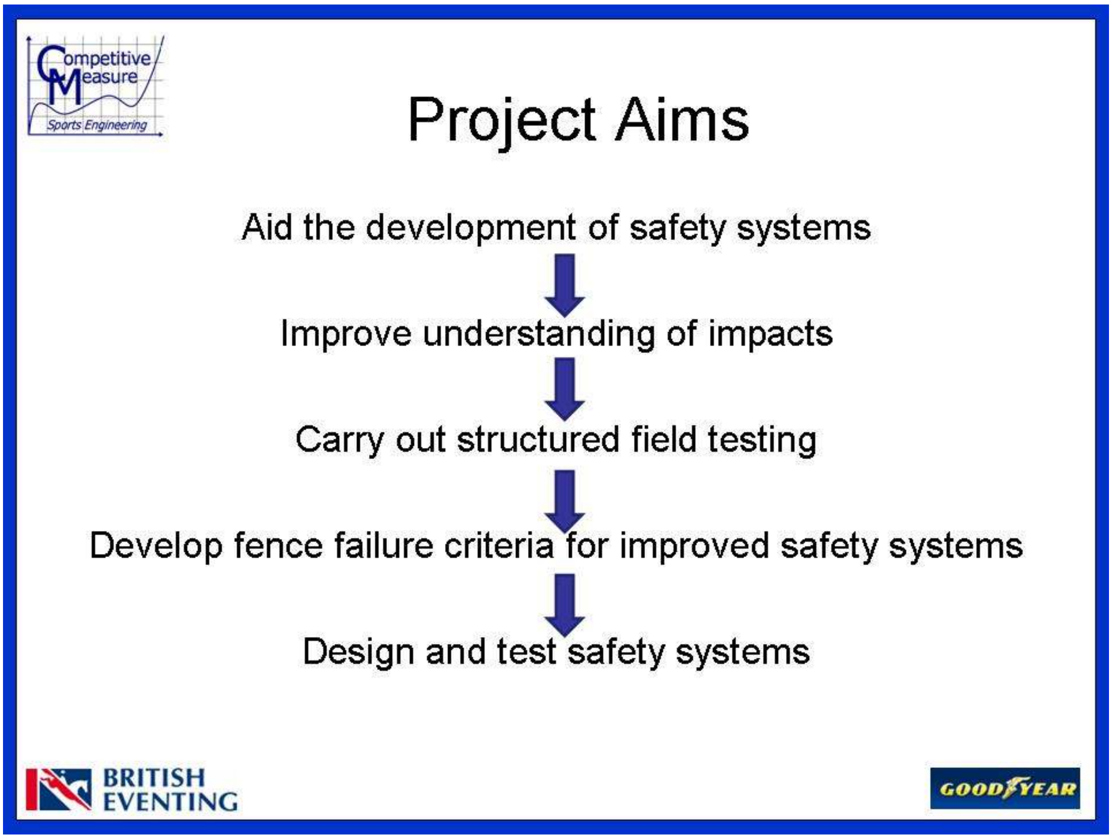
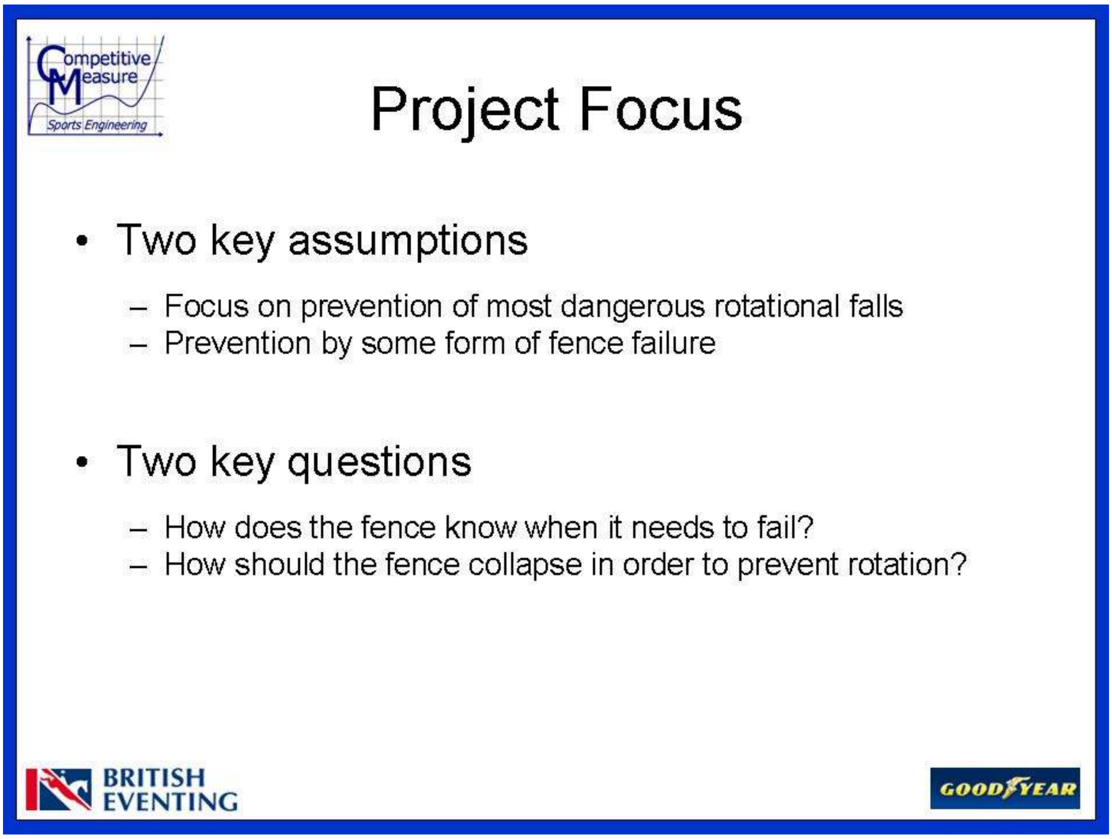

- Goodyear Safety Research Project 2008 Presentation by Competitive Measure at the FEI Eventing Safety Forum
- Hartpury College, 24th January 2009
- Presented by Tim Deans and Martin Herbert


- The presentation discusses the Goodyear Safety Research Project carried out by Competitive Measure over the 2008 season.

- It gives an overview of the project followed by general statistics from the field testing. More detailed analysis of the data is then reviewed together with an approach that utilises the results for safety fence design. The presentation concludes with the outcomes and future of the project.




- The initial aims for the Goodyear safety project:
  - Use the data from the project to improve and develop safety systems in the sport.
  - Improve the understanding of impacts between horses and fences in the field.
  - Carry out testing in the field at real competitions monitoring impacts between horse and fence.
  - Use the results to specifically develop fence failure criteria.
  - Have the understanding to design and test new safety systems.




- The project will deal with the prevention of rotational falls, it is not concerned with other aspects of safety although improvements may be achieved as a by-product.
- In this case the prevention of rotational falls will be achieved by a form of fence failure focusing on altering the construction of the fence. Training and rule changes will not be considered within this work.

- If a rotational fall is to be prevented how does the fence determine when it needs to be activated?
- The fence is most likely to be activated by a weak link mechanism set to fail at a known load.
- In order to specify and design this mechanism, impacts between horse and fence need to be understood better.
- After the fence failure point has been specified the next consideration is how the fence needs to move in order to stop a rotational situation resulting in a somersault fall.
- This year has focused on when the fence needs to fail.

Competitive Measure
Sports Engineering

# 2008 Summary

- Construction of specialist Goodyear fence
- Force and high speed video capture
- 19 days competition Goodyear Fence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- The Goodyear fence was a specialist fence constructed by Competitive Measure.
- The fence was an ascending spread with a top rail, the profile chosen by British Eventing based on statistical data.
- The portable fence was fully height adjustable and used for novice and intermediate levels.

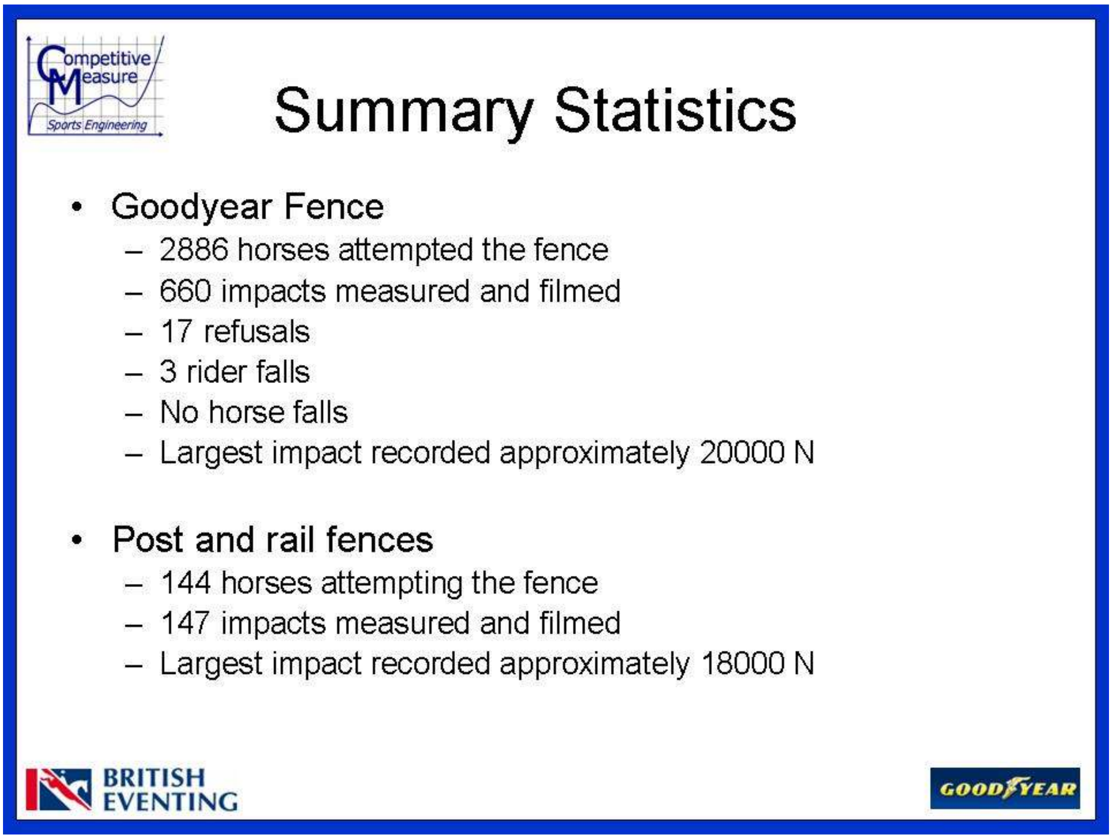
- The ‘intelligent’ fence was capable of measuring impact force on the top rail allowing highly detailed analysis of the impact force.
- High speed video was also captured of each impact at the fence to allow complete examination of the horses’ motion over the fence.

- In total field testing was undertaken at 19 days of competition, at 13 different events.

# 2008 Summary

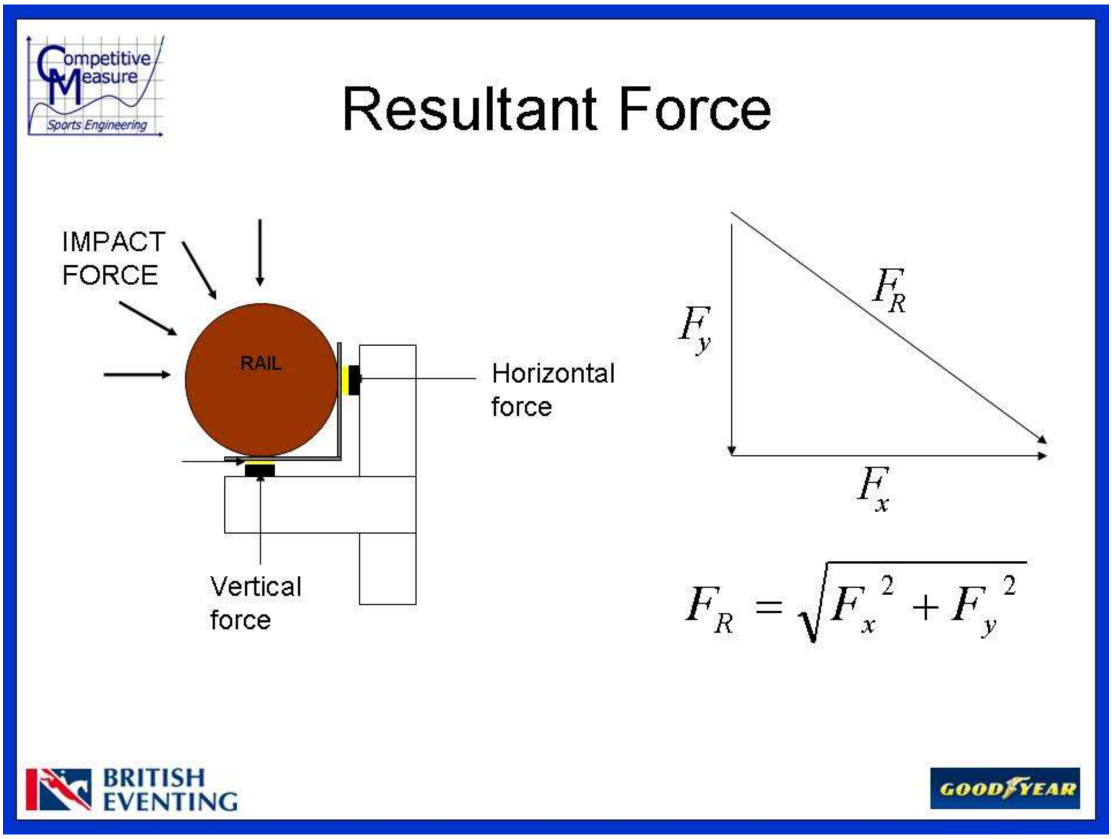
- Development of Post and Rail monitoring system
- 3 days competition Post and Rail
- Force and high speed video capture

- In addition to carrying out field testing with the Goodyear fence, further monitoring was carried out with existing post and rail fences.
- Impact force on the rail was again measured in addition to high speed video footage of impacts.
- Sensors were applied directly onto the frangible pins to ensure that the safety of the fence was not compromised.
- Three days of monitoring were carried out
  - 2 days at Gatcombe on a parallel fence monitoring 2 rails
  - 1 day at Burghley on a single rail

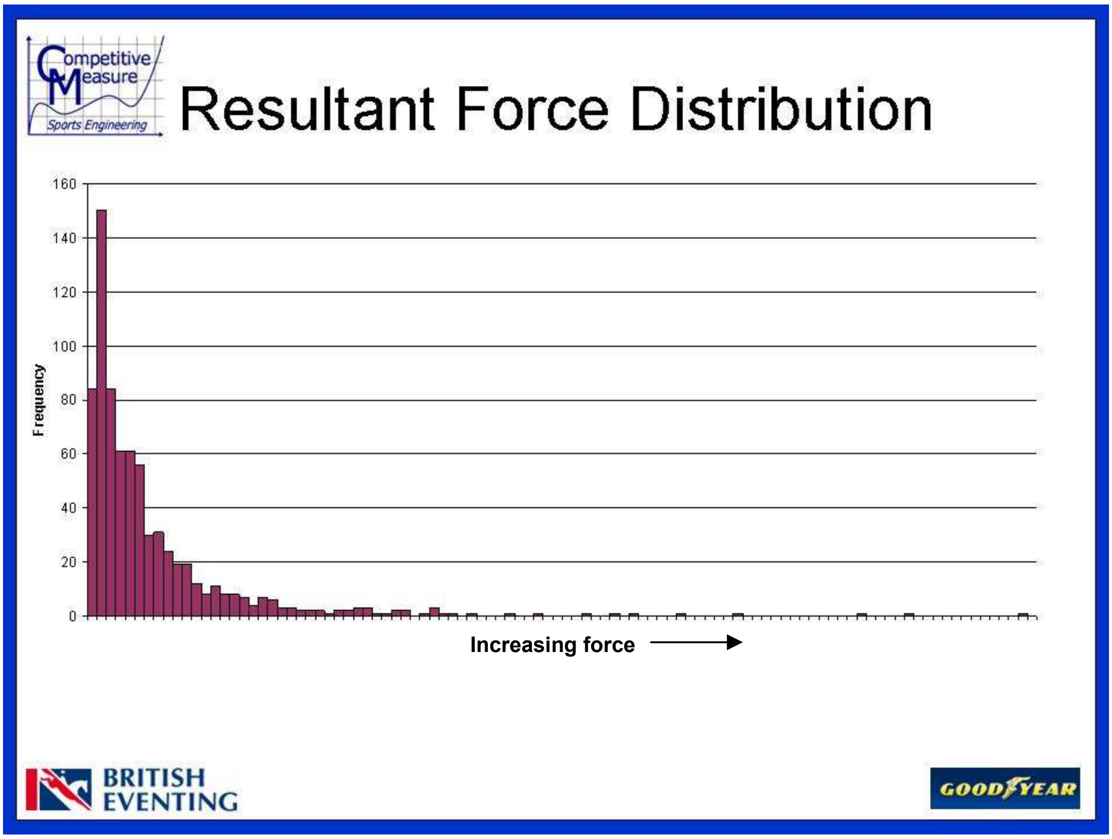



- Over 19 days of monitoring, 2886 horses attempted the Goodyear fence with 660 impacts measured and filmed
- 660 impacts with force and video data are now on file.
- 17 refusals at the fence and 3 rider falls were recorded.
- The largest impact recorded was 20000 Newtons
    - 20000 N is approximately 2000 kg (2 tonnes)

- Over 3 days of monitoring, 144 horses attempted the post and rail fences monitored at Gatcombe and Burghley.
- 147 impacts were measured. This is greater than the number of horses attempting the fence because:
    - Each horse may impact the rail with front and hind legs, giving two individual impacts
    - At Gatcombe, two rails were monitored meaning a horse may impact both rails.

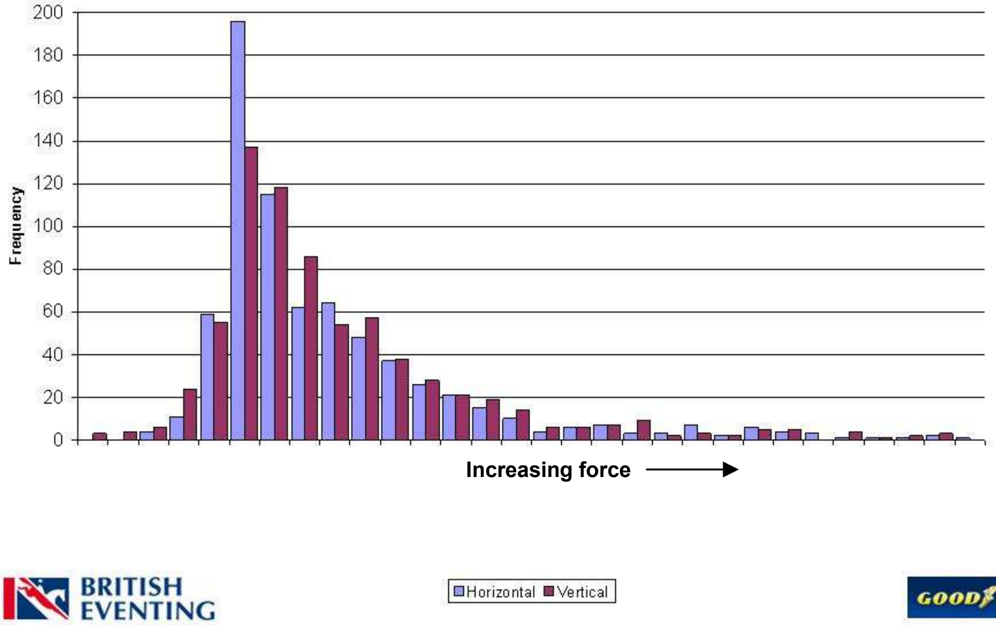



- To measure all impacts on the rail, force sensors known as load cells are used in the horizontal and vertical directions on the rail.
- Using a simple equation (Pythagoras' theorem), the horizontal force component and vertical force component can be resolved to give the resultant force.
- The resultant force is the actual force that the horse exerts on the fence.
- The instrumented fence is capable of measuring from 1kg through to 5000 kg (5 tonnes).



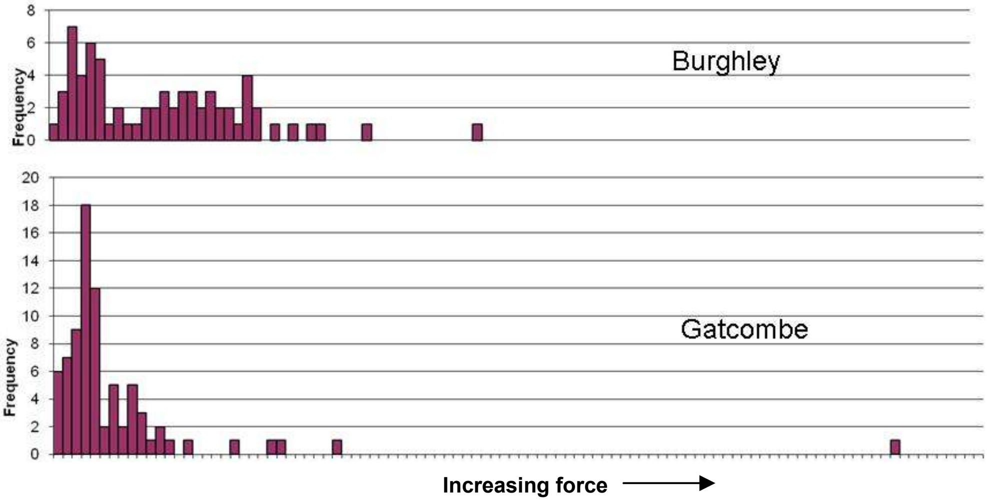

- The force data for the Goodyear fence can be represented in a force distribution.
- Resultant impact forces are grouped into intervals ranging from 0 through to 20000N (maximum measured force).
- The impacts are plotted onto a graph
  - Horizontal axis: force categories
  - Vertical axis: frequency of impacts in force category
- Force distribution is well developed with a large number of data points.
- The force distribution can be used to predict what can be expected at the Goodyear portable fence in a competition
  - The most probable impact type can be predicted
  - The least probable larger infrequent impacts can be predicted
- All impacts shown on graph are safe impacts where the horse continued in the competition.

# Horizontal and Vertical Force Distribution




- The force data can also be plotted in a distribution as its horizontal and vertical components.
- This allows comparison between the horizontal and vertical forces measured on the fence.
- The graph shows similar trends between the two forces.

# Post and Rail Fences

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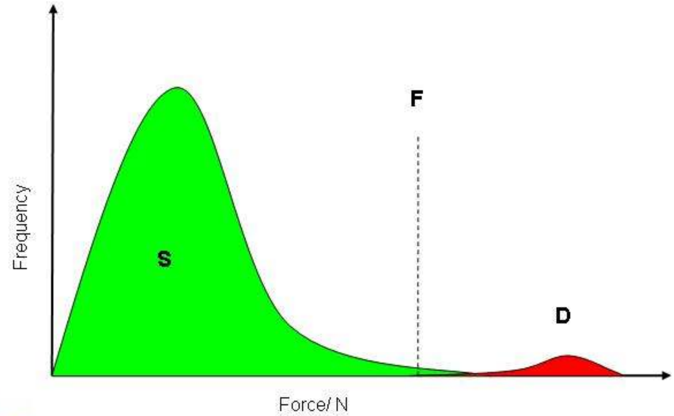
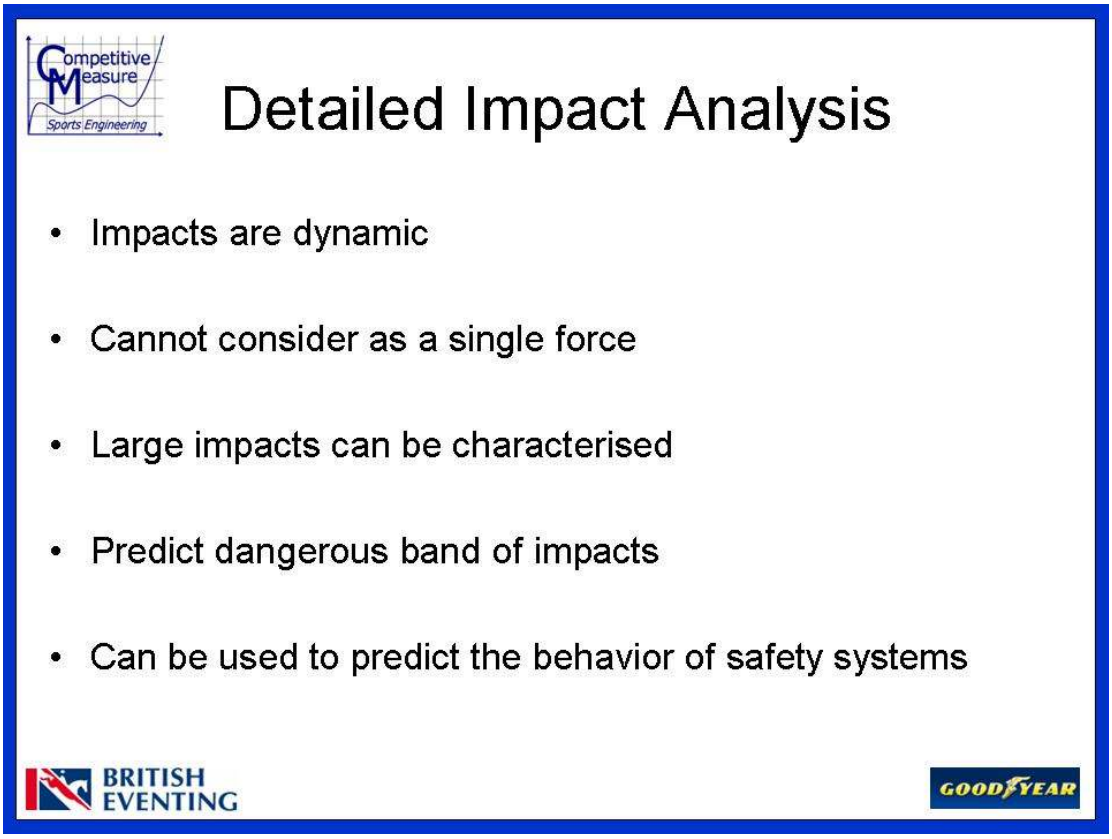
- The graphs show force distributions for the post and rail fences that were monitored.
- The graphs are separate for Burghley and Gatcombe because the fences were significantly different.
- The distributions here are less well developed with fewer data points.
- More field testing needs to be carried out for post and rail fences to improve the force distributions.

# Fence Failure Criteria

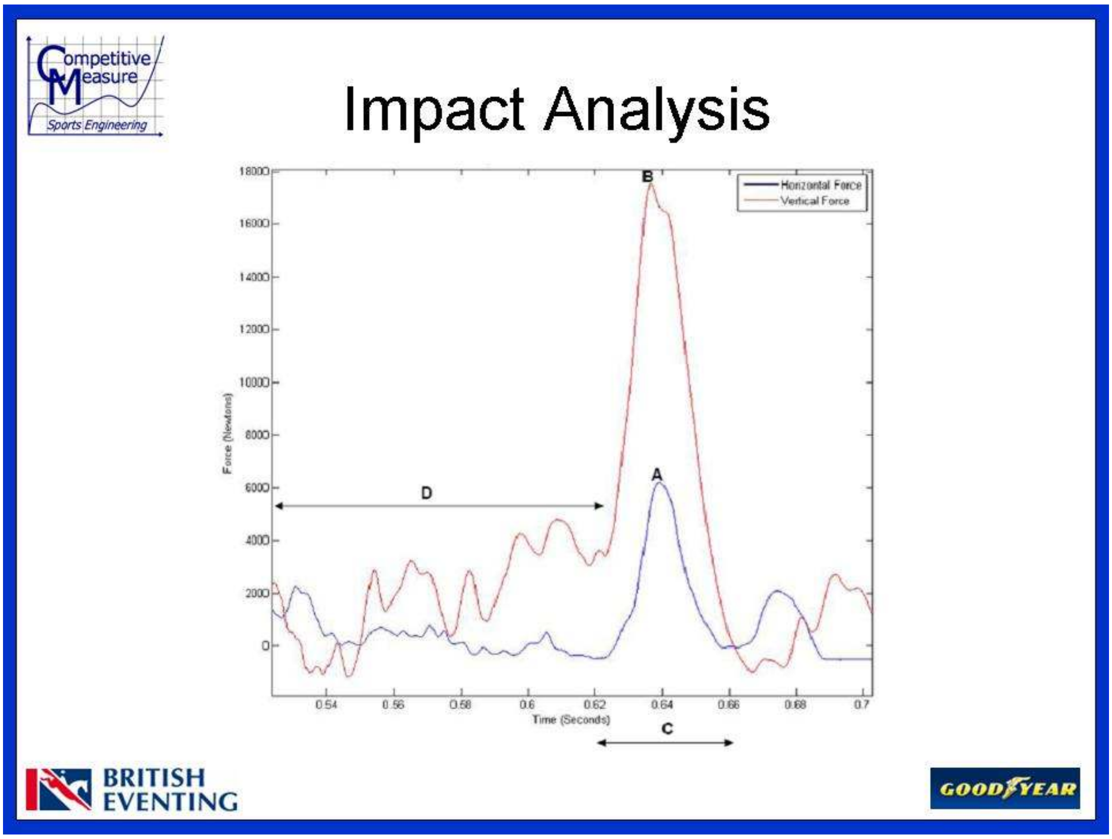
- Statistical force distribution
- Detailed impact force analysis
- Factor of safety




- Previously the failure point for fence safety systems has been determined using estimates of the force required to rotate a horse.
- This is very hard to do; calculations are incredibly complex with the current data on horses. Modelling horses is difficult due to their complexity.
- The illustration shows impact force range on the horizontal axes and the frequency of those forces occurring at a cross country fence on the vertical axes.
- The green region S represents safe impacts where there was no danger to horse or rider; the red region D represents dangerous impacts that could cause a rotational fall.
- It will always be difficult to predict the red dangerous region D.
- The force distributions previously discussed are represented by the safe region S. This is real data colleted from the Goodyear fence that can be used with confidence.
- Using the safe and dangerous regions the failure point F can be set. A balance can be achieved using a significant safety factor between F and D so that rotation is unlikely whilst ensuring that the point is not too far into S where failure will become too frequent affecting the competition.
- This approach uses the well understood ‘safe’ data along with the less well understood ‘dangerous’ data in a two pronged approach giving a more effective failure point with maximum influence on safety and minimum influence on the competition.
- Note frequency increase at D is only for purposes of illustration.



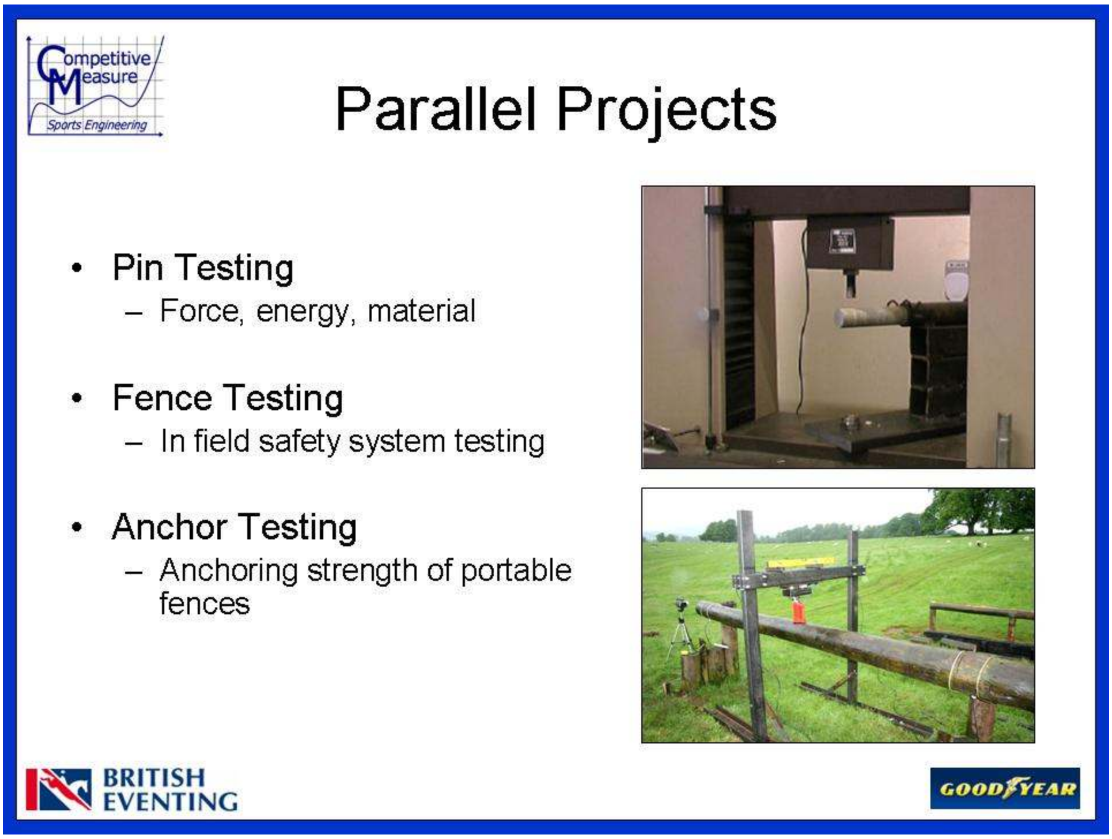

- Data from field testing can also improve the understanding of the region D by characterising the large impacts measured and filmed.
- Up to this point the data has focused on peak force.
- Impacts are dynamic events with force constantly changing during the impact.
- Impact duration and the build up of force in time are vital to understand when considering the operation and reactions of a safety fence.
- Analysing larger impacts will improve the estimations for rotational impact force as well as predicting the behaviour of potential safety fences.



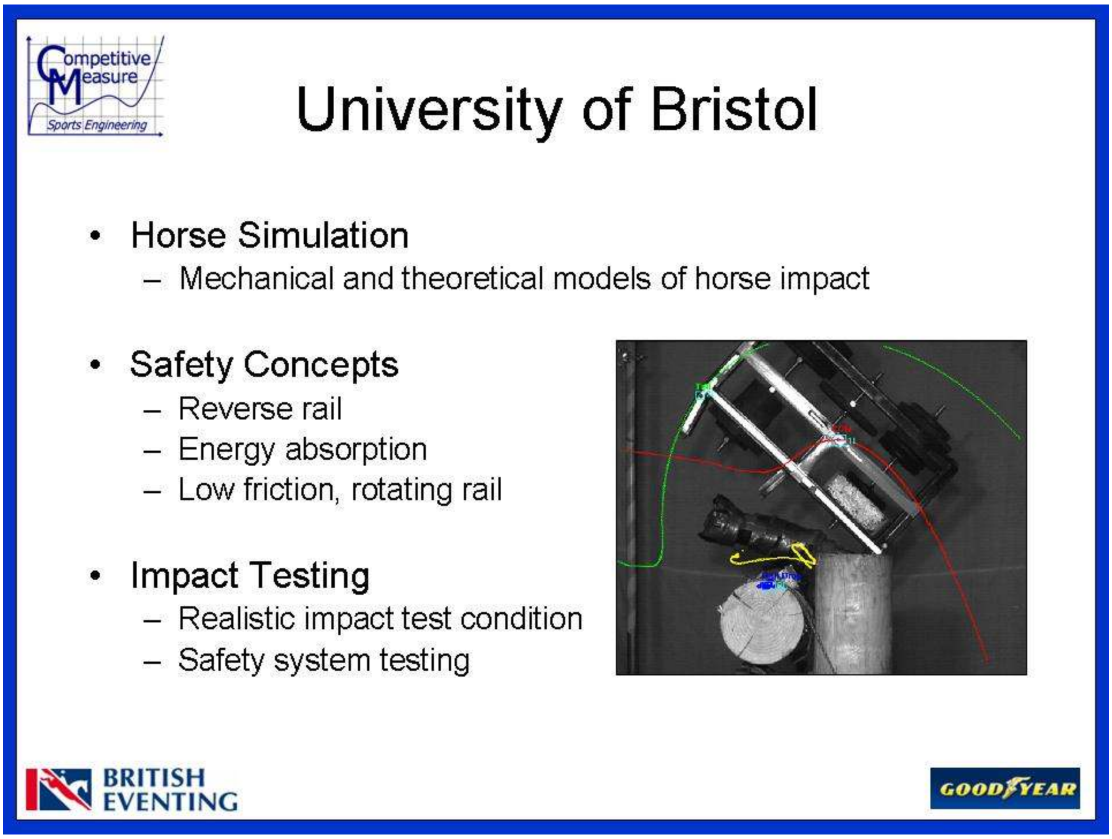

- The graph above shows impact force on the vertical axes (0-18000N or 1.8 tonnes) and time on the horizontal axes over a period off 2/10’s of a second.
- Horizontal force is plotted in blue and vertical force in red.
- The graph displays the relationship between horizontal and vertical force, timings and magnitudes of impacts.
- This information is very useful when designing safety systems.

- Point A shows peak horizontal force
- Point B shows peak vertical force
- Region C shows main impact duration
- Region D shows initial contact between horse and fence

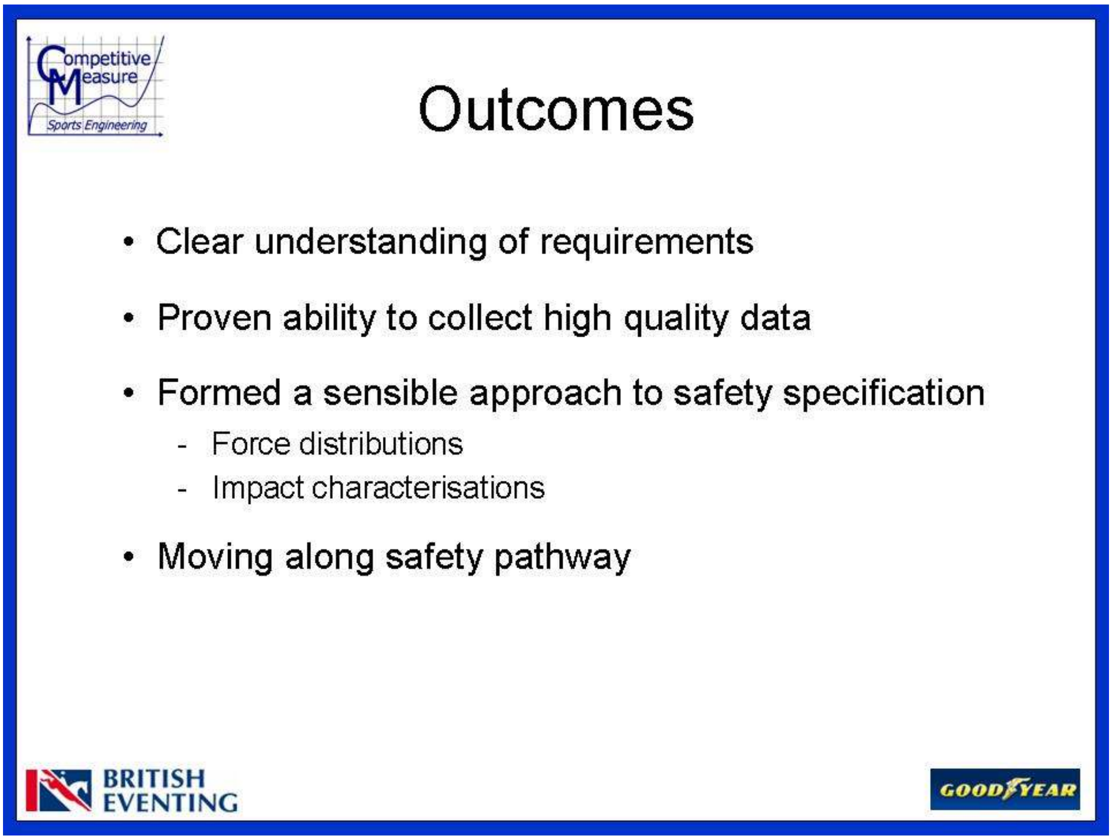

- Several videos of a horse/fence collision were shown
  - Video 1 – video played at full speed as a normal video sequence would play.  Very difficult to identify what is happening in clip.
  - Video 2 – high speed video at 125 frames per second played at slow motion allowing analysis of the horse through collision.
  - Video 3 – high speed video and impact force data graph synchronised together allowing full analysis of collision. Video/force analysis program developed by Competitive Measure.



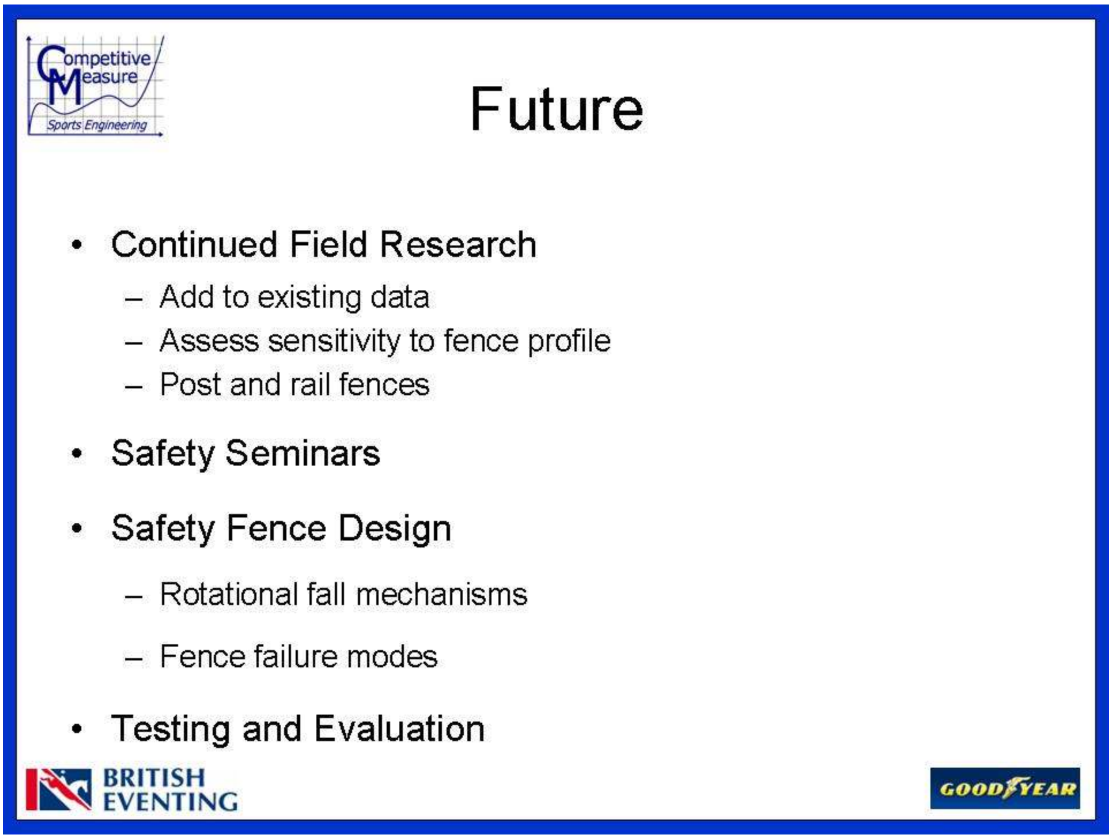

- Data from the Goodyear research project has been useful for other projects through 2008.
  - Pin testing: further development work and testing of the frangible pin system has been undertaken in the laboratory.
  - Fence testing: testing of existing fences in the field to ensure that specification is met.
  - Anchor testing: using forces measured a the Goodyear fence, different anchoring techniques have been tested on portable fences determining effectiveness in different ground conditions.




- Competitive Measure and British Eventing maintain strong links with the University of Bristol.
- Over the last three years a number of research projects aimed at improving safety in the sport have been undertaken.
    - Horse Simulation: a scale model mechanical horse has been developed for laboratory testing. Theoretical models have also been developed allowing comparison to laboratory data.
    - Safety Concepts: many different safety concepts have been developed and tested at the University.
    - Impact Testing: An undergraduate project for 2009 is focusing on reliable impact testing, using data from the Goodyear field testing to try and replicate impacts in the laboratory.




- Carrying out the Goodyear research project throughout the 2008 season working with course builders, designers, competitors and those in the sport has led to a clear understanding of the requirements of a safety system to be introduced to the sport. Such a system must be simple, effective, inexpensive, quick to reinstate when activated and importantly must not affect the nature of the sport.
- Competitive Measure has developed monitoring systems well suited to measuring data in the field in real competition situations.
- A sensible approach has been developed using the measured "safe" impacts from the Goodyear fence to predict what is expected at a fence in a competition situation.
- Analysis of larger impacts allows safety fence design characteristics to be determined including operation time.
- Safety within the sport is progressing. Improving safety is a gradual process requiring continual development over time.




- It is vital to continue field testing. The most important element of future testing will be to assess how the data is influenced by different fence profiles.
- Gathering design ideas from within the sport will be speed up the development of systems as part of safety seminars
- Determining how a rotational fall is initiated will be important in determining exactly how a fence should fail.
- For safety to improve within the sport the systems developed will have to be continually evaluated and tested.

# Goodyear Safety Research Project 2008

**Research in partnership with British Eventing supported by Goodyear**

**Tim Deans**
**Martin Herbert**