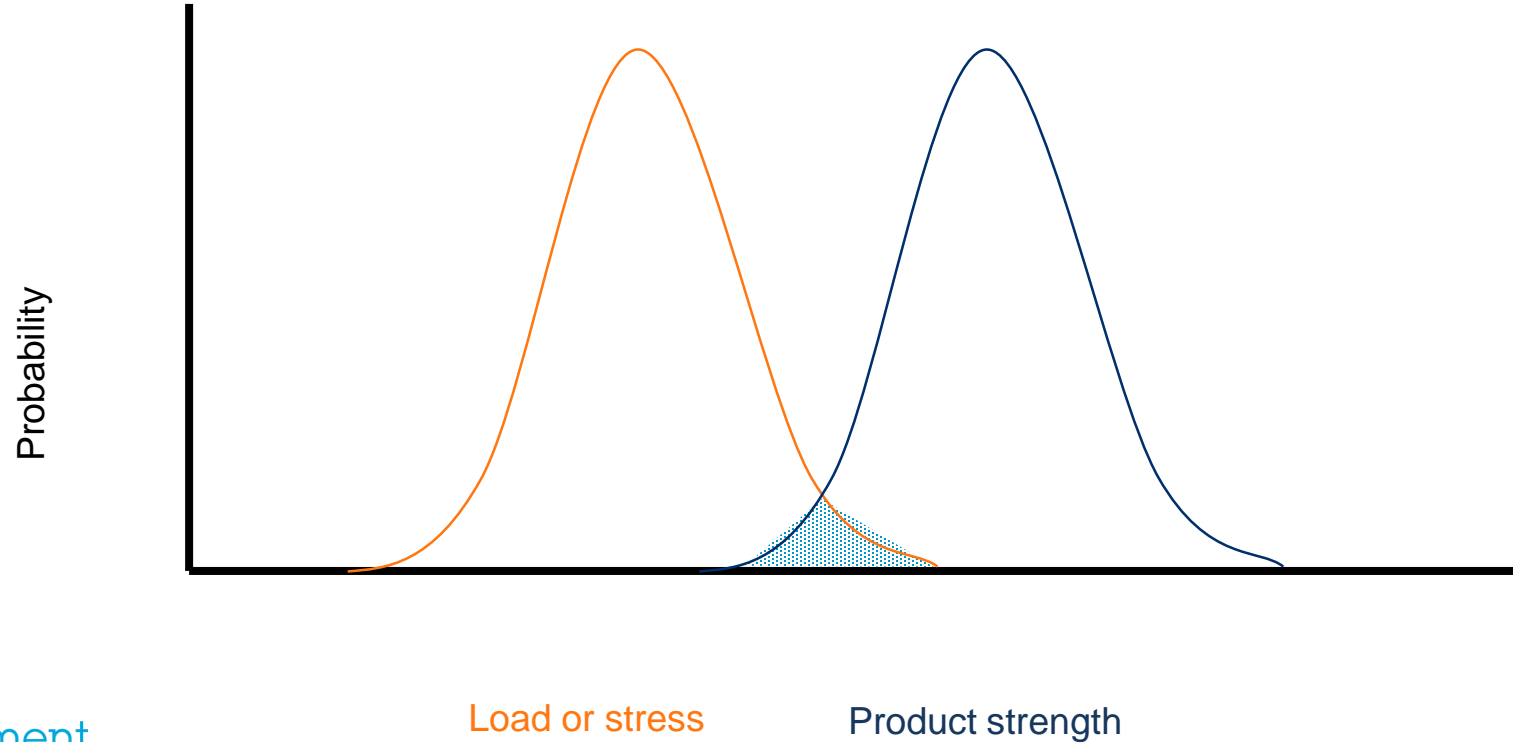


# More haste less profit?



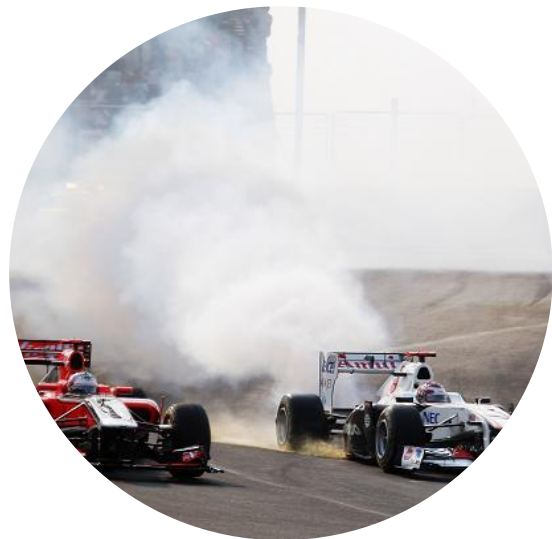
# The real environment and product resistance

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# What do you do?

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# Agenda

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Reliability – It's not just about statistics

Product Life Cycle – Know your enemy

# Product Life: From Manufacture to Delivery

Manufacture/Shipping/  
Transportation  
Storage / Logistics  
Supply



Induced Environments

e.g. Manufacturing and Handling Shocks / Transport Vibration  
/ Lifting and Tilt / Strength etc.

Natural Environments

e.g. Temperature / Rain / Salt Fog / Solar Radiation etc.

# Product Life: In-service

In-service / Mission /  
Sortie Use



Induced Environments

Operational and Handling Shocks / Engine Induced  
Vibration / Gunfire Vibration / Acoustic Noise etc.

Natural Environments

Temperature / Rain / Salt Fog / Sand & Dust etc.

# Shipping and storage environments

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## Established Markets

- UK/European/Worldwide off the beaten track

## Shipping length

- Miles
- Days

## Road Transport

- Well maintained roads

## Courier

- Standard courier
- Fragile goods courier

## Type of packaging

- Bespoke
- Commercial

## Storage

- Warehouse
- In the yard?



# Product life cycle - solar powered HGV trailer tracking device

Bench handling  
during  
assembly

Transport and  
storage

Handling / pre-  
load during  
installation

Combined  
vibration /  
temperature

Mechanical  
shock

Solar heating

Driving rain

Thermal  
cycling



# Product life cycle – if you can't beat it protect from it

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# Agenda

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Reliability – It's not just about statistics

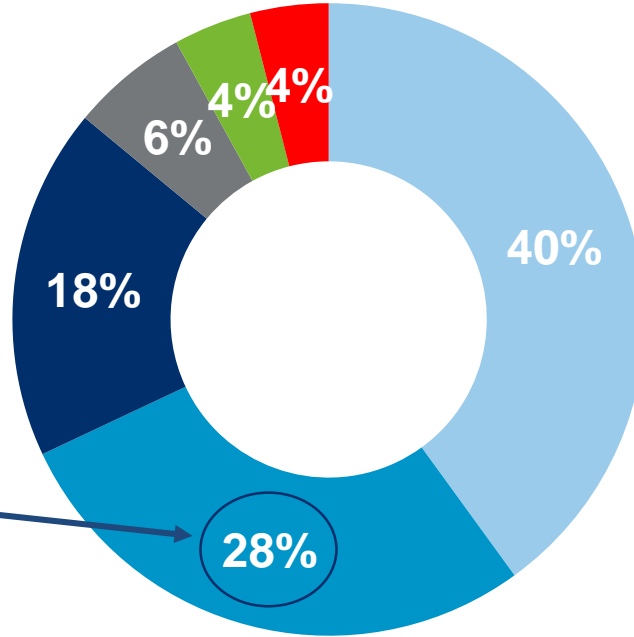
Product Life Cycle – Know your enemy

In service stresses – proving the design

# Which environment causes most failures?

Typical environmental factors that cause products to fail from infancy to end of life

Vibration hardest to design for



Temperature

Vibration

Humidity

Sand and Dust

Salt

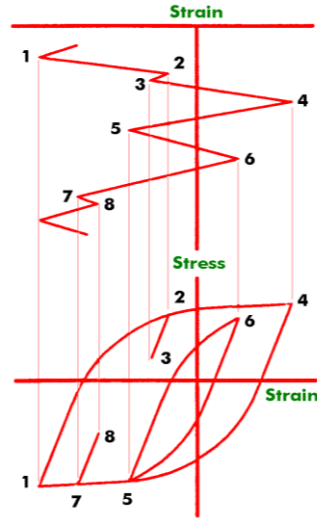
Other

# Low Cycle Fatigue Analysis / Testing / Life Prediction

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***In-service  
measurements***

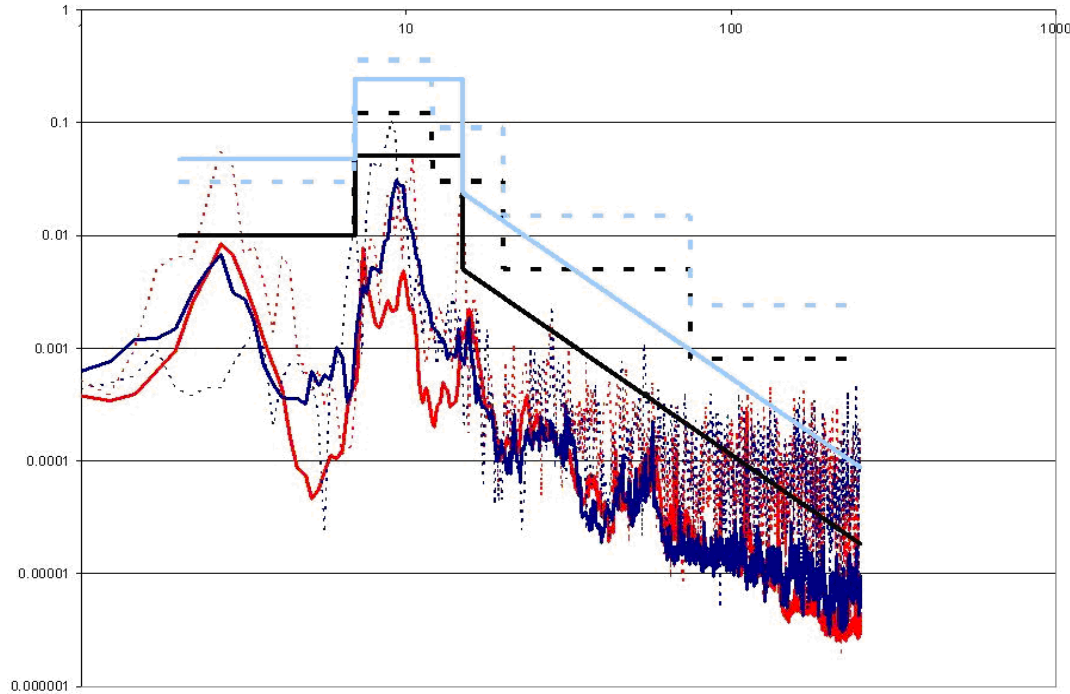


***Data reduction and analysis***



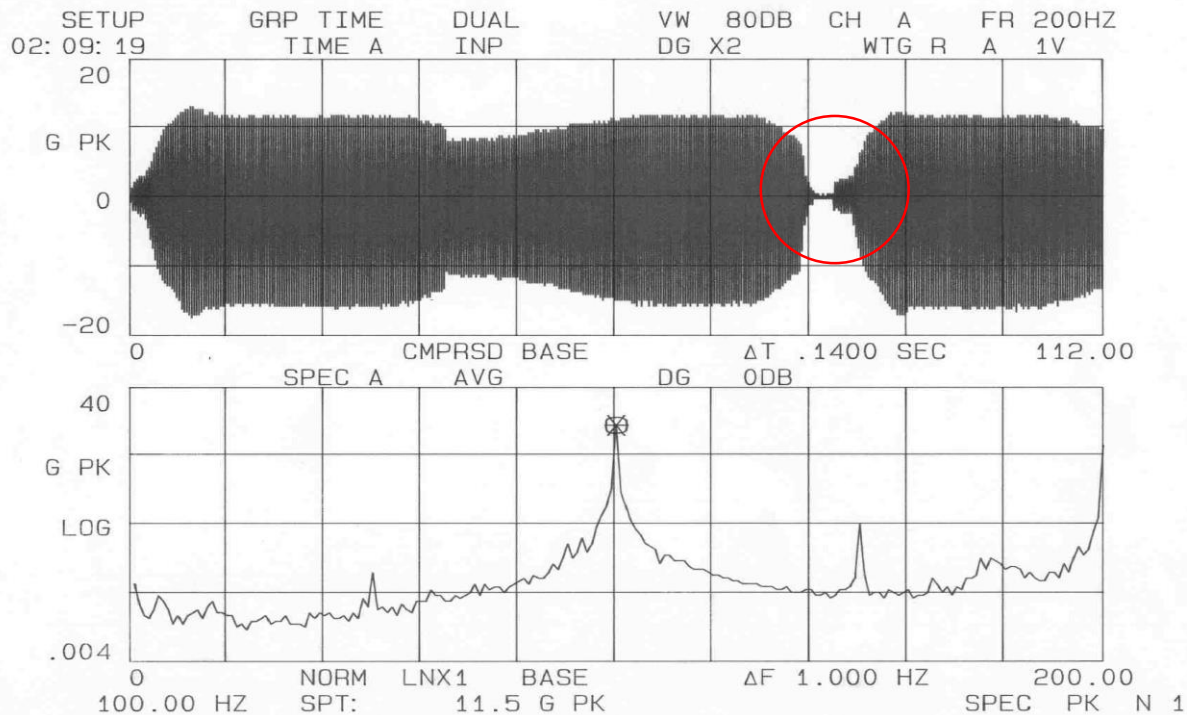
***Laboratory testing***

# Vibration - High Cycle Fatigue



HGV trailer:  
broadband  
shaped

# Vibration - High Cycle Fatigue



Inside traction  
transformer:  
single  
frequency  
excitation



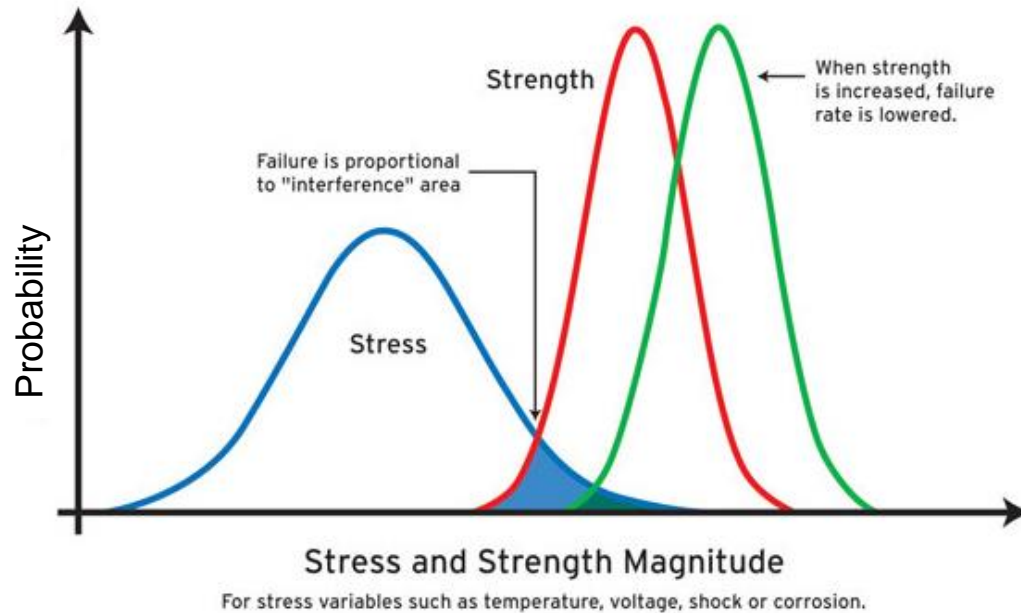
# Vibration - High Cycle Fatigue – model, validate and update

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# “Strengthening” the product

## The Real Environmental and Product Resistance



# Agenda

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Testing

# Which test standard?

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## The test standards

International Standards  
(Commercial)

IEC 60068 and  
IEC 60721

NATO Standard

STANAG 4370  
(AECTP 100 to 500)

ITOPS

National Defence Standards (including most military aircraft)

US MIL-STD 810

France  
GAM EG 13

UK  
Def Stan 00-35

Aerospace / Commercial Aircraft

US  
RTCA DO-160

Europe  
EURACAE / ED-14

# Standard tests

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## PROS +

- Understood by customers and therefore have a wide acceptance
- Quick and easy to use
- Cheap – just find correct severities and go test

## CONS -

- Can be very old/historic and do not relate to modern platforms/sources of vibration
- All tests have been accelerated and have margins built into them
- Generally very bad for test items with non-linear behaviour – combine too many vibration sources and may be over-accelerated

# Bespoke/tailored tests

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## PROS +

- Very relevant with specific platforms/environments
- Can be tuned so that they better reflect the distribution of real life stresses – far better for test items with non-linear behaviour
- Reduces margin of over-engineering

## CONS -

- Require time and intellect to determine life
- Time and expense to measure all real life events!
- Time and expense to analyse measurements and determine test severities / levels
- Require co-operation of customers and therefore require time and effort to gain acceptance



# Analysis & test – complementary processes or alternatives?

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Some remarks I have heard...

Test is real,  
analysis is  
approximate...

It's never  
failed like  
that in  
service...

The prediction  
said it would  
fail but  
when we tested  
it, it didn't...

We can't seem to  
replicate in-  
service failures  
by testing...

## Qualification - Which test?

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Vibration

Temperature

Shock

Impact

Functional endurance  
(operational cycles switching  
on / off)

Combine all the above

## Reliability - Which test?

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ESS

HASS

HALT

RGT

TAF

RDT

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Summary



Foster a culture of reliability in  
your organisation.

Involve all personnel in the  
process and encourage  
feedback from design through  
commissioning to maintenance.