G6 Front Bumper Development Project
A Hybrid Solution for Corner Impact
Brief Introduction to Shape

- World leader in automotive and industrial products manufacturing
- Founded in 1974
- Over 1100 employees and 5 plants
- Headquarters in Grand Haven, Michigan
- Global presence
  - Sales offices in:
    - Madison Heights, Michigan
    - Tokyo, Japan
    - Frankfurt, Germany
Shape Customers

Shape is proud to be the selected supplier to all of these fine companies and many others:

- GM
- Herman Miller
- Toyota
- Allsteel
- Mitsubishi
- Ford
- Mazda
- DaimlerChrysler
- Case
- Tower
- Nissan
- Whirlpool
- Xerox
- Dana
- Honda
- Orion
- Hart & Cooley
- Subaru
- Trendway
- Valeo
- Calsonic
- Metalsa
Manufacturing Excellence

- Roll forming
- Stamping
- Welding
- Injection molding
- E-Coating
- Assembly
Engineering and Design

**Design**
- CATIA
- AutoCAD
- TogoCAD
- Unigraphics
- SDRC
- IGES
- 3D Modeling
- C3P
- IDEAS
- Solid Works
- Pro Engineer

**Dynamic Testing**
- IIHS
- CMVSS

**CAE**
- LSDYNA 3D
- Hyperview

[Images of various engineering and design tools and projects]
G6 Front Design Challenges

Design Challenges:
• Malibu front bumper was intended to be carry over for G6
• Insufficient space available between the G6 fascia and end of beam to provide adequate energy absorption and fascia protection for corner impacts. The fascia design cut through the end of the beam
• Two typical countermeasures to create more space:
  1. Mitre cut & cap end of beam
  2. End-form beam “crush and tuck”
• Secondary operations are expensive, produce waste, and can require additional capital investment
Malibu and G6 Comparison

Malibu Front Bumper

G6 Fascia and Bumper

www.autosteel.org
Design Constraints

- Only 65 mm packaging space was allowed at the bumper corner due to the fascia styling change.
- The Malibu bumper intended for use on the G6 is 70mm deep fore-aft at the bumper corner, which violated the available packaging space and left no room for an energy absorber (EA).
- The initial intrusion target for 5MPH corner impact was 45mm with 65kN per rail load capabilities.
- High speed impact and modal analysis demands the UHSS (DP965) beam continue to span the rails cross-car.
Development Plan

- Experiment with various means of reducing UHSS bumper section depth at the ends to accommodate the G6 fascia
- Experiment with energy absorber technologies that work in conjunction with UHSS bumpers to improve IIHS corner barrier performance
- Run dynamic impacts on sub-system level to attain design direction
- Final vehicle weight was not known at development stage, so the Malibu vehicle mass of 3200 Lbs was used for testing purposes
Bumper End Concepts

• “Crush & Tuck”
  – Means of reducing section depth by pre-setting beam using steel die tooling

• “Cut & Cap”
  – Mitre cut an angle on the end of the beam and weld on a stamped UHSS cap
Energy Absorber Technologies

• **EPP Foam**
  – Easy to prototype and test. EPP foam was selected for initial dynamic crash testing experiments in conjunction with end treatments.

• **Injection Molded PC/PBT Energy Absorber**
  – Higher efficiency in crash performance. Injection molded PC/PBT was ultimately selected for this application due to the efficiency in conjunction with UHSS bumper section.
Dynamic Test Plan

• Experiment with the following end configurations:
  – A) “Crush & Tuck” at (4) different depths
  – B) “Cut & Cap” at (3) different depths
  – C) Cut the beam short and wrap the ends with Injection Molded EA

• Run 5MPH 30 degree corner barrier impact crash tests

• Document load vs. displacement results for all dynamic Impacts
40mm deep beam Crush & Tuck
45mm Deep Beam Crush & Tuck
50mm Deep Beam Crush & Tuck
60mm Deep Beam Crush & Tuck
Crush & Tuck Summary

GM X381 Front Bumper
IIHS 30° Fixed Barrier Impact @ 5 mph
End Formed Beams

Total Beam/EA Package Height of 65 mm @ Corner
Vehicle Weight = 3200 lbs., 6.6pcf Energy Absorber

System Stroke (mm)

End Form Design #1 - 40mm of beam height fore-a
End Form Design #2 - 45mm of beam height fore-a
End Form Design #3 - 50mm of beam height fore-a
End Form Design #4 - 60mm of beam height fore-a
24mm Deep Beam Cut & Cap
40mm Deep Beam Cut & Cap
60mm Deep Beam Cut & Cap
Cut & Cap Summary

GMX381 Front Bumper
IIHS 30° Fixed Barrier Impact @ 5 mph
Beams Cut & Capped
Total Beam/EA Package Height of 65mm @ Corner
Vehicle Weight = 3200 lbs., 6.6 pcf Energy Absorber

Cut & Cap Design #1 - 24mm of material fore-aft
Cut & Cap Design #2 - 40mm of material fore-aft
Cut & Cap Design #3 - 65mm of material fore-aft
Injection Molded EA Solution

- Shorten the beam crosscar (Y) and allow Injection molded EA to fill packaging space at ends
- Beam still spans the rails for modal and high speed load transfer
- Crush cone forward of the rail bracket reacts against the rails and the beam ends during 30 degree impact
**Concept:** Eliminates the “cut and cap” and weld operations or the crush and tuck” and replace EPP EA with a NetShape injection molded EA.

**Anticipated advantages**

- Reduced absorber cost ( $1.00 to $3.00 anticipated)
- Improved corner impact performance
- Reduced mass and cost of impact bar ( ~ 1.00 lb and $1-3 savings potential)
- Elimination of Mitre-cutting equipment cost
- The ability to translate savings and performance enhancements on other vehicles (Common beam strategy)
Injection Molded EA Impact
Final Design Advantages

Shape/NetShape Solution
• $1.64 saved per part (Beam Only)
• $2.00 saved on the EA
• $3.64 total savings on piece cost
• $1,025,000 in annual savings vs. Malibu Front Beam
• $450,000 saved in secondary tooling
• Enhanced corner impact performance
• Enabled styling requirements of the G6
• Mass savings of 0.22lbs vs. Malibu Front bumper system
Additional Advantages

- Steel beam assembly is produced using GMX 380 production tooling which contributed to the tooling investment cost savings.
- Injection Molded PC/PBT energy absorber supplied as POA to fascia.
- Injection Molded EA provides additional fascia support under headlamps compared to EPP foam solution.
- Higher dimensional stability of injection molded product improves gap condition to the fascia.
Final IIHS Repair Estimate

- IIHS total corner damage limited to $592
- IIHS damage includes
  - Replacing the EA
  - Repair only of bumper
  - Repair only of fascia
  - Re-aiming headlamps
  - Labor and touch up paint