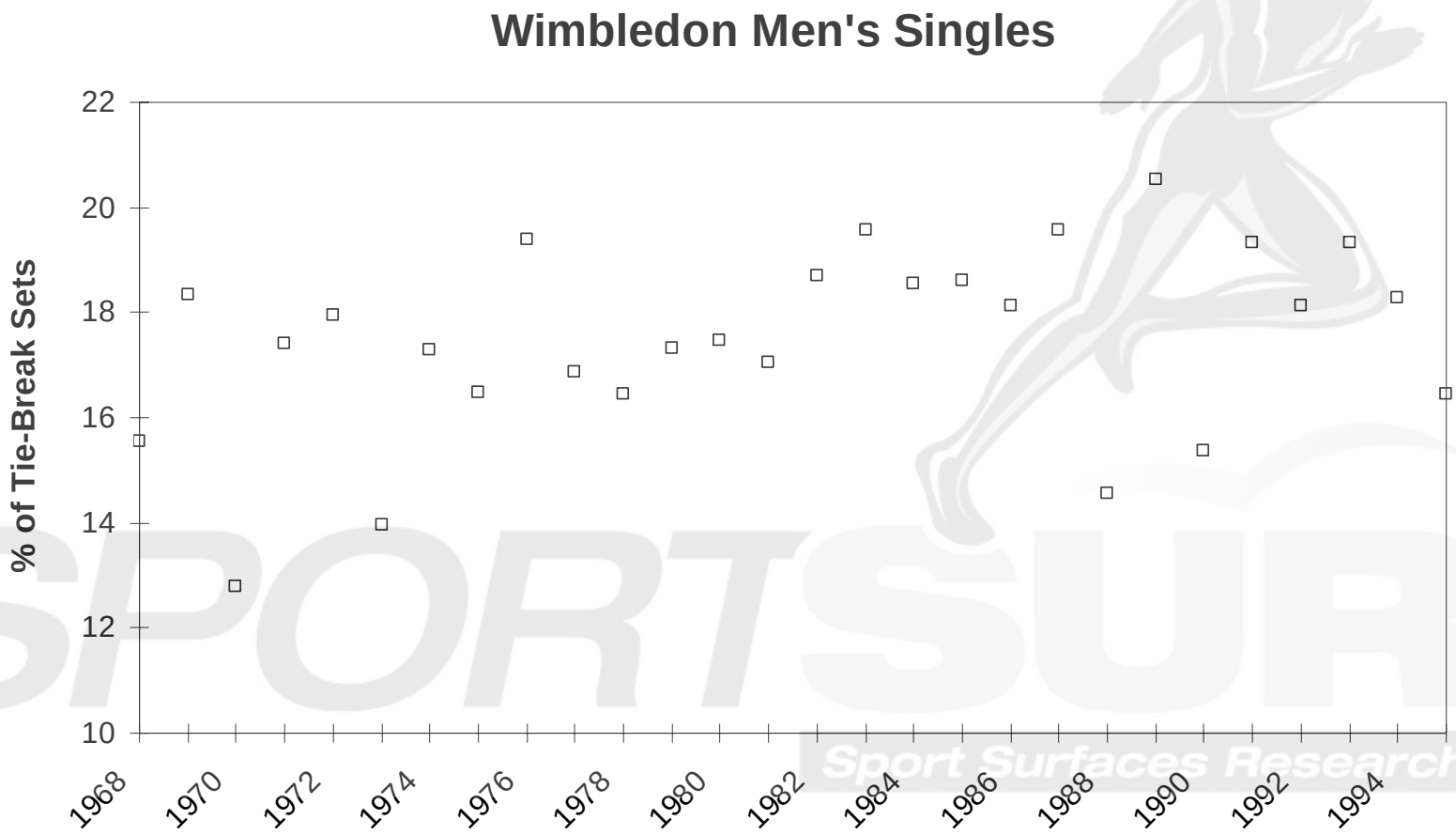
An *Initial ITF Study on Performance Standards for Tennis Court Surfaces*

Stuart Miller & Jamie Capel-Davies

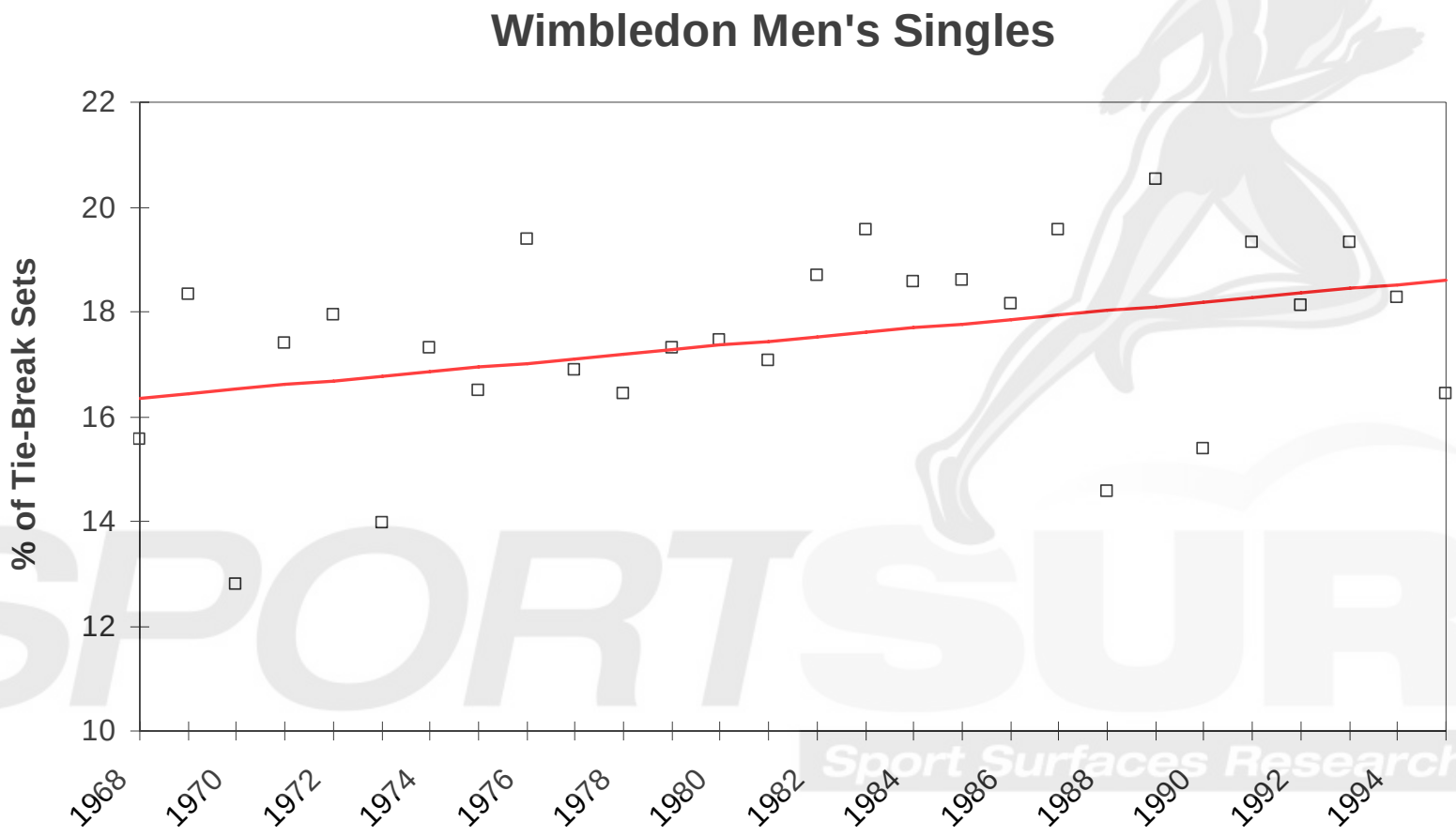
Background



Source: ITF I.T. Dept.

ITF Technical

Background



Source: ITF I.T. Dept.

Background

- Concerns regarding speed of the game – rallies becoming shorter
- Racket/ball research programme, but little surface-specific
- Nothing in Rules of Tennis regarding surface
- Performance standards should be sport-led – rejected by CEN

October 1995

- ITF *Performance standards for tennis surfaces* working group
  - ITF, LTA, FFT, DTB, USTA, KNLTB
- Terms of reference
  - To agree an international system of classification and terminology for tennis courts
  - To agree key performance criteria and a common system of test methods
- "Impossible to have an international standard to cover all countries and climates"

October 1995

- Restrict to sports performance…

1. Vertical ball bounce
2. Angled ball behaviour
3. Shock absorption
4. Friction
5. Spin
6. Slope/evenness
7. Reflectance
8. Permeability
9. Colour

- Follow-up questionnaire to NAs

April 1996

Parameter	Tested devices	Adopted device(s)
Vertical ball bounce	Video (UK), acoustic (Ger), photo-cell (Fra)	
Angled ball bounce	Sestée (UK / Fra)	
Dynamic friction	TRRL (UK) / Leroux (Fra) / 'falling mass' (Ger) pendulums	
Static friction	Traction tester (UK)	
Shock absorption	Berlin (Ger) / 'Papendal' (Hol) / 'Le Mans' (Fra) Artificial Athletes	
Spin	No device (but TA…)	

April 1996

Parameter	Tested devices	Adopted device(s)
Vertical ball bounce	Video (UK), acoustic (Ger), photo-cell (Fra)	All
Angled ball bounce	Sestée (UK / Fra)	Sestée
Dynamic friction	TRRL (UK) / Leroux (Fra) / 'falling mass' (Ger) pendulums	TRRL pendulum (adapted)
Static friction	Traction tester (UK)	Further consideration necessary
Shock absorption	Berlin (Ger) / 'Papendal' (Hol) / 'Le Mans' (Fra) Artificial Athletes	Papendal Athlete
Spin	No device (but TA…)	None

April 1996

Parameter	Tested devices	Adopted device(s)
Slope / evenness	Straight edge	
Reflectance	None	
Permeability	Concentric rings (UK)	
Colour	N/A	

April 1996

Parameter	Tested devices	Adopted device(s)
Slope / evenness	Straight edge	Straight edge
Reflectance	None	None
Permeability	Concentric rings (UK)	Concentric rings
Colour	N/A	N/A

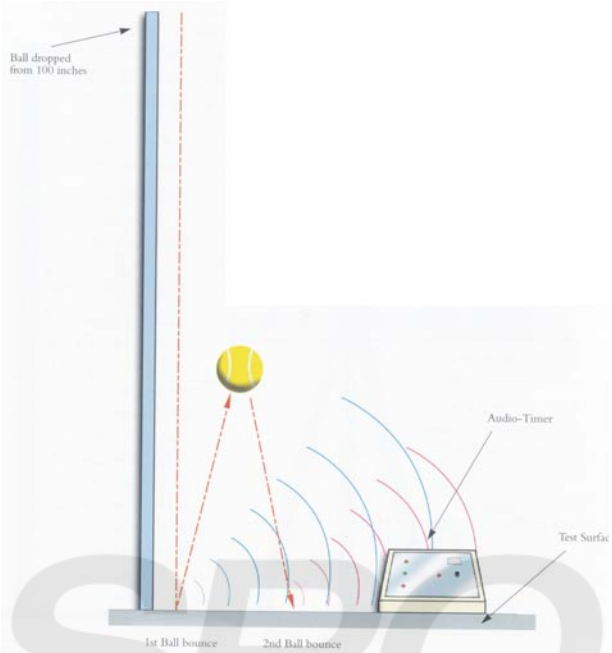
July 1996

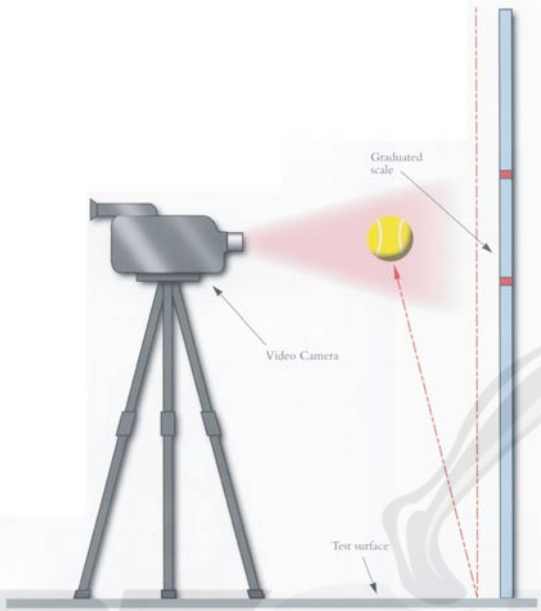
- Original objectives
  - To agree an international system of classification and terminology for tennis courts
  - To agree key performance criteria and a common system of test methods
- New objectives
  - Guidance to NFs for development of new or refurbished courts
  - Guidance to manufacturers and suppliers for product development
  - Describe minimum requirements for ITF events

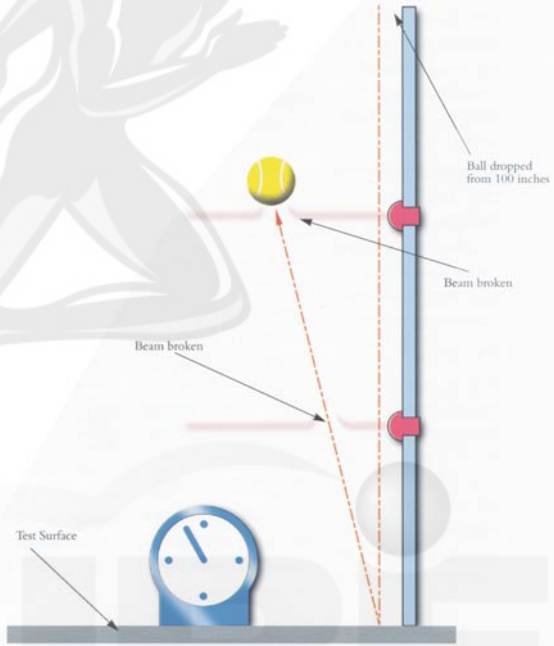
June 1997


An Initial ITF
Study on Performance
Standards for Tennis
Court Surfaces
ITF

Vertical ball bounce







Criteria for Vertical Ball Rebound (ITF CS05/01)

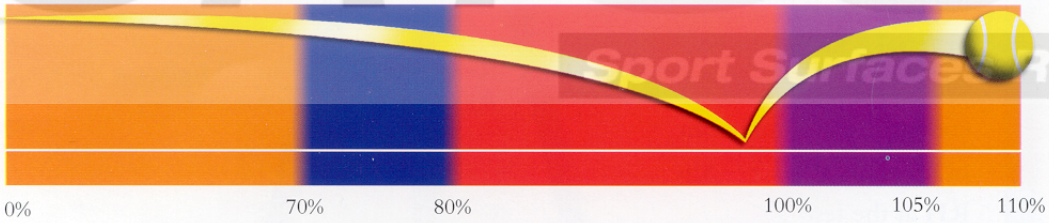


Figure 11: Classification of Vertical Ball Rebound

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Surface Pace

Criteria for Surface Pace (ITF CS 01/01)

Figure 2: ITF Surface Pace Rating

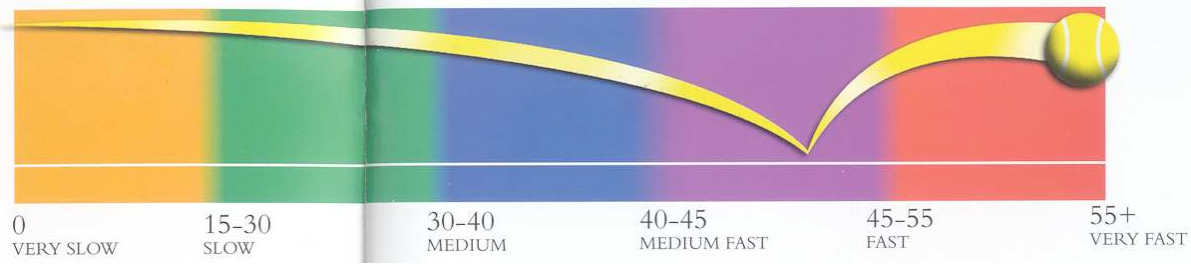
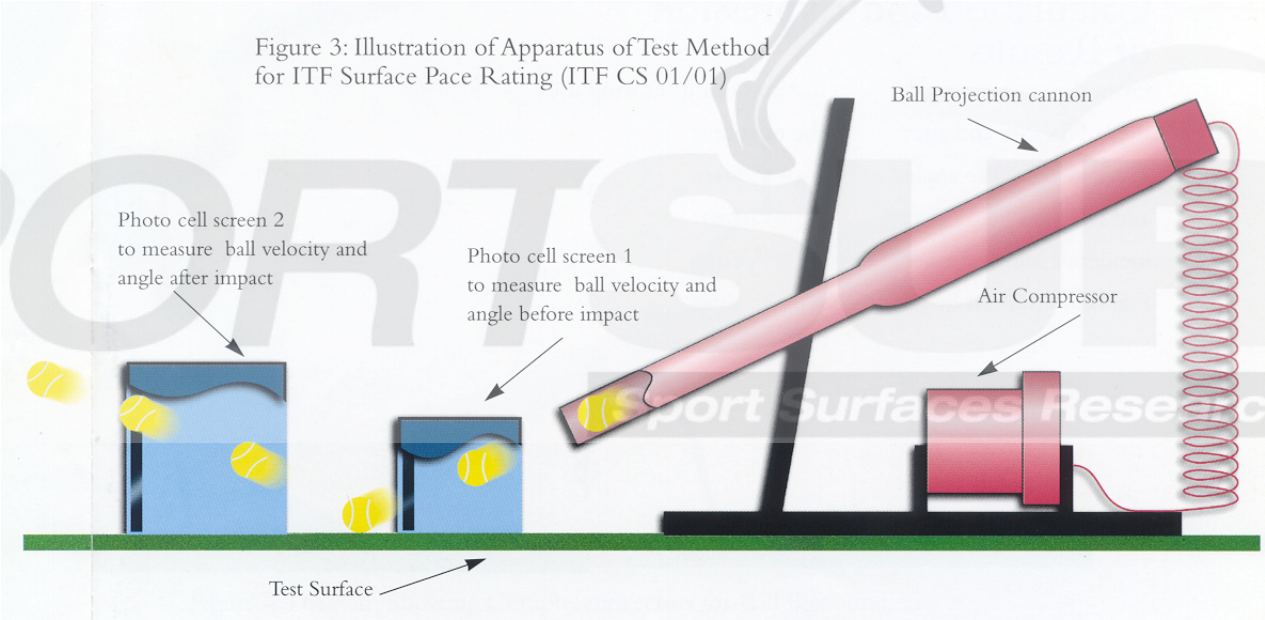
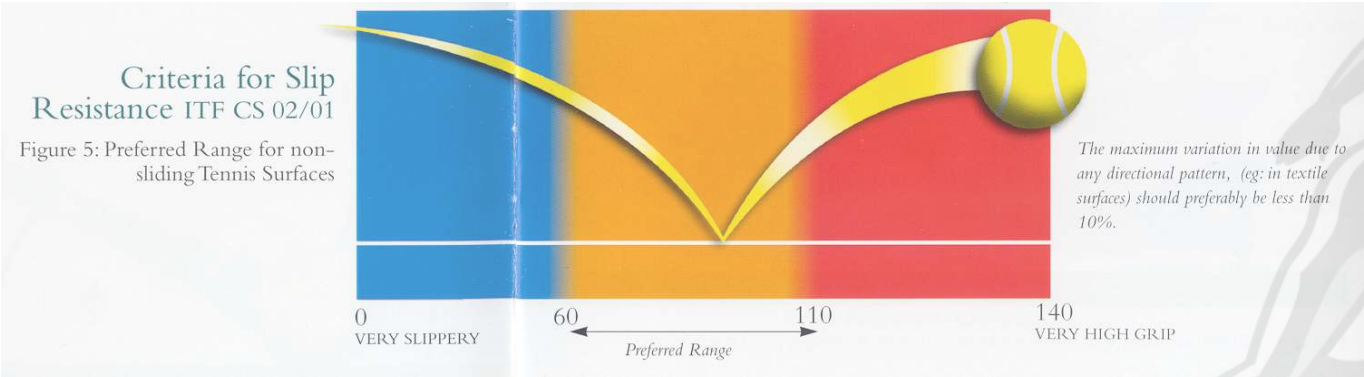
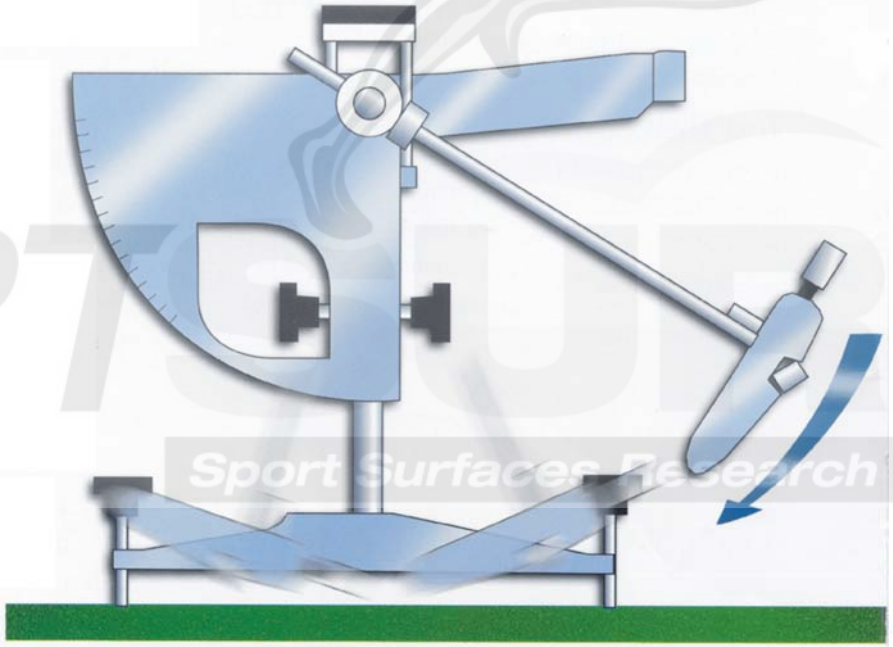


Figure 3: Illustration of Apparatus of Test Method for ITF Surface Pace Rating (ITF CS 01/01)

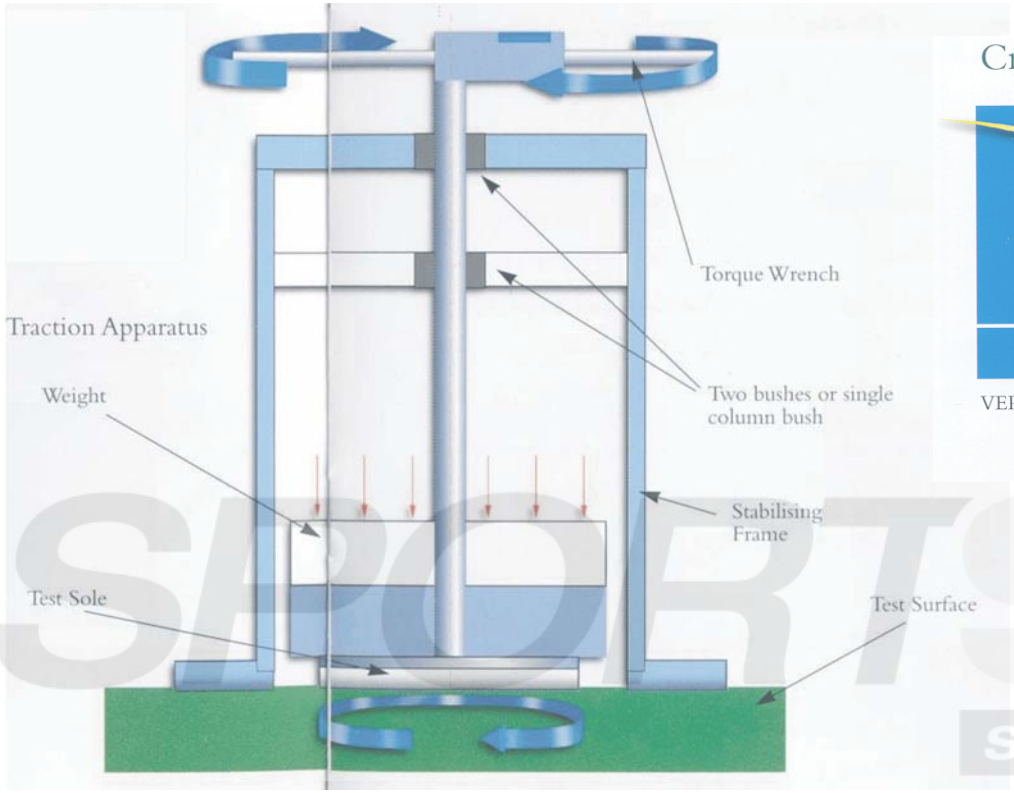


Dynamic Friction





Static Friction



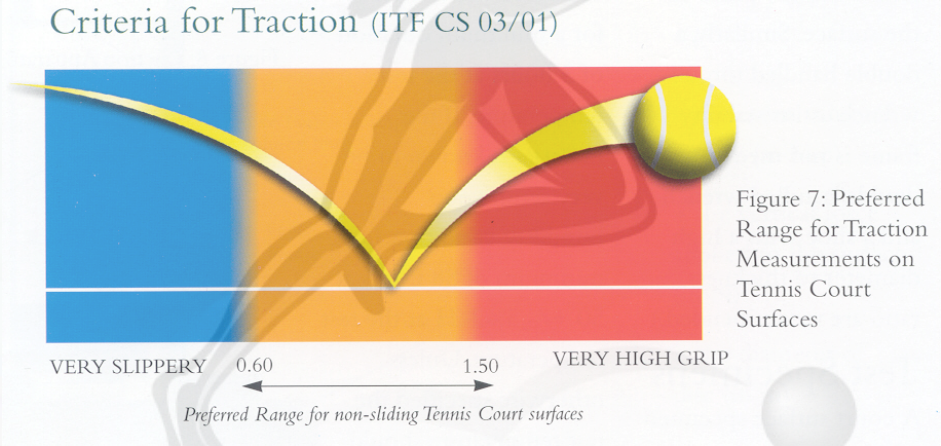
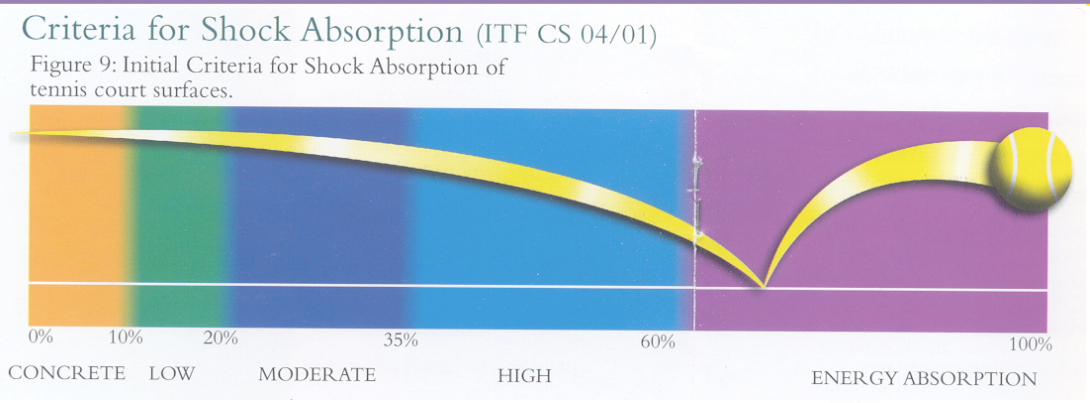
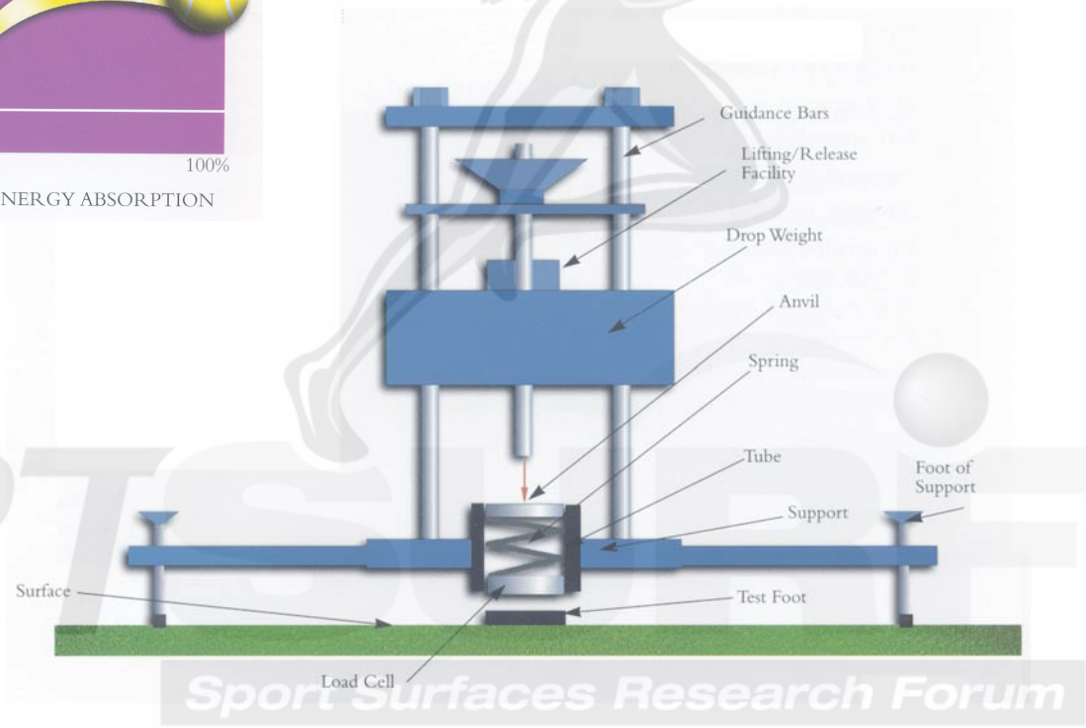


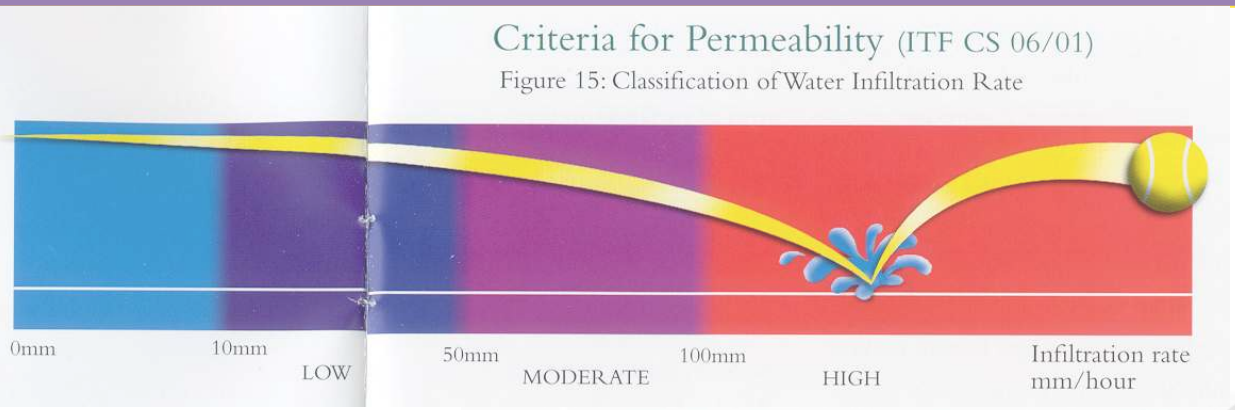
Figure 7: Preferred Range for Traction Measurements on Tennis Court Surfaces

Shock Absorption





Permeability



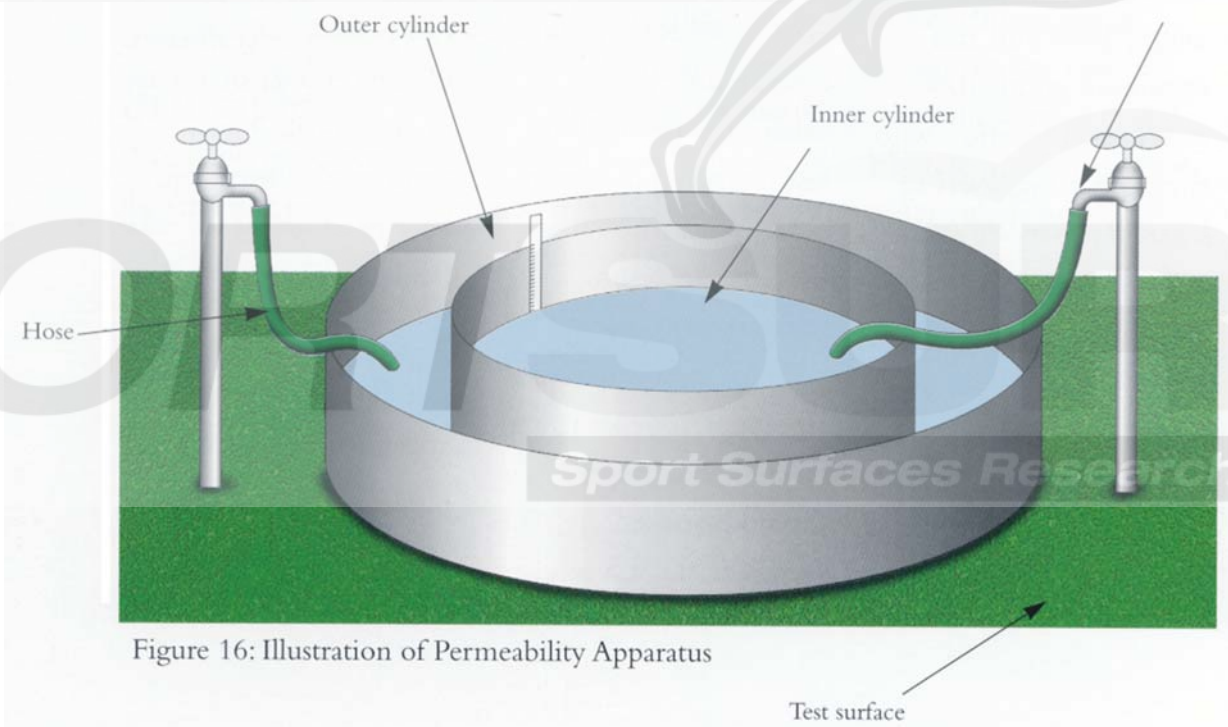
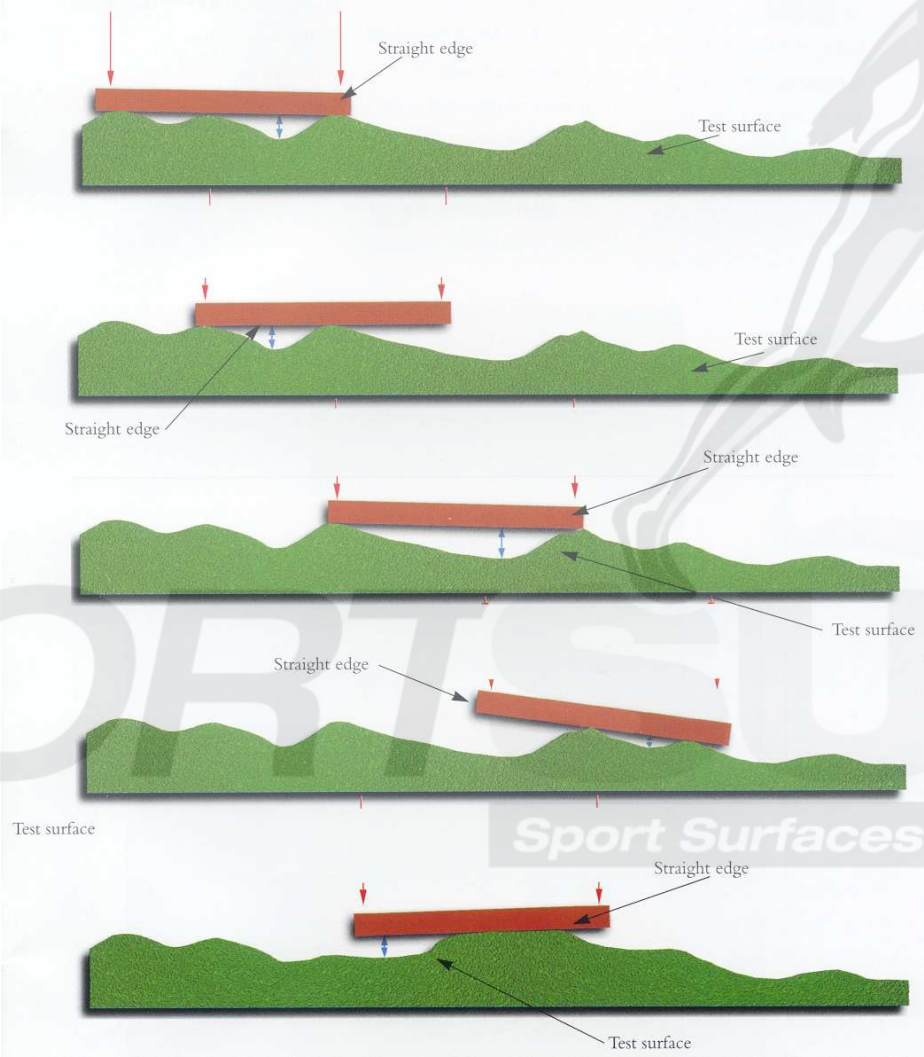


Figure 16: Illustration of Permeability Apparatus

Slope

Evenness



Issues

- Introduction without sufficient industry consultation
- Perceived as a definitive document by many users
- USTC&TBA comments complimentary and covered in amendments
- “Test methods…are likely to be amended and improved”

Initial Study review

Aims

Define and quantify key properties that affect play, such that:

- A minimum level of quality can be established, and high-quality workmanship is encouraged
- Standards can be improved, based on what is achievable by experienced contractors using quality materials and conventional methods at reasonable cost
- Courts can be compared, giving constructors and end-users a common language
- Contractors are protected against unreasonable demands by customers

Introduction

- Stage 1 – theoretical review: what is important?
- Stage 2 – review existing properties and tests: what should we keep?
- Stage 3 – research new tests where appropriate: what should we add?
- Stage 4 – produce revised document

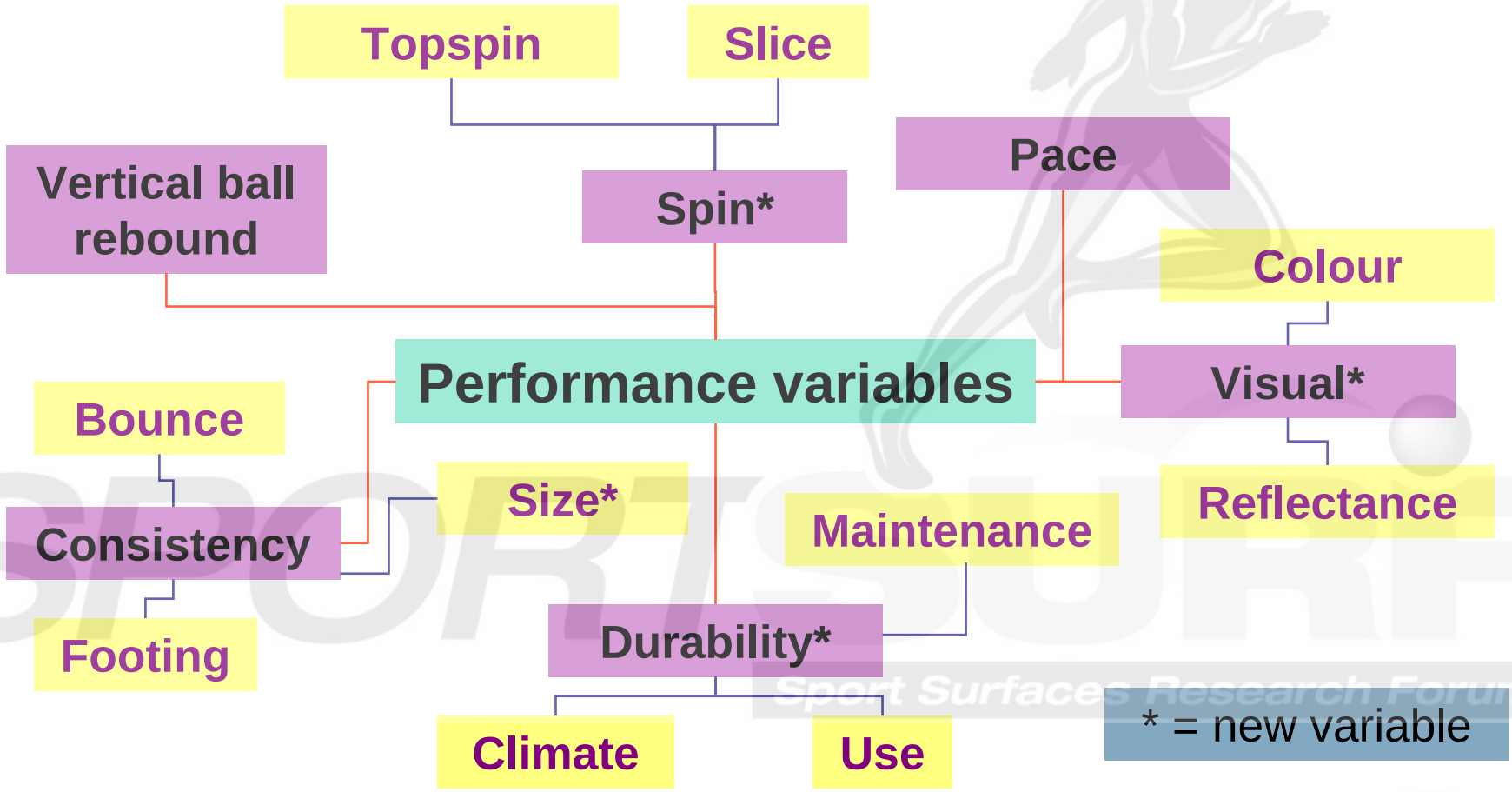
Test selection

1. Identify variables: Relevant? Measurable?

2. Assess test method: Validity? Accuracy? Reliability? Portability? Time? Operators? Ease of use? Destructive?

3. Specify achievable criteria inc. tolerance. Surface-specific?

Identifying variables



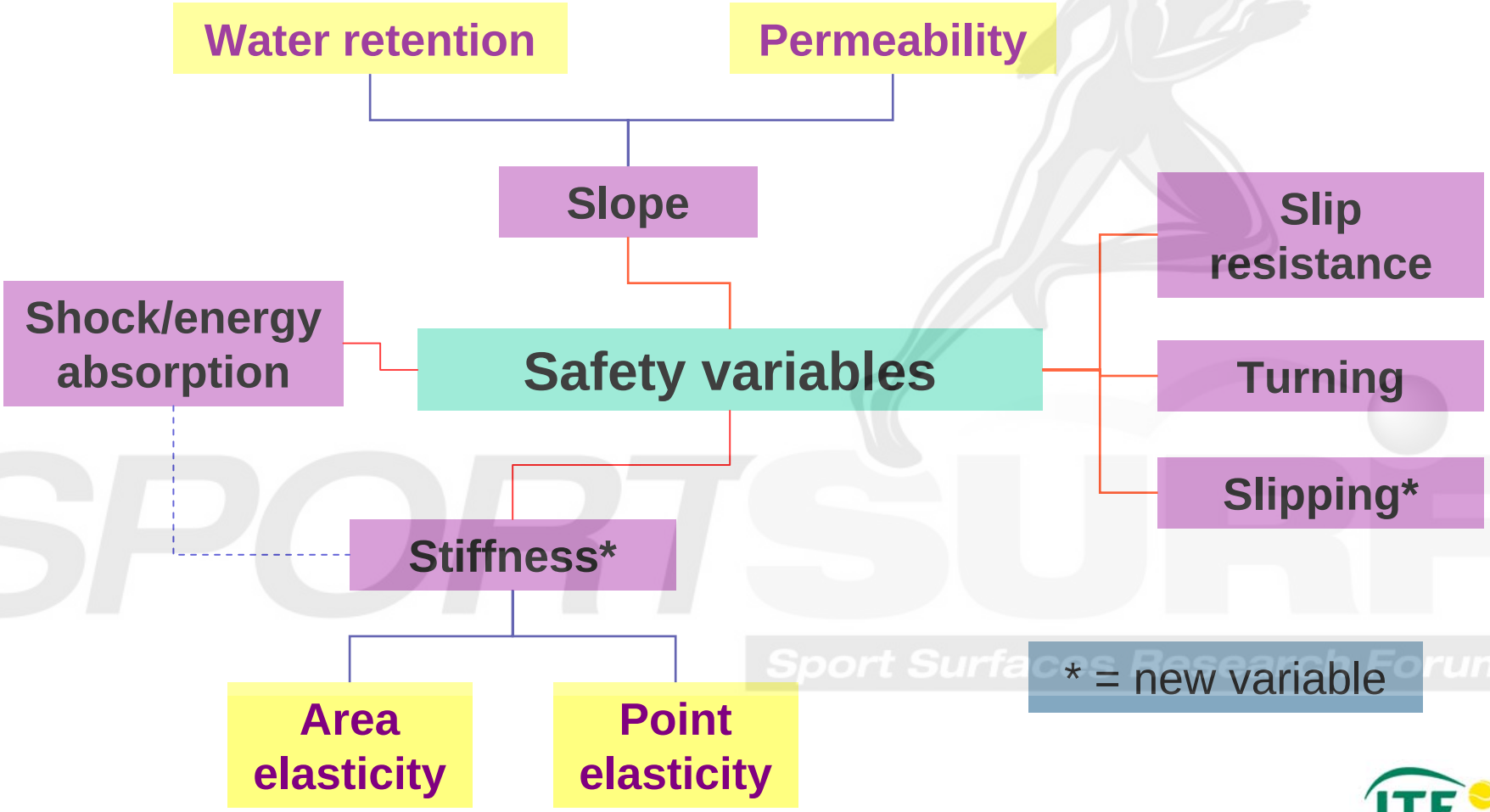
Existing tests

Parameter	Existing Test	Change Test?	Advantages	Disadvantages
Vertical ball rebound	Vertical ball rebound (CS05/01)	Yes (Sestée).	Accurate and realistic	Expensive
Pace	Surface pace (CS01/01)	No. Develop (conversions for) low-cost devices (Tortus, Haines Pendulum, Crab)	Accurate and realistic	Expensive
Consistency	Evenness (CS08/01)	No. Review criteria	Simple, cheap, accessible	

New tests

Parameter	Proposed Test	Advantages	Disadvantages
Spin	None (surface pace adequate)	N/A	N/A
Visual	None (no agreed method of measurement)	N/A	N/A
Durability	Surface pace, slip resistance, vertical ball rebound, shock absorption, evenness	Consistency in recommendations for resurfacing	See relevant tests

Identifying variables



* = new variable

Existing tests

Parameter	Existing Test	Change Test?	Advantages	Disadvantages
Shock absorption	Berlin Athlete (CS04/01)	Possibly (LWD, AAA)	All surfaces, mobile, realistic	Cost, somewhat bulky
Slope	CS07/01	Currently refers to CivEng procedures?		
Slip resistance (coefficient of dynamic friction)	TRRL pendulum (CS02/01)	No		

New tests

Parameter	Proposed Test	Advantages	Disadvantages
Stiffness (deflection)	LWD or AAA?	Can be used on all surfaces, quick	Cost; somewhat bulky
Slipping (coefficient of static friction)	None identified (XL inadequate)	N/A	N/A
Consistency (size)	Dimensions	Simple, cheap, accessible	Time consuming

Deleted tests

Parameter	Existing Test	Reason for deletion
Water infiltration	Permeability (CS06/01)	Destructive; not appropriate to all surfaces; not a factor determining safety or performance
Turning	Traction (CS03/01)	Delete

Summary

Original *Initial Study*	Revised *Initial Study*	Review
Surface pace (retain unchanged)	Surface pace (retain unchanged)	Durability (retest onsite tests; tbc)
Slip resistance (retain unchanged)	Slip resistance (retain unchanged)	Spin (no)
Traction (delete)	Shock/energy absorption (BAA, LWD and/or AAA)	Slipping (to be determined)
Shock/energy absorption (expand with new devices)	Vertical ball rebound (Sestée)	Visual (no)
Vertical ball rebound (change device)	Slope/evenness (new specifications)	Stiffness (to be determined)
Permeability (delete)	Dimensions	Dimensions
Slope/evenness (retain; new specifications)		

Key characteristics

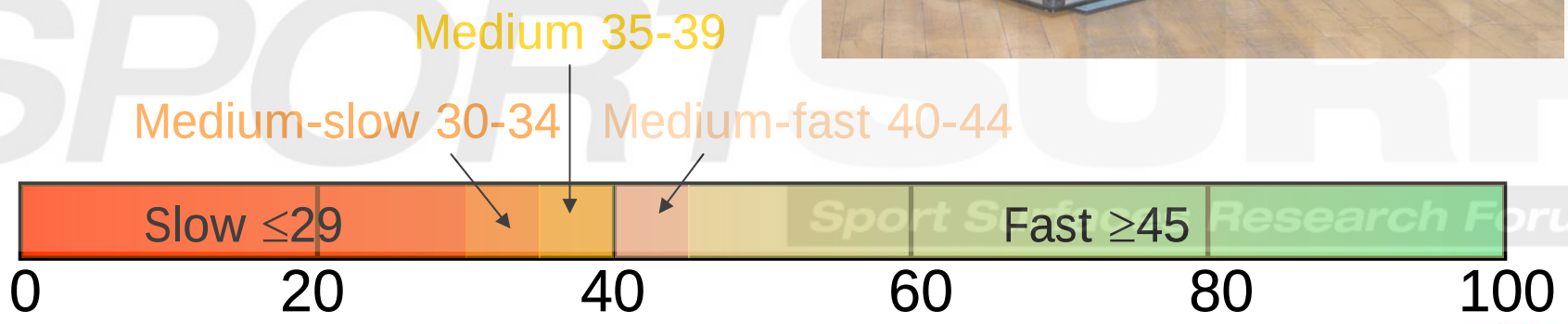
- *Surface pace*: The 'speed' of the court; the change in speed and angle of a ball following impact with the surface
- *Friction*: The resistance to movement of the player on the court surface:
  - Force at the beginning of movement, which prevents slipping, and/or
  - Force that acts during movement, which opposes sliding (slip resistance)

Key characteristics

- *Shock/energy absorption (elasticity)*: The surface's ability to absorb/return energy
- *Topology and dimensions*:
  - Geometrical regularity (evenness)
  - Gradient (slope) and planarity
  - Location of court markings (lines)
- *Consistency*: Uniformity of properties over the playing area and their stability with time, use and maintenance

Surface pace

- Existing test, existing apparatus
- Tolerance: +/- 5 SPR

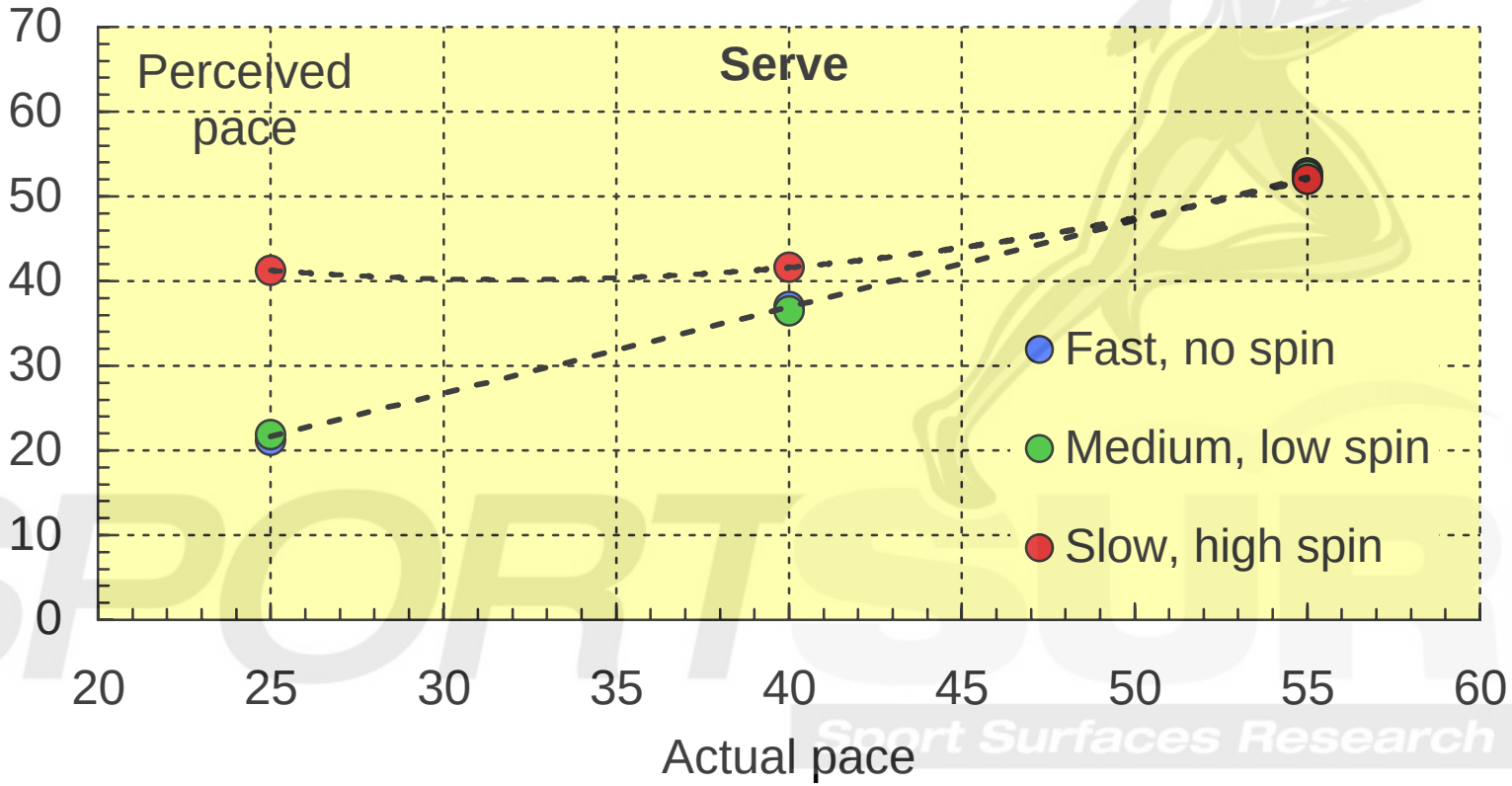


Surface pace - simulation

- Sestée simulates a 120 mph flat serve
- What about other shots?

		Serve		
		Fast	Medium	Slow
Initial Velocity	(m/s)	51	48	45
Direction of Motion	( )	-6.0	-4.0	-1.7
Initial Spin	(rad/s)	0	150	300
Initial Height	(m)	2.74	2.74	2.74
Impact speed	(m/s)	35.5	33.1	30.7
Flight time	(s)	0.43	0.46	0.49
Impact distance	(ft)	60	60	60
impact angle	(rad)	-0.204	-0.242	-0.285
impact angle	( )	-11.7	-13.8	-16.4

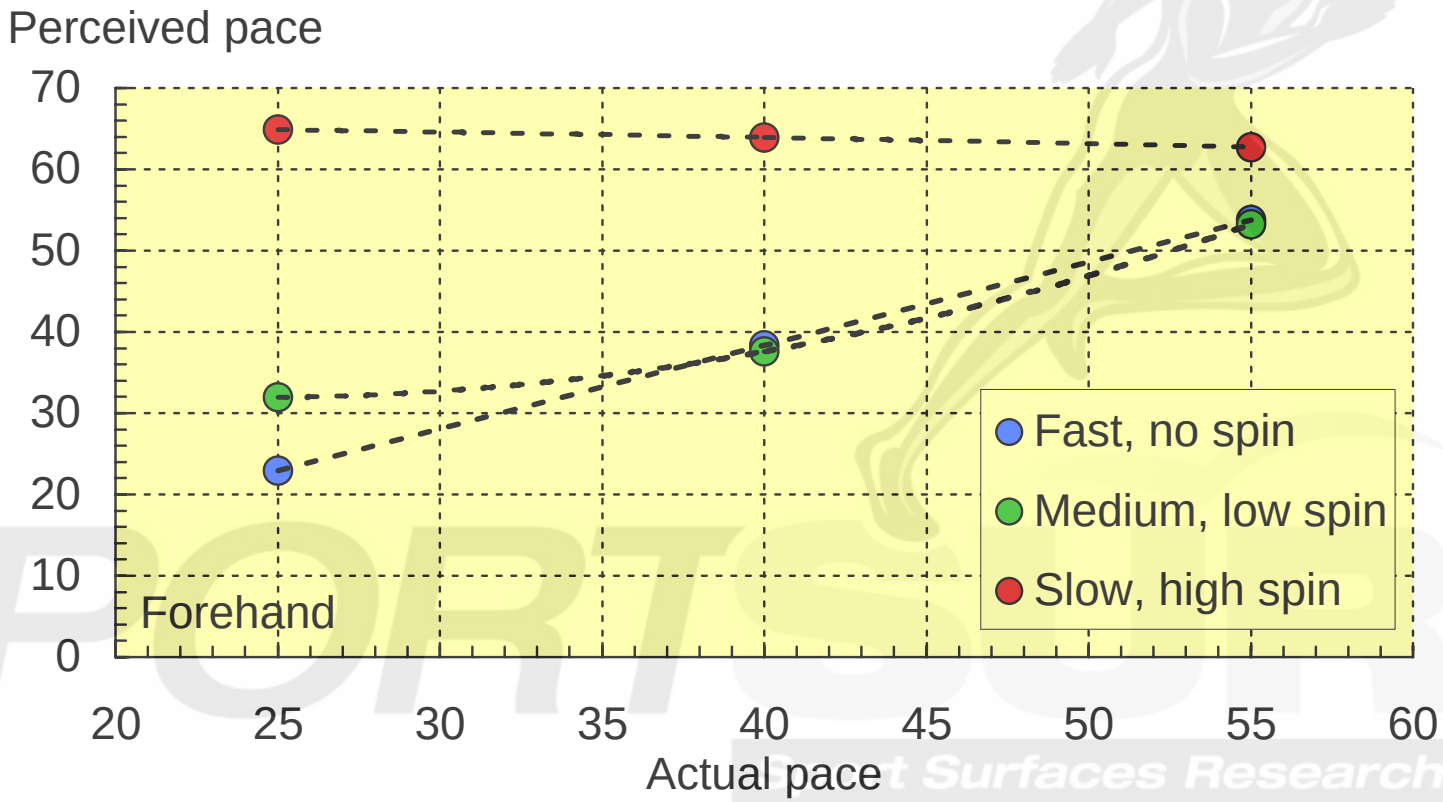
Surface pace - simulation



Surface pace - serve

- Players with fast serves should perceive pace just like SPR test
- Players using topspin or slice may disagree on slow and medium courts

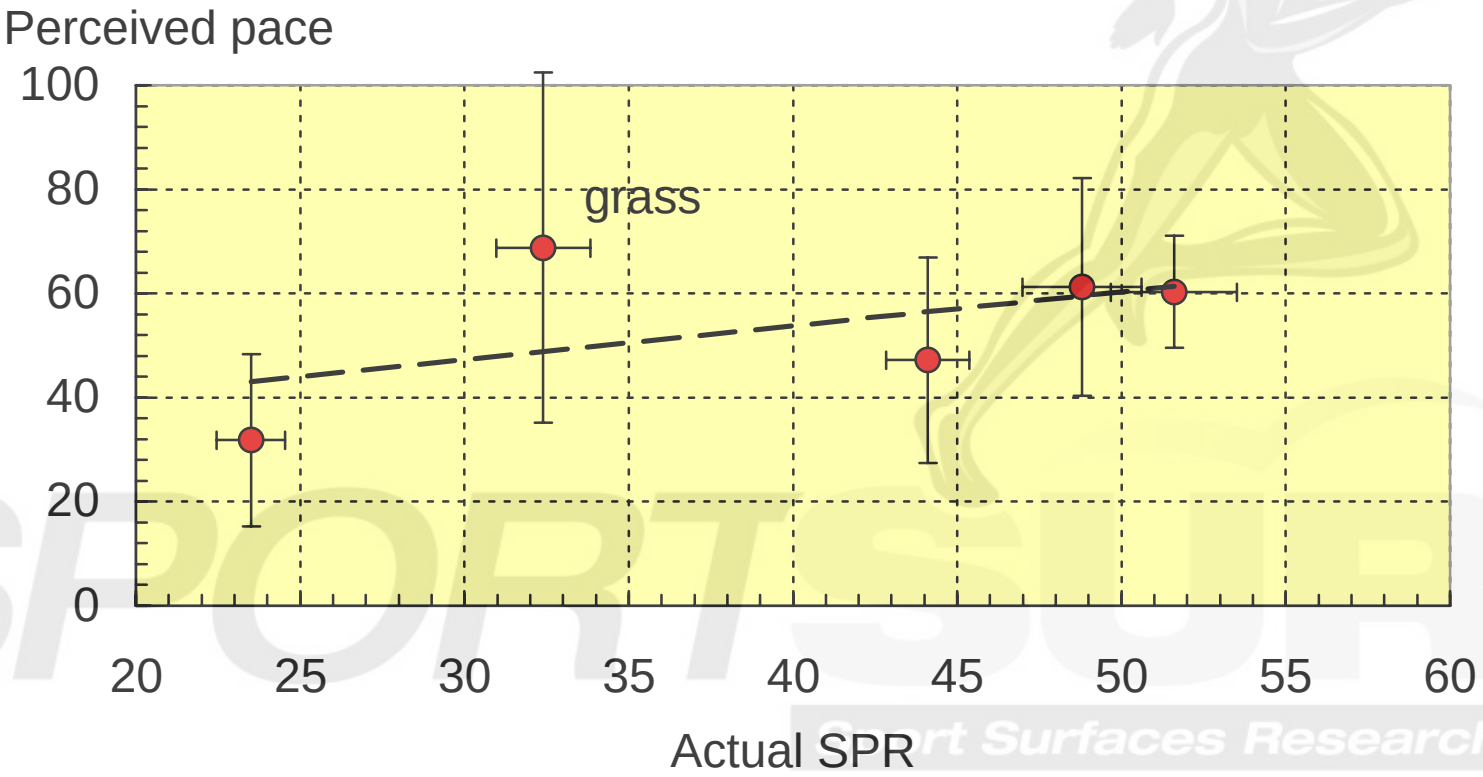
Surface pace - simulation



Surface pace - forehand

- Players with fast (flat) forehands should perceive pace just like SPR test
- Players always using topspin or slice may perceive all courts to be the same

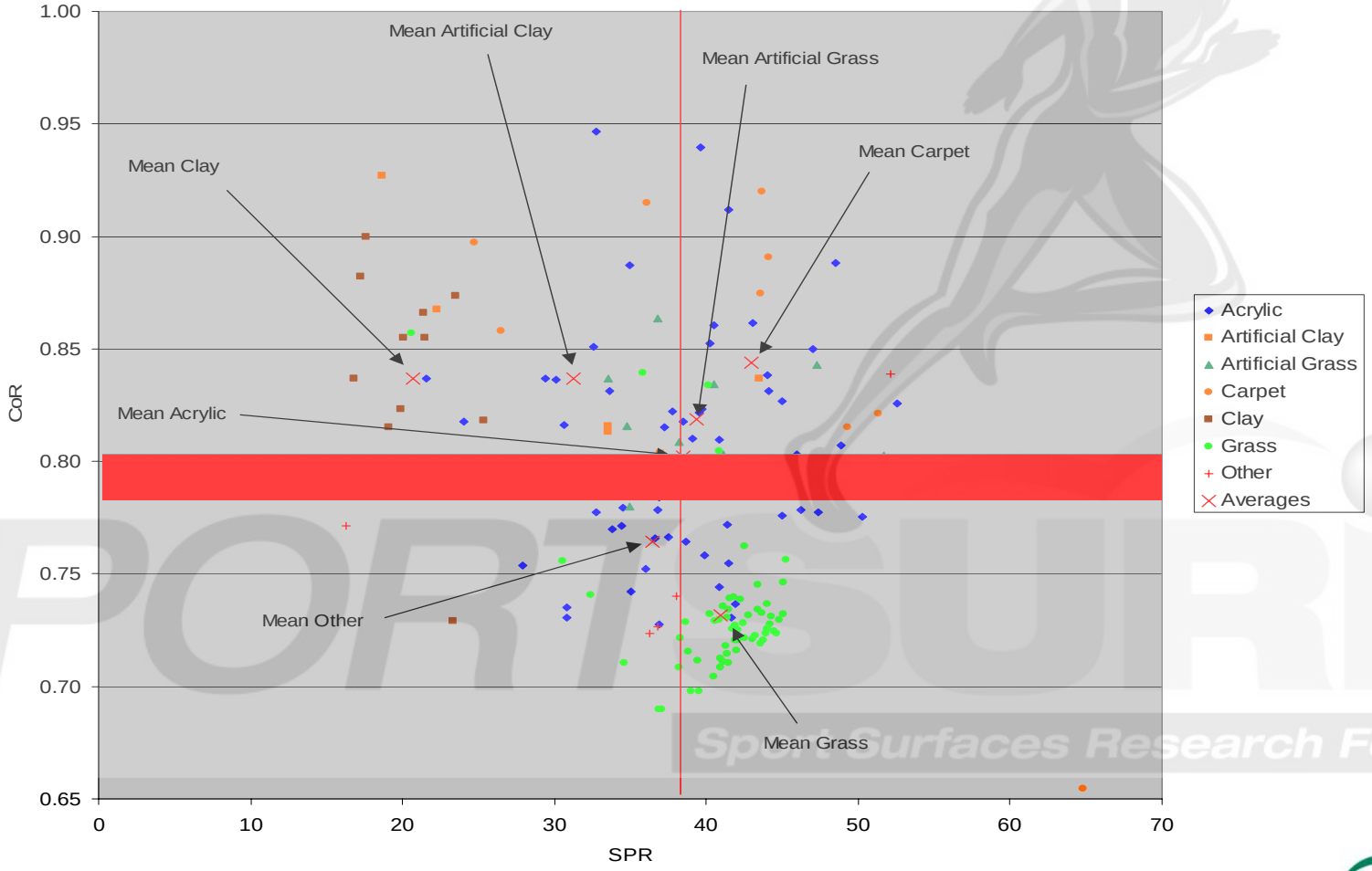
Surface pace - perception



Surface pace - definition

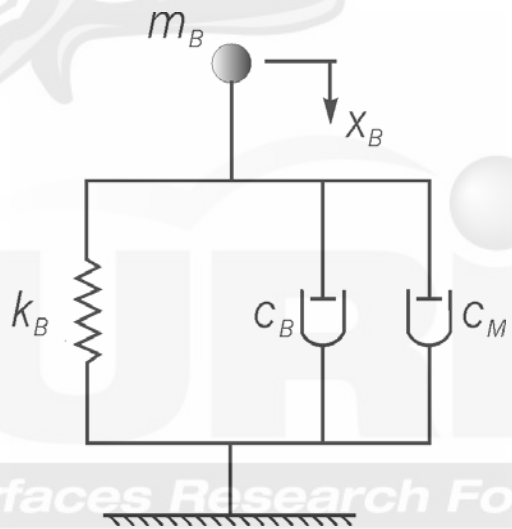
- Players do not always play shots as in SPR test
- ‘Fast’ players should perceive SPR as expected
- ‘Spin’ players could perceive SPR ‘wrongly’
- Grass can be different to other surfaces
- Player perception correlates with SPR…
- …with the possible exception of grass

Surface pace - definition



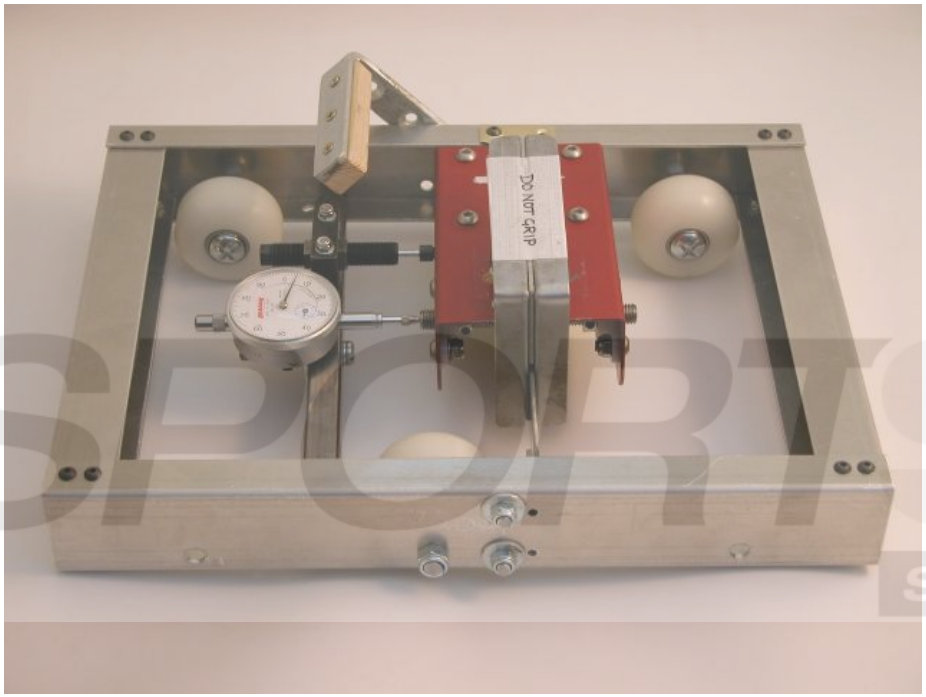
Surface pace – definition

- Tennis GUT uses a damping/ramping model (of a non-rigid surface) to include VCOR
- Can a revised definition of surface pace do the same?

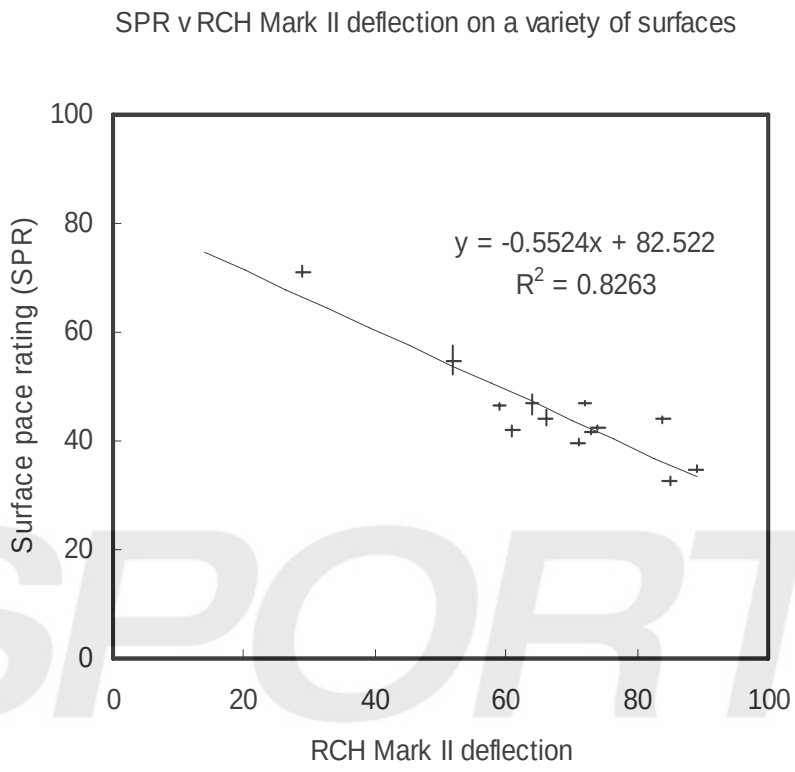


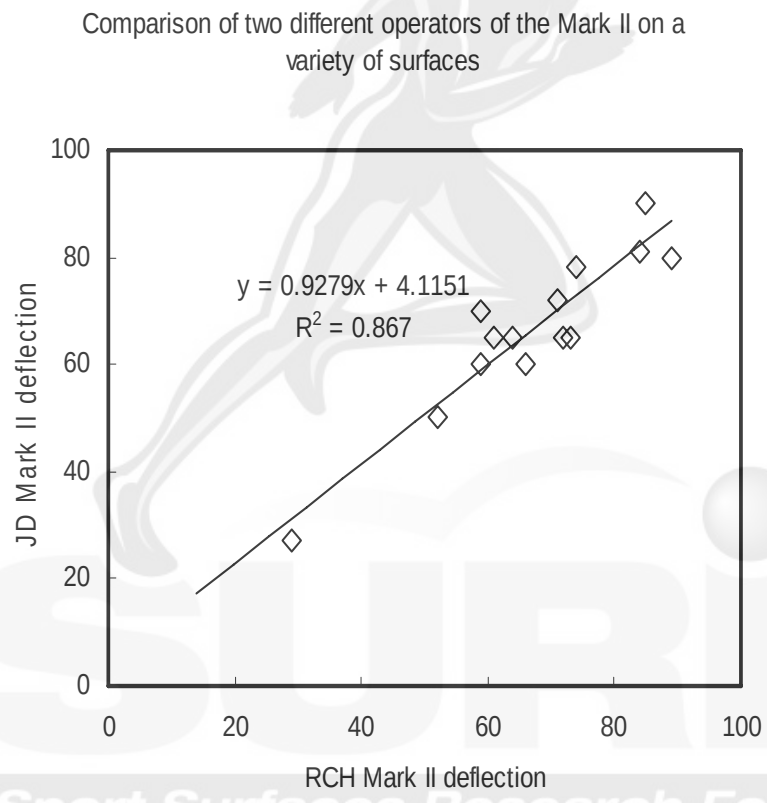
Surface pace - prediction

- Crab Mark II

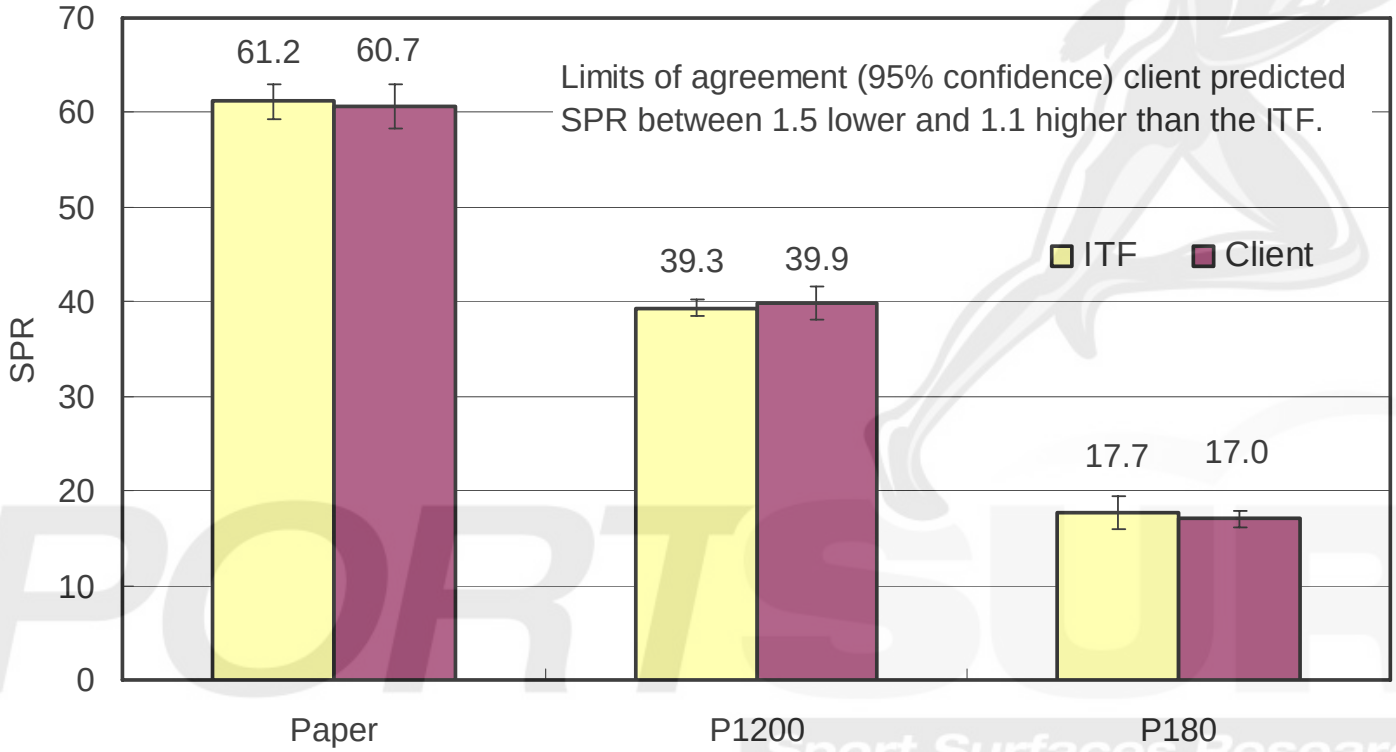


Surface pace - prediction

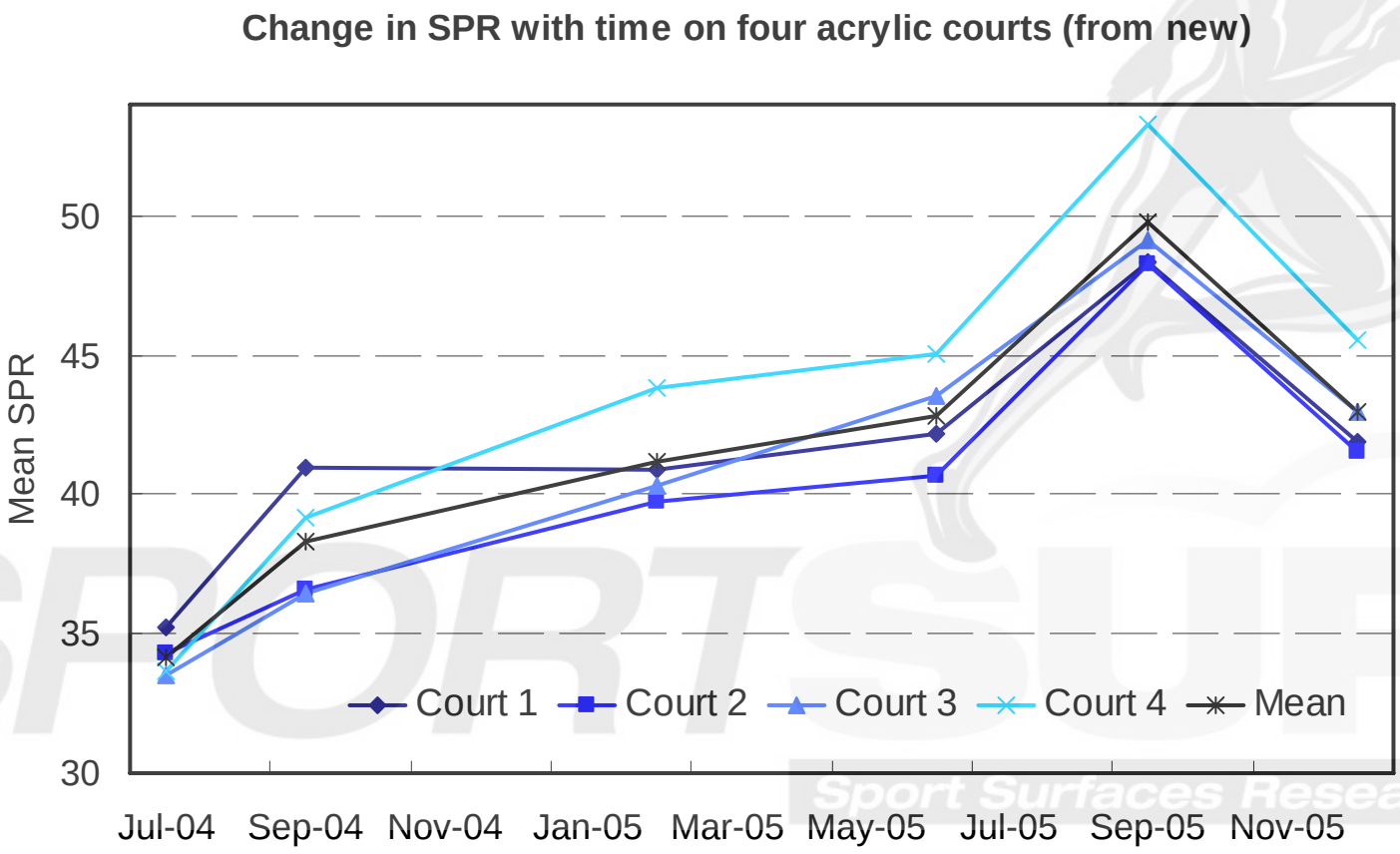




Surface pace – accreditation



Surface pace – durability

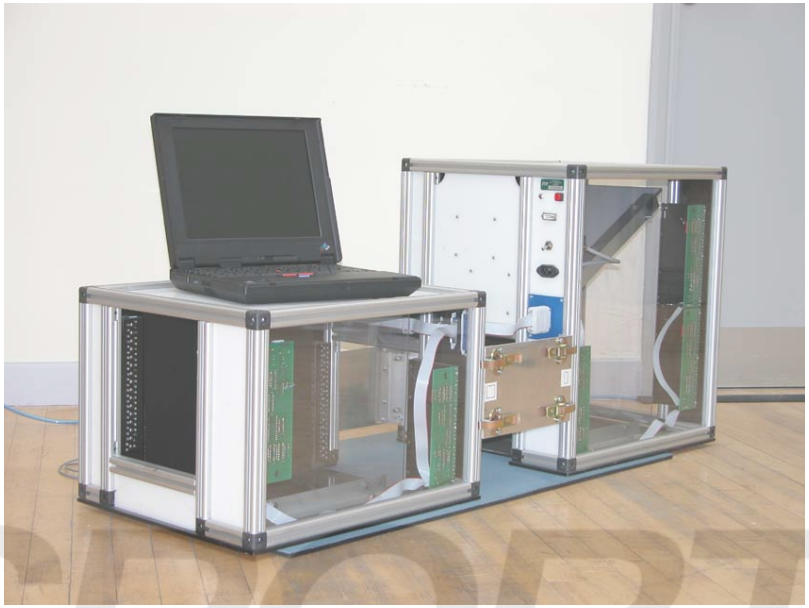


Friction (slip resistance)

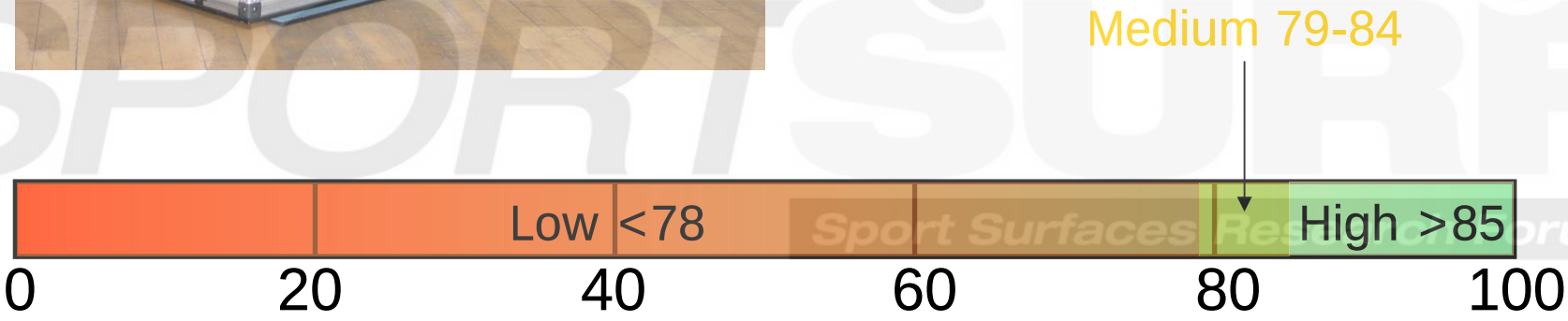
- Existing test, existing apparatus
- Acceptable range:

  60-110 (dry and wet)
- Tolerance: N/A

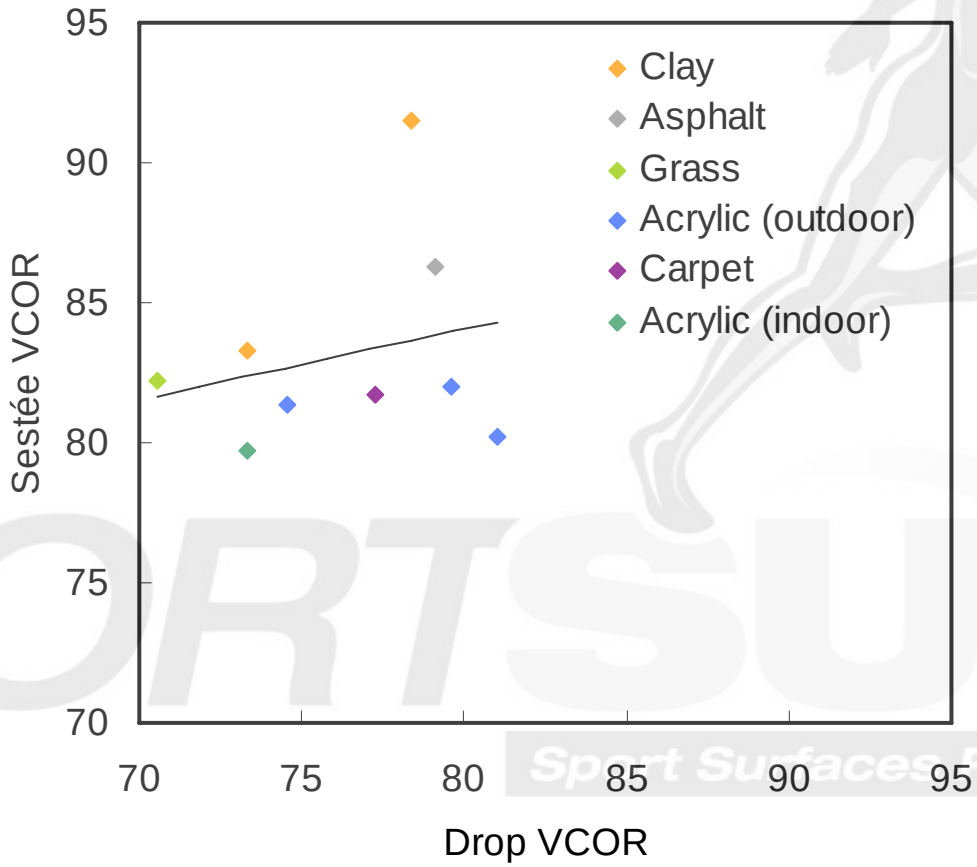
Vertical ball rebound



- Revised test, using Sestée
- Tolerance: TBA



Vertical ball rebound - angle



Shock/energy absorption

- Revised test (new apparatus)

- Categories: TBA
- Tolerance: TBA

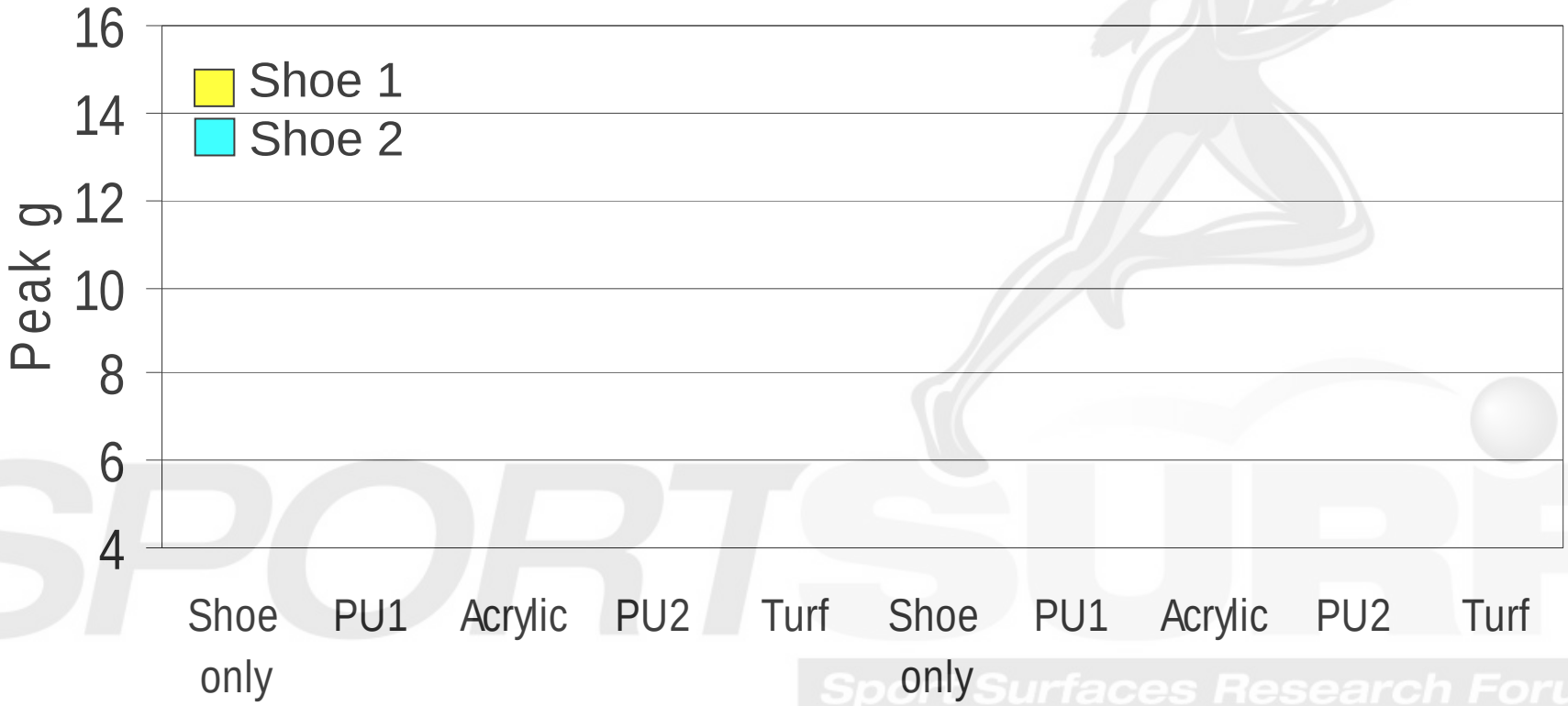
Lightweight deflectometer

- Problems with existing device (BAA)
  - Cumbersome
  - Limited applicability to tennis?
- Project aims with Loughborough
  - Establish relevance and validity of LWD for tennis
  - Establish a test protocol

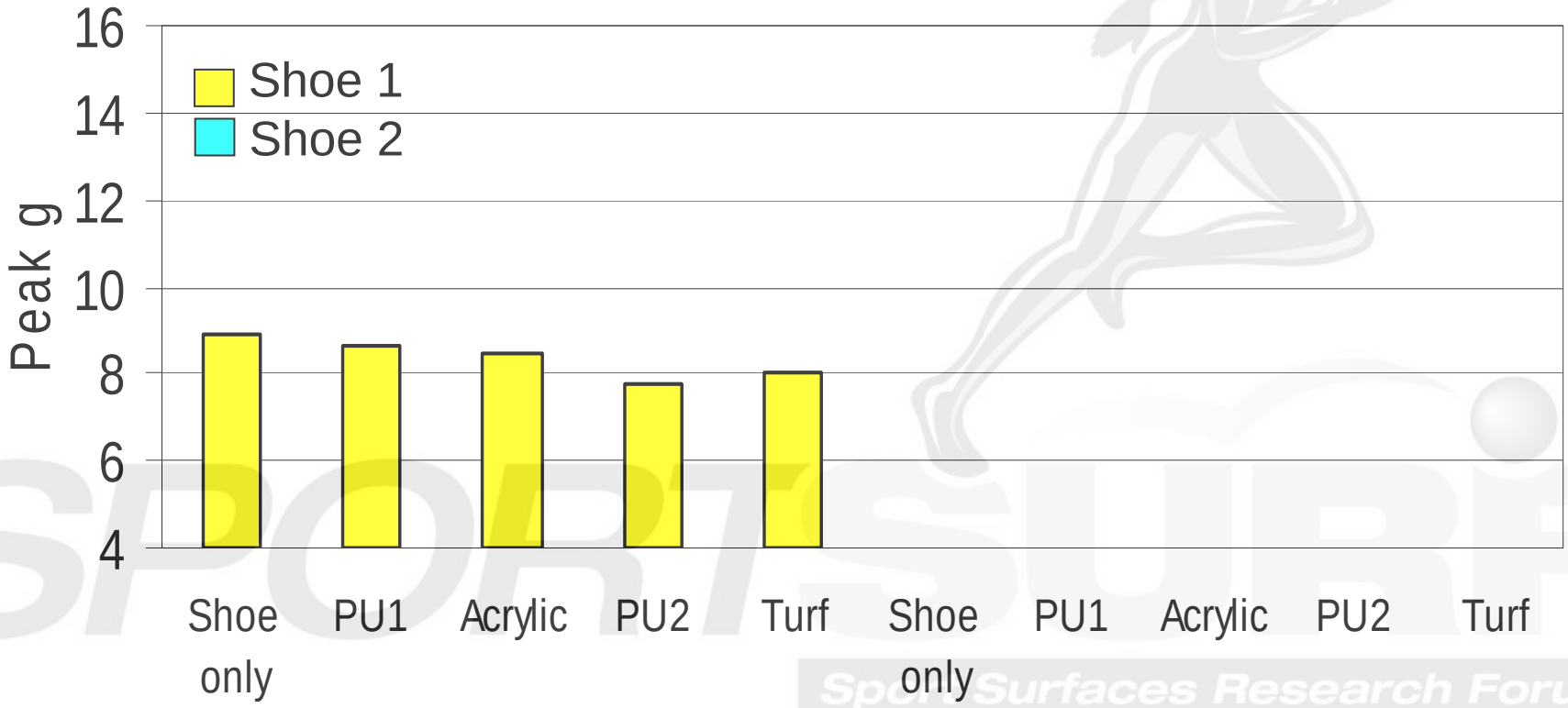
Lightweight deflectometer

- Range and sensitivity appropriate for tennis (particularly for harder surfaces)
- Good repeatability and reproducibility
- Plate size and drop height can varied to simulate tennis conditions
- Protocol needs finalising (test procedure and calculation of results)
- Need to compare with AAA

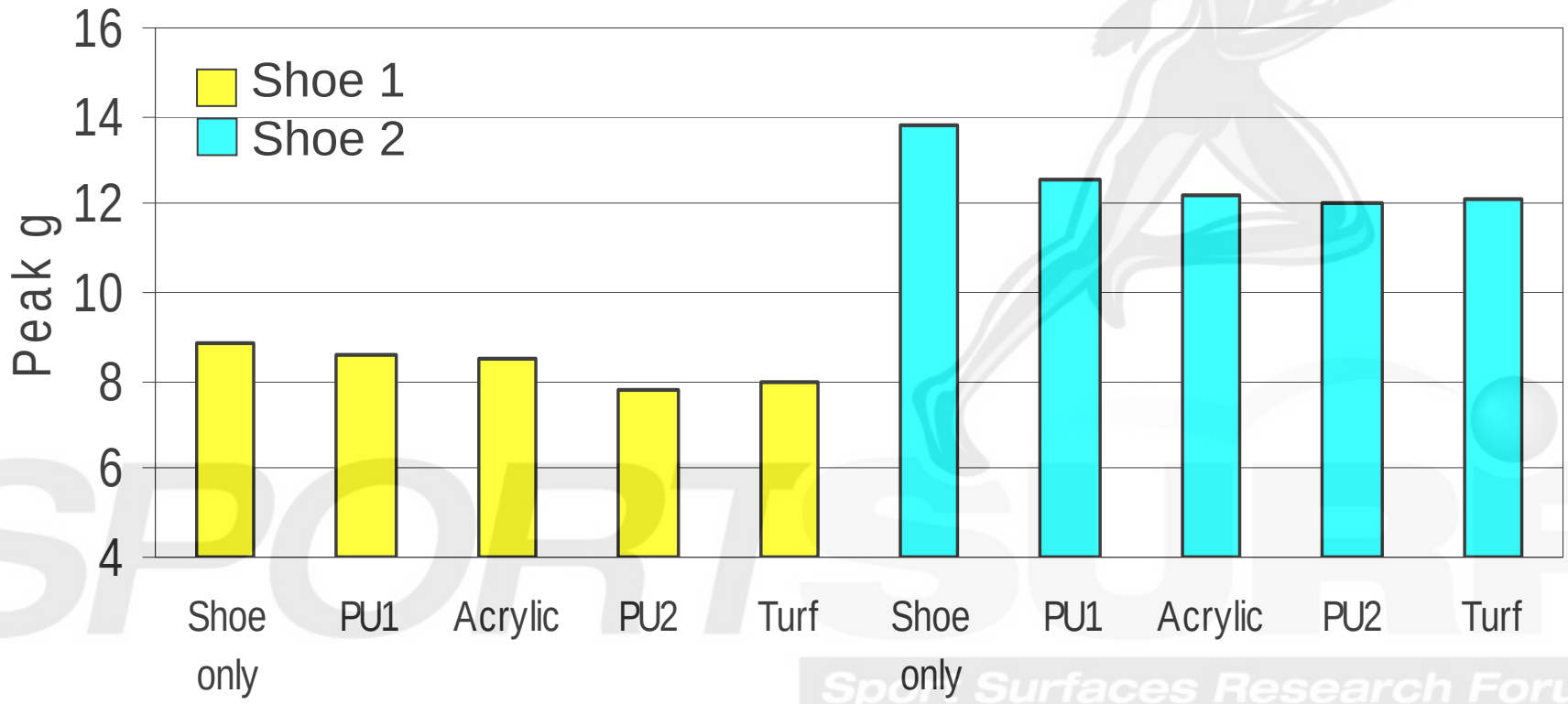
Shoe-surface - peak g



Shoe-surface - peak g



Shoe-surface - peak g



Shoe-surface combinations

- Impact absorption
  - Surface influential in reducing impact forces (as measured by BAA)
  - Need to establish effects of shoe-surface combinations
  - Shoes may be more important than surfaces

Evenness and dimensions

	Acrylic	Artificial Grass/Clay; Carpet	Asphalt/Concrete	Clay	Grass
Gradient	1:100[1]	1:120 (max.)	Impervious: 1:100 (max) Porous: 1:120 (max)	1:120 (max)	1:120 (max)
Evenness[2] **Deviations[3]**	6 mm (95% of all measurements)[2] 5% of measurements[3]	6 mm 2 (PPA)/4 (TPA)[4]	10 mm (single layer), 8 mm (2 or more layers)[4] 4 (PPA)/8 (TPA)[4]	7 mm N/A	6 mm
Planarity[5,6,7]	± 10 mm from true ± 25 mm from true	± 10 mm from true ± 25 mm from true	± 10 mm from true ± 25 mm from true	± 10 mm from true ± 25 mm from true	± 10 mm from true ± 25 mm from true
Dimensions	0.05% (12 mm length, 6 mm width)	0.05% (12 mm length, 6 mm width)[8]	0.05% (12 mm length, 6 mm width)	0.05% (12 mm length, 6 mm width)	0.05% (12 mm length, 6 mm width)[8]

Notes

[1] 1:120 where courts are required to drain.

[2] Measured with a 3 m straight edge.

[3] In no instance should any imperfection exist that could cause the ball to deviate significantly from its path on a perfectly level surface, or expose a player to a significantly increased risk of injury.

[4] Specifications are for porous asphalt. For impervious asphalt, see 'acrylic'.

[5] This should only be established when there is appropriate equipment available to do so.

[6] Unless design, specification or construction necessitate otherwise.

[7] 10 mm specification is for laser-guided paving; 25 mm specification is for hand-laid paving.

[8] Movement of the grass should be taken into account.

To do

- Receive feedback from industry
- (Re)define surface pace
- Review/develop predictor devices
- Establish test(s) for surface elasticity
- Establish test for static friction
- Recommend limits for durability
- Investigate climate-sensitivity
- Further understanding of perception

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