ADVANCED PROTECTIVE HELMET
FOR FORMULA ONE

SNELL HIC CONFERENCE
May 2005

Andrew Mellor
Q. WHY MORE PROTECTION?

Since accidents of Senna, Ratzenberger, Wendlinger, Hakkinen
FIA introduced:

- Extensive survival cell and crashworthiness improvements
- high cockpit sides
- energy absorbing headrests
- collapsible steering columns
- wheel tethers
- HANS system

Is more head protection required?
Q. WHY MORE PROTECTION?
A. Drivers continue to suffer head injuries
Q. WHY MORE PROTECTION?

A. Opportunity to use latest composite technologies to advance helmet safety performance and reduce weight

  Alternatively, manufacturers may exploit this technology to reduce size of helmets with no increase in safety performance

A. Establish the ‘state of the art’ then transfer technology to all levels of Motor Sport
AGREED AREAS FOR IMPROVEMENT

*Headrest compatibility*
Impact attenuation
Crush protection
Penetration
Rotation
Shell hardness
Chinguard impact
Reduced mass (same geometry)
PERFORMANCE IMPROVEMENTS

<table>
<thead>
<tr>
<th>Feature</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headrest compatibility</td>
<td>50%</td>
</tr>
<tr>
<td>Impact attenuation</td>
<td>50%</td>
</tr>
<tr>
<td>Crush protection*</td>
<td>50%</td>
</tr>
<tr>
<td>Penetration</td>
<td>30%</td>
</tr>
<tr>
<td>Rotation**</td>
<td>25%</td>
</tr>
<tr>
<td>Shell hardness</td>
<td>50%</td>
</tr>
<tr>
<td>Chinguard impact**</td>
<td>50%</td>
</tr>
<tr>
<td>Reduced mass</td>
<td>20%</td>
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</tbody>
</table>

* new dynamic crush test
** new test based on ECE Regulation 22-05
TEST TOOLS (SNELL and ECE R22)
CURRENT HELMET IMPACTS @ 10m/s Hemi-Flat-Edge
DESIGN TARGET: LINEAR IMPACT

- Current 300g@7.5m/s
- Target 300g@10m/s

Absorb impact energy over controlled volume of liner material independent of impact surface

STRONG STIFF SHELL – OPTIMISED LINER
DESIGN TARGET: PENETRATION

- Current 3kg spike falling from 3m
- Target 3kg spike falling from 4m

Tolerate high stress concentration at point of contact.
Dissipate load to liner

STRONG STIFF SHELL (Kevlar net)
DESIGN TARGET: CRUSH

- Current: No requirement
- Target: 30% improvement

Absorb kinetic energy whilst ensuring load exerted on drivers head does not exceed tolerance for injury

STRONG DUCTILE SHELL
OPTIMISED LINER
DESIGN TARGET: OBLIQUE IMPACT

- Current: No requirement
- Target: 30% improvement

Minimise tangential impact load and maintain angular inertia of helmet

LOW SURFACE FRICTION
LOW NORMAL IMPACT LOAD
MASS AT EXTREMITY
SPECIFICATION FOR NEW HELMET

SHELL
• Bending stiffness EI 450 N/m² (10x)
• Bending strength 1200 Nm (8x)
• Weight 0.85kg
• Thickness 5mm (max)
• Outer surface BARCOL 60

CARBON and KEVLAR
SOLID LAMINATE and SANDWICH CONSTRUCTIONS
SPECIFICATION FOR NEW HELMET

LINER

- Efficient energy absorption (0.4N/mm²)
- Temperature stability (-20°C to + 50°C)
- Lightweight (<50g/l)
- (Hybrid structure)

*EPS EPU EPE  RATE-RESPONSIVE
CERAMIC BALLS  HONEYCOMB*
Tests on flat samples to evaluate stiffness, strength and penetration

- Conditioning (-20°C and + 50°C)
- Impact tests at 5m/s, 7.5m/s and 10m/s
- Penetration tests at 3m and 4m

3 manufacturers
Total of 20 laminates
INFINITELY STIFF LAMINATE
CURRENT SHELL LAMINATE
BEST SOLUTION SHELL LAMINATE

![Graph showing impact acceleration vs. displacement for different tests.](graph.png)
BEST SOLUTION (equivalent to 5mm carbon steel)

Carbon sandwich with foam core (CFT Ltd – UK)

Kevlar improved penetration but reduced strength

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>4.1mm</td>
<td>&lt;5mm</td>
</tr>
<tr>
<td>Mass</td>
<td>0.81kg</td>
<td>&lt;0.85kg</td>
</tr>
<tr>
<td>7.5m/s</td>
<td>185g</td>
<td>&lt;200g</td>
</tr>
<tr>
<td>10m/s</td>
<td>270g</td>
<td>&lt;300g</td>
</tr>
<tr>
<td>Penetration</td>
<td>4m</td>
<td>&gt;3m</td>
</tr>
</tbody>
</table>
FULL GEOMETRY EVALUATION

- 5 laminates (sandwich vs solid)
- Polyethylene foam energy absorber

- Linear impact tests
- Penetration tests
- Crush tests
- Oblique impact tests
BEST SOLUTION

*T800 Solid carbon laminate 13 plys @ 0.22mm (<800g)*

- **7.5m/s**: <190g (current ~270g)
- **10m/s**: <230g (current ~620g)
- **Penetration**: 4m (current 3m)
- **Mass**: 1.3kg (current 1.4kg)
- **Crush**: 72mm (current 82mm)
- **Oblique**: 4,200rad/s² (current 5,900rad/s²)
CURRENT HELMET IMPACTS @ 10m/s Hemi-Flat-Edge
ADVANCED HELMET IMPACTS @ 10m/s Hemi-Flat-Edge
ADVANCED PRODUCTION HELMET

Partnership FIA-TRL-CFT-SPORTS BELL Europe

6 variants of shell laminate
BEST SOLUTION ACHIEVED ALL PERFORMANCE OBJECTIVES

- **SHELL**
  - T1000 11 ply carbon fibre with UD reinforcement
  - Shell (only) mass 670g

- **LINER**
  - Hybrid EPS 25g/l and 30g/l
  - with PP interface between shell and liner
  - Rate responsive comfort padding fitted after certification
  - Chin guard padding (to ECE Reg 22-05)

  Rate responsive comfort padding
  (fitted after homologation for further protection)
DEVELOPMENT AND AGREEMENT OF NEW STANDARD

- March 2003. Draft FIA standard proposed (complimentary to Snell)
- May 2003. Meeting of FIA helmets group
  - Repeatability and reproducibility
  - Energy vs performance consistency / Hardness
  - Technology transfer to second manufacturer (Schuberth Engineering)
- November 2003. Performance agreement with BELL and SE
- December 2003. FIA 8860-2004 to World Council
- January 2004. SE and BELL achieved FIA and Snell
- May-June 2004. Arai and SPARCO achieved FIA and Snell
- 1 July 2004. Successful introduction to Formula One (4 manufacturers)
## FIA 8860-2004 vs SNELL SA2000

<table>
<thead>
<tr>
<th>Feature</th>
<th>Snell SA2000</th>
<th>FIA 8860</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact attenuation</td>
<td>150J (300g)</td>
<td>225J (300g HIC 3500)</td>
</tr>
<tr>
<td>Crush protection</td>
<td>-</td>
<td>500J</td>
</tr>
<tr>
<td>Penetration</td>
<td>3kg@3m</td>
<td>4kg@3m</td>
</tr>
<tr>
<td>Rotation</td>
<td>-</td>
<td>ECE Reg 22</td>
</tr>
<tr>
<td>Hardness</td>
<td>-</td>
<td>BARCOL 60</td>
</tr>
<tr>
<td>Chinguard test</td>
<td>‘Crush’</td>
<td>ECE Reg 22</td>
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FUTURE WORK

• Transfer of technology and cost reduction
• Helmets for young drivers
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