Automotive Mega Trends & ArcelorMittal

Mr. Bala S Krishnan, ArcelorMittal
I believe the auto industry will change more in the next five to 10 years than it has in the last 50

Mary Barra
CEO and Chairman of General Motors
Automotive Society Trends

- Connected cars
  V2I & V2V
- Car/Ride Sharing
  Pay-per-use
- Autonomous
  Driving
- Lightweight
  Materials
- Augmented Reality
  & Machine Learning
- Alternative
  Powertrains
- Alternative
  Powertrains
What does it mean for the OEMs?
The future is ACES
Autonomous Connected Electrified Shared
ELECTRIFICATION
A global story

China
- Permanent air pollution drives ZEV development
- Promotion EV’s & PHEV by state
- Supercredits EV/PHEV

Japan
- Permanent high share HEV (20%)
- PHEV & EV still niche (infrastructure)
- Fuel Cell in the focus

Nafta
- Volume driver xHEV thru CAFÉ regulations
- Technology driver thru local ZEV legislation
- Tesla & new players active

20 Mv by 2025
25% of global sales by 2030
Summary of market changes: we are moving quickly towards an electrified world

VW to spend $40bn on electrification in next five years

GM to launch at least 20 new electric vehicles by 2023

Raft of announcements from OEMs in the last three months, announcing investments in electrification

- 63% rise in BEVs sales, year on year
- 1 million BEV sales expected

Source: Bloomberg New Energy Finance
Cost and range are two key drivers

However, there are many other benefits that will attract consumers:

• BEVs have roughly 1/8 the rotating parts, meaning less wear and tear and potentially up to 1,000,000 km vehicle life.

• Regular maintenance is significantly lower (eg. no oil changes)

• Operating costs per km are significantly lower
Growth forecast for electric vehicles – the 2025 tipping point

- Growth is expected to come from China and Europe, NAFTA likely to lag.
- Growth will accelerate as battery technology improves:
  - Range above 500km
  - Reduction in recharge time
  - Reduction in cost
Electrical vehicles today favor lightweight design similar to traditional vehicles

Designing vehicles with cost effective weight reduction:

The mass-market Tesla Model 3 body is a blend of steel and aluminum, unlike the Tesla Model S which is an aluminium body (Source: Tesla website*)

86% steels including 44% of AHSS on the body-in-white of the Chevrolet Bolt (source General Motors)

* https://www.tesla.com/compare

Electric vehicles today employ advanced lightweighting to achieve their range goals
The improvements in battery performance – impact on lightweighting

- Less pressure on lightweighting due to battery technology improvements (costs & driving range)

- Small increase in numbers of batteries will likely be more cost effective at adding range than lightweighting with alternative materials

- Steel will remain a cost-effective lightweight material.
How does ArcelorMittal support this change?

- Global footprint
- Broadest product offer
- Downstream Solutions
- Co-engineering with OEMs
- Broad set of emerging solutions
Global presence – Global reach

Vehicle production 2016
- > 20 M veh
- > 15 M veh & < 20 M veh
- > 10 M veh & < 15 M veh
- > 5 M veh & < 10 M veh
- > 2.5 M veh & < 5 M veh
- > 1 M veh & < 2.5 M veh
- < 1 M veh

Global supplier with increasing emerging market exposure
Electrified vehicles
Battery Electric Vehicles: multiple changes

Strong impact of increased mass on the vehicle structure

- Center of gravity is lower
- Increased energy in crash
- Front and rear mass is rebalanced
- Chassis have to be reinforced

Distribution of spaces

Tesla Model X P90D: 2500kg
Battery: 579 kg (410 km)

Limited influence of mass on range, acceleration, max speed

Management of noise and vibrations

No CO2 emission whatever the mass
Our solutions for e-mobility and lightweighting

**Usibor®**
- Press hardenable steels (PHS) / hot stamping steels offer strengths up to 2000 MPa
  - Usibor® 1500, Usibor® 2000, Ductibor® 450, Ductibor® 500, Ductibor® 1000
  - Can be combined thanks to laser welded blanks (LWB)

**Fortiform®**
- Third-generation UHSS for cold stamping.
  - Cold rolled and coated products 980 and 1180 MPa strength levels
  - 1470 MPa in 2018

**MartINsite®**
- Cold rolled fully martensitic steels with tensile strengths currently from 900 to 1700 MPa
  - Dedicated to roll forming applications

**Innovative coatings**
- Full range of innovating coating supporting the development of UHSS
  - Jetgal® as hydrogen free process, Zagnelis® Zinc-Magnesium as improved corrosion protection, innovative coatings improving PHS in wet areas

**iCARe®**
- Electrical steels for electrified power train optimization
  - Our ranges Save, Torque and Speed are specifically designed for a typical electric automotive application.
ArcelorMittal Global R&D: support to carmakers

- **Painting**
- **Crash**
- **Fatigue**
- **Corrosion**
- **Dent resistance**
- **Joining & laser welding**
- **Stamping, forming**
- **Solutions engineering**

Expertise at every step of the process
ArcelorMittal Global R&D: support to carmakers
Technical support at all stages of the vehicle life

Start of production

6 years +
5 - 3 years
< 18 months

Current vehicles

Advanced projects
Vehicle advanced engineering projects
Vehicle industrialization projects

Advanced engineering
Co-engineering
EVI and processing support
Quality management

through

- Product innovation
- Generic steel solutions

through

- Vehicle Design support
- Product promotion
- Approval

through

- Assistance to stamping & joining

through

- Reactivity to customer technical needs
- Pro-active optimization of product/process
S-in motion

Steel
Saving weight
Saving costs
Sustainability
Safety
Service
Strength
Solutions
S-in motion® suite of lightweighting solutions

ArcelorMittal generic steel solutions include BIW, closures, chassis parts and seats

<table>
<thead>
<tr>
<th>S-in motion®</th>
<th>ICE C-Segment</th>
<th>Electric C-Segment</th>
<th>Hybrid C-Segment</th>
<th>D-Segment EU market</th>
<th>Mid-size Sedan NA market</th>
<th>Mid-size SUV</th>
<th>Light Commercial</th>
<th>Pick-up Trucks</th>
<th>Truck Cabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>-70kg (-18%) vs current ICE baseline</td>
<td>-60kg (-15%) vs current ICE baseline</td>
<td>-50 kg (-16%) vs current PHEV baseline</td>
<td>-98 kg (-25%) vs BIW and closures current baseline</td>
<td>-86 kg (-23%) vs current Mid-size sedan baseline</td>
<td>-102 kg (-20%) vs current Mid-size current baseline</td>
<td>-140 parts upgraded</td>
<td>-174 kg (-23%) vs current Pick-up baseline</td>
<td>-54 kg (-17%) vs current cab baseline</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Twist beam</th>
<th>Suspension</th>
<th>Control arms</th>
<th>Front subframes</th>
<th>Pick-up frame</th>
<th>NA rear subframe</th>
<th>Front seat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 17% of mass-savings for C-segment vehicles</td>
<td>-4 kg (-18%) using flat and long products</td>
<td>Up to 25% of potential weight-savings</td>
<td>Up to 15% of mass-savings on C-segment vehicles</td>
<td>-55 kg (-23%) vs current Pick-up frame baseline</td>
<td>-5.9 kg (-20%) vs current D-segment baseline</td>
<td>-2.3 kg (-18%) vs current C-segment seat baseline</td>
</tr>
</tbody>
</table>

From a steel provider, to a global solution provider.
### Electrified vehicles
Multiple opportunities for steel

- Battery cell protection requires strong steel solutions
- Higher mass requires Ultra High Strength steels to absorb energy
- Reduction of the importance of mass savings will remove the threat of expensive materials (carbon fibers)
- Needs to reinforce chassis should be favorable to steel
- Request for electrical steels will boom

#### 2018 S-in motion ® Battery pack concept

<table>
<thead>
<tr>
<th>Component</th>
<th>Material/Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Top cover</td>
<td>HSLA280 - 0,65mm</td>
</tr>
<tr>
<td></td>
<td>High performance coating (Zagnelis, prepainted...)</td>
</tr>
<tr>
<td>2. Cross-members</td>
<td>MS1500 - 1,2 &amp; 2,0 mm</td>
</tr>
<tr>
<td>3. Cladded cooling system</td>
<td>HSLA420 2 x 1,0mm</td>
</tr>
<tr>
<td>4. Frame</td>
<td>MS1500 - 2,0 mm</td>
</tr>
<tr>
<td>5. Brackets to BiW</td>
<td>CPM0VR - 2,5 mm</td>
</tr>
<tr>
<td>6. Lower shield</td>
<td>DP780 - 0,7 mm, MS1500 - 1,35 mm</td>
</tr>
</tbody>
</table>

Weight is in the benchmark for our 100% steel solution.
Electrified vehicles
On going ambitious S-in motion BEV

- Will be done on a SUV model
- First outcomes in March 19
- Final results in June 2019 followed by deployment through customer events

2019 S-in motion © Battery Electric Vehicles
ArcelorMittal automotive steel products used in recent projects

### STEEL FAMILIES

<table>
<thead>
<tr>
<th>1ST ArcelorMittal GENERATION steel grades</th>
<th>STEEL FAMILIES</th>
<th>ArcelorMittal NEW GENERATION steel grades</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Usibor®1500</strong></td>
<td><strong>PHS &gt; 1300 MPa</strong></td>
<td><strong>Usibor®2000</strong></td>
</tr>
<tr>
<td><strong>Ductibor®500</strong></td>
<td><strong>PHS &gt; 450 MPa</strong></td>
<td><strong>Ductibor®1000</strong></td>
</tr>
<tr>
<td><strong>DP1180</strong></td>
<td><strong>AHSS &gt; 1500 MPa</strong></td>
<td><strong>Fortiform®1180 / 1180HF</strong></td>
</tr>
<tr>
<td><strong>DP980</strong></td>
<td><strong>AHSS &gt; 1180 MPa</strong></td>
<td><strong>Fortiform®980 / 980HF</strong></td>
</tr>
<tr>
<td><strong>FF280DP / DP490 Exposed</strong></td>
<td><strong>AHSS &gt; 900 MPa</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DP590</strong></td>
<td><strong>AHSS &gt; 780 MPa</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>AHSS &gt; 590 MPa</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>AHSS &gt; 450 MPa</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>HSS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>MartInsite®1500</strong></td>
<td><strong>AHSS &gt; 1180 MPa</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CP1000</strong></td>
<td><strong>AHSS &gt; 900 MPa</strong></td>
<td></td>
</tr>
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<td></td>
<td><strong>AHSS &gt; 780 MPa</strong></td>
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<td></td>
</tr>
<tr>
<td></td>
<td><strong>HSS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DP780 / CP800</strong></td>
<td><strong>Mild Steels</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Tensile strength values</strong></td>
<td></td>
</tr>
</tbody>
</table>
Cold forming applications

- In addition to PHS, ArcelorMittal Steel product offer includes the latest AHSS for cold forming.
- Among them, BIW applications have been studied through the S-in motion® solutions with high mass savings potential.

- **MartInsite® 1500**
  - 1500MPa Steel grade suitable for roll forming applications.

- **Fortiform® 980 / 980HF**
  - 3rd Generation AHSS with High Strength and High Formability.

- **Fortiform® 1180 / 1180HF**
  - DP490 grade for exposed panels.
### Indicative tensile-properties after press hardening + paint baking (ISO20x80)

<table>
<thead>
<tr>
<th>Substrate</th>
<th>YS (MPa)</th>
<th>UTS (MPA)</th>
<th>Typical total elongation (1)</th>
<th>Bending angle (2)</th>
<th>AS80</th>
<th>AS150</th>
<th>GI</th>
<th>GA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductibor® 450</td>
<td>&gt; 340</td>
<td>&gt; 460</td>
<td>16</td>
<td>&gt; 120 (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductibor® 500</td>
<td>&gt; 400 (4)</td>
<td>&gt; 550</td>
<td>15</td>
<td>&gt; 120 (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usibor® 1500</td>
<td>&gt; 1050</td>
<td>&gt; 1400</td>
<td>5</td>
<td>&gt; 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductibor® 1000</td>
<td>&gt; 800</td>
<td>&gt; 1000</td>
<td>6</td>
<td>&gt; 80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usibor® 2000</td>
<td>&gt; 1400</td>
<td>&gt; 1800</td>
<td>5</td>
<td>&gt; 45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Elongations to rupture are only indicative. More relevant is the minimum bending angle.
(2) Bending angle following to the VDA238-100, referring to 1.5mm thickness test specimen
(3) Bending angle following to the VDA238-100, referring to 1.0mm thickness test specimen
(4) For thickness > 1.20 mm

These indicative min. values (YS and TS) are fulfilled if the quenching speed is > 50° C/s between 750° C and Ms and if the forming start temperature is > 750° C

Since 2001, ArcelorMittal completed its portfolio of AS coated hot stamping steels. Alternatives to the AS coating have been developed to answer to specific demands (GI&GA) with limited volumes and limited substrates.
Dramatic increase in PHS consumption…
Demand to grow from 1 million tons in 2013 to 3 million through 2018

2006 - 2011: Low ramp-up: from 0 to 500,000 tons, mainly in Europe and the US
2012 - 2018: Globalization with booming demand in China - 3 million tons
Beyond 2018: Globalization continues (Brazil, India,…) + robust demand in mature regions

Exploding demand for PHS since beginning of 2000
ArcelorMittal’s 2nd generation of AS-coated Usibor® 2000 and Ductibor® 1000

Crash ductility

Weight saving with high ductility grades

Ductibor® 450
Ductibor® 500
Ductibor® 1000
~20-25% weight reduction

Crash ductility sufficient for energy absorption parts

Usibor® 1500
Usibor® 2000
~10% weight saving

Crash ductility sufficient for anti-intrusion parts

1st Gen PHS
2nd Gen PHS

Weight saving with higher strength steels

The weight saving potential of ArcelorMittal’s 2nd generation hot stamping steels is available NOW
Ductibor® 1000 AS
Product information

**Product description**

- Steel for hot-stamping
- Best-in-class crash ductility for this level of strength, makes it suitable for crash energy absorption applications
- Chemistry: C-Mn-Si-Ti-Nb-B
- Can be associated with other grades of the Usibor® and Ductibor® family through LWBs

**Indicative mechanical properties after hot stamping + paint baking**

<table>
<thead>
<tr>
<th>Direction</th>
<th>YS (MPa)</th>
<th>TS (MPa)</th>
<th>Tel % A50 ASTM typical</th>
<th>Bending angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal</td>
<td>≥ 800</td>
<td>≥ 1000</td>
<td>6</td>
<td>≥ 80</td>
</tr>
</tbody>
</table>

Bending angle following to the VDA238-100 for a thickness of 1.50 mm YS and TS fulfilled if the quenching speed is > 50°C/s between 750°C and Ms and if the forming start temperature is > 750°C.

**Chemistry (max weight %)**

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12</td>
<td>2</td>
<td>0.80</td>
</tr>
</tbody>
</table>

**Worldwide availability status**

- Coating: EU, NA, SAM, CHI
- AS: Commercial

**Coating**

- AS 80 and AS150 (Aluminum-Silicon)

**Gauges**

- 0.80 mm - 2.00 mm
- Running development to reach at least the same feasibilities as Usibor® 1500 AS (thickness, width)
Usibor® 2000 AS
Product information

Product description

› Steel for hot-stamping
› Usibor® 2000 AS metallurgy allows to reach a best-in-class compromise between strength, crash ductility, and resistance against hydrogen embrittlement
› Usibor® 2000 AS is a unique coated product at this level of strength allowing to get rid of any post heat treatment
› Can be associated with other grades of the Usibor® and Ductibor® family through LWBs

Worldwide availability status

Indicative mechanical properties after hot stamping + paint baking

<table>
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<tr>
<th>Direction</th>
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<tbody>
<tr>
<td>Longitudinal</td>
<td>≥ 1400</td>
<td>≥ 1800</td>
<td>5</td>
<td>≥ 45</td>
</tr>
</tbody>
</table>

Bending angle following to the VDA238-100 for a thickness of 1.50 mm
YS and TS fulfilled if the quenching speed is > 40°C/s between Ms & 200°C

Chemistry (max weight %)

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.37</td>
<td>0.80</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Coating

› AS 150
(Aluminum-Silicon)

Gauges

› 0.80 mm - 2.00 mm
› Running development to reach at least the same feasibilities as Usibor® 1500 AS (thickness, width)
**Usibor® 2000** two important properties
Crash ductility and resistance against delayed fracture

- **Bending test – evaluation of the fracture strain in plane strain**

- **The 4-point bending test**

**VDA-238**

<table>
<thead>
<tr>
<th></th>
<th>RD</th>
<th>TD</th>
</tr>
</thead>
<tbody>
<tr>
<td>DQ state</td>
<td></td>
<td></td>
</tr>
<tr>
<td>170°C/20min</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>DQ+PB state</td>
<td>55</td>
<td>55</td>
</tr>
</tbody>
</table>

DQ = Die quenched
PB = Paint baking

The fracture strain target of 0.25 is reached after paint baking

Usibor® 2000 can sustain an applied stress of 100% YS without delayed fracture without any post degassing heat treatment as long as the diffusible hydrogen is lower than 0.5 ppm
The hot stamping of a lower B-pillar in 1.5 mm thickness at ArcelorMittal Research allowed to demonstrate a hot stamping behavior comparable with the Usibor® 1500 and the reliability of the material cards used for the hot stamping simulation:

Similar hot stamping behavior of Usibor® 2000 AS and Usibor® 1500 AS (same press forces): Usibor® 2000 AS specific material cards are available.

With a blank designed to study the rupture of the material, two areas with a risk of rupture could be identified with the hot stamping simulation:

The two identified critical areas could be confirmed experimentally:

Usibor® 2000 is compatible with the existing Usibor® 1500 hot stamping lines. Hot stamping simulations showed reliable results with the available rheological data.
Usibor® 2000 + Ductibor® 1000 B-pillar prototype Hot-stamping feasibility assessment

- Hot stamping feasibility assessed by numerical simulation: part is safe
- Feasibility confirmed by physical hot stamping tests
Coatings for hot stamping
Development roadmap

Usibor® 1500 AS150
Usibor® 1500 AS150

Usibor® Ultraprotect
Usibor® Ultraprotect

Protect+ & ZnO
Protect+ & ZnO

1st Gen PHS
Today offer

2nd Gen PHS

3rd GEN PHS

Hot stamped GI140
Hot stamped GI140

Hot stamped GA180
Hot stamped GA180

GI cold stamped = best-in-class
GI cold stamped = best-in-class

Corrosion performance as close to a cold stamped Zn coating as possible
+ Compatibility with the direct hot stamping process
+ Compatibility with today Usibor® AS hot stamping lines
+ Large process windows
+ No micro-cracks in the steel
+ No additional risk of stress corrosion cracking compared to Usibor® AS

Red rust pitting
8µm E-coat
Stone chipping
20µm E-coat

GI cold stamped
GI cold stamped

New bath
New bath

Usibor® 1500 AS150
Usibor® 1500 AS150

Corrosion performance

Hot stamped GI140
Hot stamped GI140

Hot stamped GA180
Hot stamped GA180
A great variety of steel solutions validated, that can be adapted to OEM specific structure considering its material strategy.
Steel is back!

40% steel
17% Usibor®
Much more than the best STEEL
Thought Exchange

Visit our automotive website: automotive.arcelormittal.com