Summary of feedback on pin vs. blade

Company	
BMW	Our connector colleagues prefer Radsok.
DCX	DC votes for a round pin, no matter if formed or solid though both systems can be made to work for our requirements. Flat designs have some drawbacks but might be slightly cheaper.
Ford	Our preference is for Choice #1, a flat blade on the battery. This is for several reasons. First, we believe this design can be manufactured to meet the required performance specifications with less expense than choices 2 or 3. Second, we want multiple competent automotive connector suppliers to make the wiring harness connector; we are confident that Delphi, Tyco and Yazaki all can make acceptable designs, which gives us confidence in this choice.
GM	We have had more discussion on blade versus pin and want to change our vote to a blade connection.
PSA	The round pin (solid) is used at PSA.
Renault	
USCAR	Although our first choice is a blade, we could easily change to a pin with the right kind of input to sway the vote. We feel that either has the potential to get the job done with the right kind of design.

Bolder Technologies	
Delphi Automotive	Best choice is a solid round pin
Douglas Battery	
Exide	Our preferred system would be the round pin based on that experience.
Hoppecke	We as Hoppecke would clearly prefer a round pin
Johnson Controls Inc.	Regarding our dimensional preferences on battery surface area needed for the connector: our preference is to use a male pin connector on the battery.

Alcoa Fujikura Ltd.	
Cannon Weinstadt	A highly reliable battery link should consider: Round male contacts (brass) which are fixed onto the lead (Pb) terminals.
Delphi Automotive	Delphi Automotive Systems believes a flat blade connection is the best choice; however, we are prepared to deliver any of the proposed choices.
JST Corp.	
KonneKTech	Presently produce stamped pins
Molex	
Tyco (AMP)	Attached is the Tyco response. Flat blade is the preferred geometry.
Yazaki	Yazaki has experience with all three choices listed. Ranking would be choice #1, 2 and 3 (best to worst).

Companies not responding because of preference for threaded stud

Honda

We have experience with the threaded stud type only.
Regarding all of the above questions, we do not have any experiences/data.
In our HEV, we are using threaded studs for the battery module, power drive unit and electric motor. We use a waterproof connector (0.35 inch width, blade type) for the HEV DC/DC converter (14V, 70A output).

Toyota

Toyota will not respond to your questions this time.
Because Toyota does not think hand pluggable connection is appropriate.

Volvo

I asked our specialists in this field to give their input upon the questionnare.
The output from them was to avoid a "springloaded" type of connection but rather use some kind of device containing a screw to generate the clamping force between the cable terminal and the battery terminal. None of the connector types suggested in the questionnare were considered why I can´t give you any feedback on the suggested types.

Feedback on pin vs. blade for 42V battery connection systems
Responses summarized by question

Choice 1 – Flat blade
Choice 2 – Round pin – solid
Choice 3 – Round pin - formed

Industry category
C – Connection system manufacturer
W – Wiring harness manufacturer
B - Battery manufacturer
V - Vehicle manufacturer

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
Number of operations?

- *Flat blade* - Blanking of terminal and stamping of coins on edges – Delphi Automotive Systems – C
- BLADE & FORMED PIN – 1 – JST Corp. – C
- *Formed pin* - One progressive stamping operation plus plating – KonneKTech – C
- Formed pin – Complex – 5, Blade – Simple – 4 - Alcoa Fujikura Ltd. – C
- 1. The manufacturing operations for a solid blade are the simplest. Plate strip (if plated) and blank and form. (Formed hollow blades are the most difficult)
  2. Solid wire pins are only slightly more difficult assuming unplated or pre-plated wire is used.
  3. Rolled pins are the most difficult of the three to manufacture and would require multiple progressive forming steps. (Formed hollow blades are the most difficult) – Molex – C
- This is driven by the battery assembly requirements. In general, all three require the same number of operations, but the die for #3 would be more expensive with 8 to 12 progressive stations. – Molex - C
- Blade and formed pin design utilizes a progressive die process whereas a solid pin is milled. – Yazaki – North America – C

- Blade is easier to manufacture - Fewer stations in terminal die – USCAR
- 1 step plus plating /both cases – DaimlerChrysler - V

Type of operations?

- *Flat Blade* - Simple metal stamping – Delphi Automotive Systems – C
- Stamping – JST Corp. – C
- Progressive stamping die – KonneKTech - C
- Stamp in progressive dies – Alcoa Fujikura Ltd. – C
- 1. Plate and blank with a coin on the tip
  2. Plate and blank with a coin or form on the tip
  3. Plate, blank, progressive roll in the die – Molex – C

- *Flat Blade* - Male stamped, female – stamped & formed because blade has less complexity - USCAR
- Pin can be produced in different ways, either are not expensive. – DaimlerChrysler - V

Cost to manufacture?

- It is easier, and less costly, to stamp a blade than to form/roll/machine a round pin – Delphi Automotive Systems - C
- $.10 to $.12 per pin [$.20 to $.25 per battery] – KonneKTech - C
- *Formed pin and blade* – same – Alcoa Fujikura Ltd. – C

- 1. Low (assumes solid blade)
  2. Low
  3. Moderate
- Progressive die for blade or pin is more cost effective than milled pin. – Yazaki – C

- Minimum + $2.50/battery – Douglas Battery – B
- Below .50 US$. – DaimlerChrysler – V

Dimensional stability

- A blade is more dimensionally stable because it is a simple stamping, no forming is required – Delphi Automotive Systems – C
- Concentricity of the pin can be maintained with liberal tolerances when used in combination with Hyperbolic Terminal Technology – KonneKTech – C
- *Formed pin* – more steps to control concentricity of pin, *flat blade* – easy to control flatness - Alcoa Fujikura Ltd. – C
- 1. Good – some edge burr issues possible, flatness of the blade also a possible issue (easily addressed in female design)
  2. Excellent – Pin straightness is the only issue, but this should more consistent that blade. (The pin dimensional control is much better than the blade if a post plate process is used)
  3. Fair – Diameter control and seam protrusion are possible issues. – Molex C
- Choice #1 and 2 have good dimensional stability. Choice #3 has more tolerance stack-up depending on cut and bending process involved in forming a pin (concentricity of pin not as accurate as solid pin). – Yazaki – North America – C

- Better control on blade system because of single plane stamping die - USCAR
- Flatness of blade could be a problem – Douglas Battery – B
- Depends on tool. Depending on female layout the pin is self-centering, this easens the requirements, but no longitudinal or wounded sharp edges are allowed. Diameter has to be accurate to at least +/- 0.05mm for optimum performance – this is valid for radsok-design of the female and depends on the length of the contact surface. Definitely no problem with a single flat die for a blade, as long as tool is sharp!– DaimlerChrysler - V

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width)

- Do not understand question – round should take less space – Douglas Battery – B
- Blade might offer less intrusion in battery space if positioned horizontally, but the space gained is very minimal. Roll-formed pin would add a mm or two to diameter over solid pin, but again this is not significant and could be at least partially compensated for in housing and Keying design. – Bolder Technologies - B
- The space, esp. the height, for a round pin is available at DIN battery lids. – Hoppecke – B
- Regarding our dimensional preferences on battery surface area needed for the connector: our preference is to use a male pin connector on the battery. Accordingly, we would need relatively average height and average width of this surface to be available for the connector. – Johnson Controls Inc. – B
- SIMILAR TO THREADED TERMINAL ON MARINE BATTERIES – Delphi Automotive Systems – B
- SOME EXPERIENCE BUT WE HAVE NO DATA. Our preferred system would be the round pin based on that experience. – Exide – B

- Pin design would require less surface area on battery. – Yazaki – North America - C
- For packaging reasons the connection must not exceed the total height of the battery. – DaimlerChrysler Europe – V
- A pin should have 8mm diameter, if it is formed, we recommend the use of a 10mm diameter. To go to 8mm and for ultimate proof a thermal simulation is required! – DaimlerChrysler - V

Ability to attach to internal battery conductors

- Not a big difference – Douglas Battery – B
- No difference as both must be molded into a lead part which will form the connection with the interior of the battery (this presumes the high volume production battery of choice will be lead-acid - which is safe given the 6-8X cost of nearest competitive options.) – Bolder Technologies Corp. - B
- Flat, and therfore broad blades would cause problems fastening them into the lead block. This lead block (including the base of this block) would have to be broader. The additional lead we need is not compensated by the smaller height.
  - The lead block has to fit on the breadth of one cell. The will not be sufficient for fastening the blade.
  - An vertical arrangement is not possible, because the height is limited by the lid height.
  - An immersion into a lead block in one surface with the battery lid would need in case of a blade a to large area. The available lead area is restricted by the space we need to solder the lead block to the inner side of the battery. – Hoppecke - B
- Regarding attachment to internal battery conductors: our preferred concept would use, for each terminal, an 8-mm pin insert molded into a lead bushing. The lead bushing would then be joined to the internal top lead of the battery cell via melting of both adjoining lead surfaces. – Johnson Controls Inc. - B
- SOME EXPERIENCE, NO DATA Same as above round based on our current experience. – Exide – B

- Battery manufacturers have experience attaching all 3 designs (no preference) - USCAR
- Ability to attach to battery does not affect terminal design choice. – Yazaki – North America – C
- A stamped pin can be easily designed for connection to the internal lead post in a battery. Design concepts are readily available. KonneKTech - C
- Easy and with costs as low as today's studs. – DaimlerChrysler - V

Cost to assemble?

- No difference – Douglas Battery - B
- No difference – Bolder Technologies – B
- The cost to assemble is not totally assessed at this point. We believe that the brass pin/lead bushing assembly will be in the price range of $0.75 to $1.25 each. The cost of the plastic enclosures and other parts of the terminal connection system, together with the assembly operations cost, are not assessed at this time. – Johnson Controls Inc. – B
- All the operations require secondary operations for inserts. – Exide – B

- Cost to assemble a stamped pin in the battery should not exceed the present cost to terminate a battery. – KonneKTech - C
- All terminal designs have same cost to assemble – Yazaki – North America – C
- Comparable to today's studs – DaimlerChrysler - V

Alignment stability in the battery housing?

- Round will be more stable – Douglas Battery – B
- Both blade & pin can be accommodated. Pin may present a slightly lower cost cover mold – Bolder Technologies – B
- In our proposed design concept, the battery terminal bushing is insulated by and supported by a plastic "canopy" which also extends about a quarter-inch past the end of the male pin. We believe this canopy will provide adequate protection to the male pin, to insure its alignment stability. In addition, we would design the canopies around the male pin terminals to be "keyed" such that they

would prevent a positive cable terminal from engaging with a negative battery terminal, and vice versa. – Johnson Controls Inc. – B
- ROUND PIN HAS NO ROTATIONAL ORIENTATION WITH RESPECT TO SURROUNDING PLASTIC – Delphi Automotive systems – B
- NO DATA AT THE MOMENT Until complete designs are available and analyzed this is a significant concern – Exide – B

- All options equal – USCAR
- 1. In the narrow dimension the blade is much more susceptible to bending (smaller moment of inertia)
  2. The best from a bending prevention stand point
  3. Second best depending on the material thickness and diameter needed to meet the current. – Molex - C
- Choice # 2 is more alignment stable since there are less dimensions to control. Ranking (best to worst) 2, 1, and 3 – Yazaki – North America - C
- Designs have already been presented reflecting stable alignment within the housing. Hyperbolic terminal connection systems provide flexibility to compensate for a certain amount of mis-alignment. – KonneKTech – C
- Depends on layout of the lead anchor, the pin is inserted in. Should not create problems. But: The smaller the pin, the harder it is, to accomplish mechanical stability. – DaimlerChrysler - V

Ease of "fingerproofing"?

- Blade type will be safer / easier to fingerproof – Douglas Battery - B
- Round pin will present less access and when roll-formed, allow for a insulating button to be easily installed in the end of the pin – Bolder Technologies – B
- "Fingerproofing" of the battery terminals (to render them impossible for small children to reach fingers into terminals if the battery were on display shelves in a store, for example) can be accomplished by inserting plastic "plugs" which would cover the male pins and engage into the plastic canopies. These plugs would be removed at the time of battery installation into a vehicle. – Johnson Controls Inc. – B

- Blade would allow the plastic housing to be designed with a smaller opening in one plane to keep fingers out – USCAR
- An addition of a nylon protection on the end of the pin will provide finger-proofing protection as well as protection from the damage that may occur from arcing during disconnect. Examples of pins with this feature will be available at the September 20, meeting. This will be a very low cost solution. – KonneKTech - C
- 1. Blade terminals need to be wider, but narrower than their pin counterpart. As a result no significant difference exists.
  2. No significant difference exists compared to blade.
  A hollow pin will require a larger size to carry the necessary current. This increases the potential for problem. – Molex- C
- Pin or blade on the battery side will be designed with a shroud for protection. But to protect the tip against "fingerproofing" some type of conductive material should be incorporated to the tip of the male terminal. – Yazaki – North America – C
- Is possible but pin has to be recessed pretty far or clip on protector is needed. Blade needs more space in one direction and less in the other, thus might be done in a way, that recess does not have to be that deep. – DaimlerChrysler - V

Serviceability?

- Blade bends easier, so it is easier to straighten again. – Douglas Battery – B
- Round pin might be slightly easier to service with a simple tube if realignment were necessary. Don't see this as a major issue. Pin might offer slightly lower probability for servicing need because of more limited access to common blade type instruments such as a screwdriver. – Bolder Technologies – B

- Serviceability of the terminal if the terminal pin were bent, would be (by design) not readily done by the end customer nor by an installer. In our proposed terminal concept, a connector failure mode will have been intentionally designed into the system. The weakest point in the connector system is intended to be the interface between the pin and the lead bushing. The reason is that if the connection to the battery is broken, it is desired that the break occur outside the battery container rather than inside. A break inside is more likely to result in a spark which could ignite hydrogen and oxygen that is present inside the battery container. JCI would prefer that batteries with damaged terminals not be serviced by customers or installers, but sent back to the manufacturer. The likelihood that terminals of this type could be damaged in this way (other than by intentional abuse) is considered to be low. Johnson Controls Inc. – B
- PREFERENCES IN ORDER GIVEN BELOW: INTENDED AS A STATEMENT :
  1.- AS BATTERY MANUFACTURERS WE ARE INCLINED TO SAY THAT THE MOST RELIABLE SYSTEM FOR A BATTERY WILL BE A THREADED SS STUD.
  THIS STATEMENT DERIVES FROM ITS PROVEN DESIGN AND STABILITY UNDER VARIOUS CONDITIONS OF VIBRATION, THERMAL CYCLES, CORROSION, ETC.
  2.- A SOLID PIN IS OUR SECOND CHOICE (Choice 2 -if the Stud is not adopted).
  BENT PIN DESIGNS CAN LEAD TO SERIOUS CONTACT PROBLEMS.
  3.- FLAT BLADE IS OUR LAST CHOICE GIVEN THE POSSIBLE VARIATIONS IN MATING AFTER THE BLADE IS MOLDED IN THE BATTERY CONTAINER/COVER. – Exide – B

- Whether you use a pin or a blade, it will be recessed in a plastic housing to prevent bending. – USCAR
- Bent pins can be easily straightened but as noted above, hyperbolic technology can compensation for a certain amount of pin miss-alignment. – KonneKTech - C
- 1. In the narrow dimension the blade is much more susceptible to bending (smaller moment of inertia)
  2. The best from a bending prevention stand point
  3. Second best depending on the material thickness and diameter needed to meet the current. – Molex - C
- A solid machined pin has superior bending resistance (similar to existing battery post). – Yazaki – North America - C
- If requested socket contacts can be replaceable by a simple hand tool, not destroying the connector,(just in case of repair) – Cannon Weinstadt – C
- A solid pin at 8mm is pretty strong, of it is shorter than 18mm. Since it is recessed, should not create a problem. A small deformation in a radsok pin is not really a problem as long as insertion is still possible. A bent blade is ugly, since you cannot really even it out. – DaimlerChrysler - V

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
Number of operations?

- This depends on the specific design of the female terminal – Delphi Automotive Systems – C
- Blade and formed pin – 1 – JST Corp. – C
- High volume production will be a fully automatic multiple stamping and assembly operations. – KonneKTech – C
- Simple – Alcoa Fujikura Ltd. – C
- The female terminal would follow similar operations. Plate, blank, and form. The blade box is slightly more difficult to form depending on the allowable corner radii on the box. – Molex - C
- Both female box and sleeve can be manufactured using a progressive die. But formed sleeve design may require multiple operations (i.e. 2-piece design requires assembly). – Yazaki – North America – C

- All cage designs end up in a multistep production effort. Probably the same for all three designs – DaimlerChrysler - V

Type of operations?

- Stamping, forming, plating – Delphi Automotive systems - C
- Stamping – JST Corp. – C
- Stamping and assembly on dedicated equipment. – KonneKTech - C
- Equal – Alcoa Fujikura Ltd. - C
- In line plating and progressive die. – Molex – C

- Stamping and tube production, several bending operations in all three cases, tubes are needed only for the round design, these can be formed or bought ready for use. Should not create a difference. – DaimlerChrysler - V

Cost to manufacture?

- The female terminal would be designed to the lowest cost possible that still ensures performance at specified levels. This would have to be done in order to keep any one female terminal cost competitive with product from other suppliers. – Delphi Automotive Systems – C
- $.45 to $, 50 per terminal [$.90 to $1.00 per battery] – KonneKTech - C
- Pin – less cost, blade – more cost – Alcoa Fujikura Ltd. – C
- The blade box is likely to be more expensive due to material usage and a slight increase in difficulty. – Molex – C
- Progressive die for female box or sleeve is more cost effective than milled sleeve. The sleeve design's ease of manufacturability is contingent on 1-piece or 2-piece sleeve design which effects reliability and cost. – Yazaki – North America – C

- Essentially the same since both would probably require two piece construction. - USCAR
- Below 1.50 US$ for a silvercoated 10 mm, 8 mm copper tinned is about .90US$ or less. – DaimlerChrysler - V

Dimensional stability?

- Any female terminal would be manufactured in accordance with a product print. Product would meet that print, within specified tolerances, via designated processes in order to insure product performance to specification. – Delphi Automotive Systems - C
- By using Hyperbolic Technology, dimensional stability is guaranteed within a wide tolerance band. – KonneKTech – C
- Pin - Easy to control mating hole, Blade – Easy to control mating gap – Alcoa Fujikura Ltd. – C
- The pin cylindrical terminal will be marginally more stable. – Molex – C
- Milled sleeve has excellent dimensional stability. The female box design is comparably stable to the milled sleeve. However, the formed sleeve has more dimensional tolerance stack-up (1-piece or 2-piece). – Yazaki North America - C

- Today's technology would probably result in similar dimensional stability for both options (pin or blade) - USCAR
- Round would be more stable – Douglas Battery – B
- More robust than femals for blades cause tubecovered, internal is springloaded...a cheap female for a blade is always an open design. – DaimlerChrysler - V

Questions regarding **wiring harness assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector?

- A box terminal would have to be oriented in the female terminal cavity prior to plugging. However, at the size that these terminals would be, that does not impart a heavy penalty. – Delphi Automotive Systems - W
- Pin type female may not require orientation depending on final design & in this case, would be easier to plug for the harness maker. Otherwise, no difference. - USCAR
- Same – Alcoa Fujikura Ltd. - W
- All terminal design have the same cost of assembly. – Yazaki North America – W

- The box progression on the reel may be larger and would result in a slight decrease in crimping rate (assumes that the box drive progression and not the crimp wings). The cylindrical terminal would not require orientation and would allow for a slight increase in assembly rate ~2-5%.? - Molex – C
- Needs to be figured, crimping ends are available. – DaimlerChrysler - V

Alignment stability in the harness connector?

- There would be no difference – Delphi Automotive Systems - W
- Pin – very good, blade – good – Alcoa Fujikura Ltd. – W
- All choices have similarly good alignment stability since the primary alignment feature is the shroud and not the terminals. Yazaki North America – W

- Plastic design dependent for both. – USCAR
- Round – do not worry about orientation – Douglas Battery – B
- The hyperbolic terminal has proven to be adaptable to a wide range of connector applications and can be easily aligned within numerous connector designs. – KonneKTech – C
- The blade connector will be lower and longer. This may drive a slight decrease in system alignment stability. This is heavily housing design dependent. – Molex – C
- Easy since selfcentering can be achived – DaimlerChrysler - V

Retention within the harness connector?

- A box terminal has a potential to have higher terminal-to-cavity retention because it offers more locking surface than a round terminal – Delphi Automotive Systems – W
- Same – Alcoa Fujikura Ltd. _ W
- All choices have the good retention. – Yazaki North America – W

- 90 N min primary lock, 130N min w/secondary lock would be our recommended minimum. Both designs should be able to achieve this. – USCAR
- This can be easily accomplished within a wide range of connector designs. – KonneKTech - C
- No significant difference. – Molex – C
- Done with plastic parts! No decisive elements – DaimlerChrysler - V

Capability to seal?

- The capability to seal exists with both designs – Delphi Automotive Systems – W
- Pin – very good, blade – more difficult – Alcoa Fujikura Ltd. - W
- All choices have capability to seal. – Yazaki North America – W

- Both designs would probably use a cable seal and thus both should be equal – USCAR
- Round – much easier to seal – Douglas Battery – B
- A hyperbolic terminal will not be a deterrent in any way to the successful sealing of the connector assembly. – KonneKTech - C
- No significant difference. – Molex – C
- No difference between approaches, but sealing around a round pin is much easier than on a blade – DaimlerChrysler - V

Serviceability?

- Both types of terminals can be serviced – Delphi Automotive Systems – W
- Same – Alcoa Fujikura Ltd. - W
- Design dependent for both – no difference. – USCAR
- All choices have same serviceability. – Yazaki North America – W

- Round – much easier – Douglas Battery – B
- This will be determined by the connector design. However, experience indicates that a hyperbolic terminal will not be a service issue. – KonneKTech – C
- No significant difference. – Molex – C
- Since crimping is available, should not be a difference in all three cases – DaimlerChrysler - V

Questions regarding **vehicle assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly?

- Same for all, but no bolt together or inertia (go/no go latches) should be used. Standard latch (USCAR type) or lever/cam lock recommended. - USCAR
- If the indexing of the connector is done by the plastic part, we don't see difference between the 3 proposed solutions – Renault – V
- The round pin (solid) is used at PSA. This kind of connection is really easy and we use a terminal SOCOP with a lever for the positive terminal. – PSA – V

- No significant difference. – Molex – C
- Pin or blade design can have the same connector assembly process. Therefore, ease of assembly is not a factor in design direction. – Yazaki North America - W
- A technical advantage would be a hand lever that guarantees a smooth and determent mating and disengaging of the plug. – Cannon Weinstadt – C

Cost of assembly?

- Same – design dependent for both – USCAR
- The cost of the assembly is different between a tool required or a hand plug connection, not between blade or pin terminal – Renault - V
- This kind of connection *(pin)* costs less than 1$ for positive connection ; 0.5$ for negative connection. – PSA – V
- Low in all cases cause of reduced time for mating in the assembly – DaimlerChrysler - V

- The blade would likely be more expensive as a total system. This is driven by component cost (material and component / harness assembly). – Molex – C
- Since this committee is not determining the method of mating (mechanically assisted), there will be no cost impact for assembly since all connector will be hand mated. – Yazaki North America – C/W

Performance of contact surface?

- Pin may have to be larger to achieve the same number of lines of contact. – USCAR
- We think there is no differences. The performance of contact surface is much more dependant of the characteristics of the metals used for the connection – Renault – V
- No difference?! – DaimlerChrysler - V

- A hyperbolic terminal provides inherent spring retention on the contact surface without the need to introduce spring devices required by blade terminals. – KonneKTech – C

- No significant difference. Multiple contact beams / points should be used to reduce contact resistance and increase stability in all female terminal designs. Plating type and normal force will have the biggest impact for each interface. With thick, soft plating the pin system would perform better assuming little or no moment at the interface. – Molex – C
- All choices have good contact surface. – Yazaki North America – C/W
- 4 slots on the contact protected by a stainless steel spring, guarantee, that 4 contact points touching the male contact on the Battery – Cannon Weinstadt – C

Durability of contact surface?

- Depends on base material and plating for both designs. - USCAR
- Round pin (formed)(choice 3) is worse as other solutions. Otherwise, same answer as previous question. – Renault – V
- No difference?! – DaimlerChrysler - V

- Hyperbolic terminals have proven to be capable of 10,000 insertions without loss of spring retention. – KonneKTech – C
- If both the pin and blade systems had the same normal force and plating thickness and the blade did not use a dimple or tight radius in the contact area, it would wear better in durability cycle testing. – Molex - C
- All choices have good durability. – Yazaki North America – C/W

Battery cable – directional orientation?

- Pin is more flexible to different orientations. – USCAR
- No differences between the 3 proposed solutions – Renault - V
- Depends of the vehicle. – PSA – V
- For the cabling people flexibility regarding the cabling takeoff direction would be of most importance. DaimlerChrysler Europe - V
- The design of the contacts will allow also a 90° crimp termination, if required – Cannon Weinstadt – C
- No difference?! – DaimlerChrysler - V

- Hyperbolic terminal is capable of 360-degree ordination. – KonneKTech – C
- No significant difference. – Molex – C
- Pin design gives better directional freedom. – Yazaki North America – C/W

Size of connection system?

- Blade allows lower profile in one plane. - USCAR
- Blade solution is the best for the volume size – Renault – V
- Should not be higher as the current pin. – PSA – V
- No difference?! – DaimlerChrysler – V

- A hyperbolic system will be equal to or smaller than present systems. – KonneKTech – C
- The solid pin system would be 20 – 30% smaller. – Molex – C
- The pin design is smaller packaging requirements than the blade design. – Yazaki North America – C/W

Reliability/Warranty history?

- It has to be very reliable according to the cost of the function. – PSA – V
- No difference?! – DaimlerChrysler – V

- The biggest issue in connector warranty is the crimp and base material supporting the crimp. It is generally independent from the male terminal shape. – Molex - C
- Blade or pin is reliable but a solid machined pin is reliable (most similar to existing battery post). – Yazaki North America – C/W

- A hyperbolic system has been utilized on EZ-Go Golf carts for 5 years without a single failure. In many areas of the country, these terminals have been disconnected and reconnected daily. – KonneKTech - C

Competitive product availability?

- We don't have any facts, but it appears that an equal number of competitors for either option could be found - USCAR
- For pins several approaches around, for blades also, but are more expensive. – DaimlerChrysler - V

- A number of companies produce hyperbolic terminals. There are two companies presently producing the low-cost stamped grid terminal. – KonneKTech - C
- Yes, many different companies have capability to manufacture either pin/blade design. – Yazaki – C/W

Serviceability/repairability?

- Same – USCAR
- Serviceablity is not effected by the choice of terminal design. – Yazaki North America – C/W
- Equal! – DaimlerChrysler – V
- As noted, this will be dependent upon the design of the terminal. – KonneKTech – C

Feedback on pin vs. blade for 42V battery connection systems
Complete responses by company

- **Various - Delphi Automotive Systems – Connection Systems Manufacturer**

Delphi Automotive Systems believes a flat blade connection is the best choice; however, we are prepared to deliver any of the proposed choices.

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
Number of operations? Flat blade - Blanking of terminal and stamping of coins on edges
Type of operations? Simple metal stamping

Cost to manufacture? It is easier, and less costly, to stamp a blade than to form/roll/machine a round pin

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)
A blade is more dimensionally stable because it is a simple stamping, no forming is required

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
Number of operations? This depends on the specific design of the female terminal
Type of operations? Stamping, forming, plating

Cost to manufacture? The female terminal would be designed to the lowest cost possible that still ensures performance at specified levels. This would have to be done in order to keep any one female terminal cost competitive with product from other suppliers

Dimensional stability? Any female terminal would be manufactured in accordance with a product print. Product would meet that print, within specified tolerances, via designated processes in order to insure product performance to specification.

- **Various – Delphi Automotive Systems – Wiring harness assembler**

Questions regarding **wiring harness assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector? A box terminal would have to be oriented in the female terminal cavity prior to plugging. However, at the size that these terminals would be, that does not impart a heavy penalty.

Alignment stability in the harness connector? There would be no difference

Retention within the harness connector? A box terminal has a potential to have higher terminal-to-cavity retention because it offers more locking surface than a round terminal

Capability to seal? The capability to seal exists with both designs

Serviceability? Both types of terminals can be serviced

- **Fernando Azevedo Acumuladores Autosil – Battery manufacturer**

We regret to inform you that we have no feedback to return to you regarding the blade/pin connection to the battery.

- **Garold Yurko – Tyco Electronics/AMP – Connection system Manufacturer**

Attached is the Tyco response.
Flat blade is the preferred geometry.

- **Rebecca A. Van Loon - JST Corporation – Connection system manufacturer**

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? *BLADE & FORMED PIN.*
Number of operations? *1*
Type of operations? *STAMPING*

Cost to manufacture? *TBD*

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)
WILL BE ABLE TO ADVISE AN ANSWER AT A LATER DATE.

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? *BLADE & FORMED PIN*
Number of operations? *1*
Type of operations? *STAMPING*

Cost to manufacture? *TBD*

Dimensional stability? *WILL BE ABLE TO ADVISE AN ANSWER AT A LATER DATE.*

- **Herbert Kranz – BMW – Vehicle manufacturer**

Our connector colleagues prefer Radsok.

- **USCAR – all disciplines**

Attached is the USCAR response to your questionnaire. This represents our total team input. (answers are in red type)
We answered all categories, since we felt that in some way or another

represented all disciplines (OEM, terminal, harness, and battery manufacturers).
Although our first choice is a blade, we could easily change to a pin with the right kind of input to sway the vote. We feel that either has the potential to get the job done with the right kind of design.

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? Blade is easier to manufacture
Number of operations? Fewer stations in terminal die
Type of operations? Male stamped, female – stamped & formed because blade has less complexity

Cost to manufacture?

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)
Better control on blade system because of single plane stamping die.

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width)

Ability to attach to internal battery conductors?
Battery manufacturers have experience attaching all 3 designs (no preference)
Cost to assemble?
Can't answer
Alignment stability in the battery housing?
All options equal
Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child)
Blade would allow the plastic housing to be designed with a smaller opening in one plane to keep fingers out.

Serviceability? (bent pin vs. blade)
Whether you use a pin or a blade, it will be recessed in a plastic housing to prevent bending.

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
Number of operations?
Type of operations?

Cost to manufacture? Essentially the same since both would probably require two piece construction.

Dimensional stability? Today's technology would probably result in similar dimensional stability for both options (pin or blade)

Questions regarding **wiring harness assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector? Pin type female may not require orientation depending on final design & in this case, would be easier to plug for the harness maker. Otherwise, no difference.

Alignment stability in the harness connector? Plastic design dependent for both.

Retention within the harness connector? 90 N min primary lock, 130N min w/secondary lock would be our recommended minimum. Both designs should be able to achieve this.
Capability to seal? Both designs would probably use a cable seal and thus both should be equal

Serviceability? Design dependent for both – no difference.

Questions regarding **vehicle assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly? (assume the same alignment features in the plastic connector for all three approaches) Same for all, but no bolt together or inertia (go/no go latches should be used. Standard latch (USCAR type) or lever/cam lock recommended.

Cost of assembly? Same – design dependent for both

Performance of contact surface? Pin may have to be larger to achieve the same number of lines of contact.

Durability of contact surface?
Depends on base material and plating for both designs.
Battery cable – directional orientation?
Pin is more flexible to different orientations.
Size of connection system?
Blade allows lower profile in one plane.
Reliability / Warranty history?
Unknown
Competitive product availability?
We don't have any facts, but it appears that an equal number of competitors for either option could be found
Serviceability / repairability? Same

- **Yasuyuki Komatsu - Honda R&D Co.,Ltd – Vehicle manufacturer**

We have experience with the threaded stud type only.
Regarding all of the above questions, we do not have any experiences/data.
In our HEV, we are using threaded studs for the battery module, power drive unit and electric motor.
We use a waterproof connector (0.35 inch width, blade type) for the HEV DC/DC converter (14V, 70A output).

- **Jean-Pierre Korb – Renault – Vehicle manufacturer**

Questions regarding **vehicle assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly? (assume the same alignment features in the plastic connector for all three approaches) ***If the indexing of the connector is done by the plastic part, we don't see difference between the 3 proposed solutions***

Cost of assembly? ***The cost of the assembly is different between a tool required or a hand plug connction, not between blade or pin terminal***

Performance of contact surface? ***We think there is no differences. The performance of contact surface is much more dependant of the caracteristics of the metals used for the connection.***

Durability of contact surface? ***Round pin (formed)(choice 3)is worse as other solutions. Otherwise, same answer as previous question***.

Battery cable – directional orientation? ***No differencies between the 3 proposed solutions***

Size of connection system? ***Blade solution is the best for the volume size***

Reliability / Warranty history? ***No Experience***

Competitive product availability? ***No Experience***

Serviceability / repairability? ***No Experience***

- **Achim Luisdorf – Douglas Battery – Battery manufacturer**

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? **N/A**
Number of operations? **N/A**
Type of operations? **N/A**

Cost to manufacture? Minimum + $2.50/battery

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)
Flatness of blade could be a problem

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width)
Do not understand question – round should take less space
Ability to attach to internal battery conductors?
Not a big difference.
Cost to assemble?
No difference

Alignment stability in the battery housing?
Round will be more stable
Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child)
Blade type will be safer / easier to fingerproof
Serviceability? (bent pin vs. blade)
Blade bends easier, so it is easier to straighten again.

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? **N/A**
Number of operations? **N/A**
Type of operations? **N/A**

Cost to manufacture? **No idea**

Dimensional stability? **Round would be more stable**

Questions regarding **wiring harness assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector?

Alignment stability in the harness connector?
Round – do not worry about orientation
Retention within the harness connector?

Capability to seal?
Round – much easier to seal
Serviceability?
Round – much easier

- **Grady Merritt – KonneKTech – Connection system manufacturer**

Questions regarding the male terminal

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? Yes-Presently produce stamped pins
Number of operations? One progressive stamping operation plus plating
Type of operations? Progressive stamping die

Cost to manufacture? $.10 to $.12 per pin [$.20 to $.25 per battery]

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)
Concentricity of the pin can be maintained with liberal tolerances when used in combination with Hyperbolic Terminal Technology.

Questions regarding installing the male terminal in the battery

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector? (blade = low height / large width, pin = average height / width)
8mm stamped pins 25mm in length have been tested in combination with hyperbolic terminals in batteries and passed to the following parameters:

500 amps at -29C for 30 seconds
150 amps at 70C for 30 seconds
130 amps continuous at 50C

Ability to attach to internal battery conductors? A stamped pin can be easily designed for connection to the internal lead post in a battery. Design concepts are readily available.

Cost to assemble? Cost to assemble a stamped pin in the battery should not exceed the present cost to terminate a battery.

Alignment stability in the battery housing? Designs have already been presented reflecting stable alignment within the housing. Hyperbolic terminal connection systems provide flexibility to compensate for a certain amount of mis-alignment.

Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child) An addition of a nylon protection on the end of the pin will provide finger-proofing protection as well as protection from the damage that may occur from arcing during disconnect. Examples of pins with this feature will be available at the September 20, meeting. This will be a very low cost solution.

Serviceability? (bent pin vs. blade) Bent pins can be easily straightened but as noted above, hyperbolic technology can compensation for a certain amount of pin miss-alignment.

Questions regarding the female terminal

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? Yes-presently produce hyperbolic terminals

Number of operations? High volume production will be a fully automatic multiple stamping and assembly operations.

Type of operations? Stamping and assembly on dedicated equipment.

Cost to manufacture? $.45 to $, 50 per terminal [$.90 to $1.00 per battery]

Dimensional stability? By using Hyperbolic Technology, dimensional stability is guaranteed within a wide tolerance band.

Questions regarding wiring harness assembly

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector?

Alignment stability in the harness connector? The hyperbolic terminal has proven to be adaptable to a wide range of connector applications and can be easily aligned within numerous connector designs.

Retention within the harness connector? This can be easily accomplished within a wide range of connector designs.

Capability to seal? A hyperbolic terminal will not be a deterrent in any way to the successful sealing of the connector assembly.

Serviceability? This will be determined by the connector design. However, experience indicates that a hyperbolic terminal will not be a service issue.

Questions regarding vehicle assembly

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly? (assume the same alignment features in the plastic connector for all three approaches)

Cost of assembly? Use of a hyperbolic terminal will eliminate the use of torque equipment and will reduce assembly cost.

Performance of contact surface? A hyperbolic terminal provides inherent spring retention on the contact surface without the need to introduce spring devices required by blade terminals.

Durability of contact surface? Hyperbolic terminals have proven to be capable of 10,000 insertions without loss of spring retention.

Battery cable - directional orientation? Hyperbolic terminal is capable of 360-degree ordination.

Size of connection system? A hyperbolic system will be equal to or smaller than present systems.

Reliability / Warranty history? A hyperbolic system has been utilized on EZ-Go Golf carts for 5 years without a single failure. In many areas of the country, these terminals have been disconnected and reconnected daily.

Competitive product availability? A number of companies produce hyperbolic terminals. There are two companies presently producing the low-cost stamped grid terminal.

Serviceability / repairability? As noted, this will be dependent upon the

design of the terminal.

- **Ralph Erskine – Ford – Vehicle manufacturer**

I am sending this as a response on behalf of Ford Motor Company. Our preference is for Choice #1, a flat blade on the battery. This is for several reasons. First, we believe this design can be manufactured to meet the required performance specifications with less expense than choices 2 or 3. Second, we want multiple competent automotive connector suppliers to make the wiring harness connector; we are confident that Delphi, Tyco and Yazaki all can make acceptable designs, which gives us confidence in this choice.

- **Alton De Claire – General Motors – Vehicle manufacturer**

We have had more discussion on blade versus pin and want to change our vote to a blade connection.

- **Richard Johnson – Bolder Technologies Corp. – Battery manufacturer**

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width) **Blade might offer less intrusion in battery space if positioned horizontally, but the space gained is very minimal. Roll-formed pin would add a mm or two to diameter over solid pin, but again this is not significant and could be at least partially compensated for in housing and Keying design.**

Ability to attach to internal battery conductors? **No difference as both must be molded into a lead part which will form the connection with the interior of the battery (this presumes the high volume production battery of choice will be lead-acid - which is safe given the 6-8X cost of nearest competitive options.)**

Cost to assemble? **No difference.**

Alignment stability in the battery housing? **Both blade & pin can be accommodated. Pin may present a slightly lower cost cover mold.**

Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child) **Round pin will present less access and when roll-formed, allow for a insulating button to be easily installed in the end of the pin.**

Serviceability? (bent pin vs. blade) **Round pin might be slightly easier to service with a simple tube if realignment were necessary. Don't see this as a major issue. Pin might offer slightly lower probability for servicing need because of more limited access to common blade type instruments such as a screwdriver.**

- **T. Tachibana – Toyota – Vehicle manufacturer**

This is the response of Toyota Motor Corporation.

Toyota will not respond to your questions this time.

Because Toyota does not think hand pluggable connection is appropriate.

- **Christian Kuper – Hoppecke – Battery manufacturer**

We as Hoppecke would clearly prefer a round pin for the following reasons:
- The space, esp. the height, for a round pin is available at DIN battery lids.
- Flat, and therefore broad blades would cause problems fastening them into the lead block. This lead block (including the base of this block) would have to be broader. The additional lead we need is not compensated by the smaller height.
- The lead block has to fit on the breadth of one cell. The will not be sufficient for fastening the blade.
- An vertical arrangement is not possible, because the height is limited by the lid height.
- An immersion into a lead block in one surface with the battery lid would need in case of a blade a to large area. The available lead area is restricted by the space we need to solder the lead block to the inner side of the battery.

- **Anders Kästel – Volvo – Vehicle manufacturer**

I asked our specialists in this field to give their input upon the questionnare.

The output from them was to avoid a "springloaded" type of connection but rather use some kind of device containing a screw to generate the clamping force between the cable terminal and the battery terminal.

None of the connector types suggested in the questionnare were considered why I can´t give you any feedback on the suggested types.

- **George Zhao – Alcoa Fujikura Ltd. – Connection system manufacturer / Wiring harness assembler**

Questions regarding the **male terminal**

	Solid Pin	Formed Pin	Blade
Manufacturing operations?	N/A	Complex	Simple
Number of operations?	N/A	5	4
Type of operations?	N/A	Stamp in progressive dies	Stamp in progressive dies
Cost to manufacture?	N/A	Same	Same
Dimensional stability	N/A	More steps to control concentricity of pin	Easy to control flatness
	N/A	Same to coining taper on the edge	Same to coining taper on the edge

Questions regarding **installing the male terminal in the battery: N/A to AFL**

Questions regarding the **female terminal**

	Pin	Blade
Manufacturing operations?	Simple	Simple
Number of operations?	Equal	Equal
Type of operations?	Stamping and assembling	Stamping and assembling
Cost to manufacture?	Less cost	More cost
Dimensional stability	Easy to control mating hole	Easy to control mating gap

Questions regarding **wiring harness assembly**

	Pin	Blade
Cost to assemble a female terminal in the harness connector?	same	Same
Alignment stability in the harness connector?	Very good	Good
Retention within the harness connector?	Same	Same
Capability to seal?	Very good	More difficult
Serviceability?	Same	Same

Questions regarding **vehicle assembly: N/A to AFL**

- **Alexandre Genevaux – PSA – Vehicle manufacturer**

Questions regarding **vehicle assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly? (assume the same alignment features in the plastic connector for all three approaches)
The round pin (solid) is used at PSA. This kind of connection is really easy and we use a terminal SOCOP with a lever for the positive terminal.

Cost of assembly?
This kind of connection costs less than 1$ for positive connection ; 0.5$ for negative connection.

Performance of contact surface?

Durability of contact surface?

Battery cable – directional orientation?
Depends of the vehicle.

Size of connection system?
Should not be higher as the current pin.

Reliability / Warranty history?
It has to be very reliable according to the cost of the function.

- **Jim Bolstad – Johnson Controls Inc. – Battery manufacturer**

Our response to this questionnaire is based on our experience as a battery manufacturer.

We are only responding to the section of the questionnaire pertaining to "installing the male terminal in the battery".

1) Regarding our dimensional preferences on battery surface area needed for the connector: our preference is to use a male pin connector on the battery. Accordingly, we would need relatively average height and average width of this surface to be available for the connector.

2) Regarding attachment to internal battery conductors: our preferred concept would use, for each terminal, an 8-mm pin insert molded into a lead bushing. The lead bushing would then be joined to the internal top lead of the battery cell via melting of both adjoining lead surfaces.

3) The cost to assemble is not totally assessed at this point. We believe that the brass pin/lead bushing assembly will be in the price range of $0.75 to $1.25 each. The cost of the plastic enclosures and other parts of the terminal connection system, together with the assembly operations cost, are not assessed at this time.

4) In our proposed design concept, the battery terminal bushing is insulated by and supported by a plastic "canopy" which also extends about a quarter-inch past the end of the male pin. We believe this canopy will provide adequate protection to the male pin, to insure its alignment stability. In addition, we would design the canopies around the male pin terminals to be "keyed" such that they would prevent a positive cable terminal from engaging with a negative battery terminal, and vice versa.

5) "Fingerproofing" of the battery terminals (to render them impossible for small children to reach fingers into terminals if the battery were on display shelves in a store, for example) can be accomplished by inserting plastic "plugs" which would cover the male pins and engage into the plastic canopies. These plugs would be removed at the time of battery installation into a vehicle.

6) Serviceability of the terminal if the terminal pin were bent, would be (by design) not readily done by the end customer nor by an installer. In our proposed terminal concept, a connector failure mode will have been intentionally designed into the system. The weakest point in the connector system is intended to be the interface between the pin and the lead bushing. The reason is that if the connection to the battery is broken, it is desired that the break occur outside the battery container rather than inside. A break inside is more likely to result in a spark which could ignite hydrogen and oxygen that is present inside the battery container. JCI would prefer that batteries with damaged terminals not be serviced by customers or installers, but sent back to the manufacturer. The likelihood that terminals of this type could be damaged in this way (other than by intentional abuse) is considered to be low.

- **Richard Johannes – Molex – Connection systems manufacturer**

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
1. The manufacturing operations for a solid blade are the simplest. Plate strip (if plated) and blank and form. (Formed hollow blades are the most difficult)
2. Solid wire pins are only slightly more difficult assuming unplated or pre-plated wire is used.
3. Rolled pins are the most difficult of the three to manufacture and would require multiple progressive forming steps. (Formed hollow blades are the most difficult)

Number of operations?

This is driven by the battery assembly requirements. In general, all three require the same number of operations, but the die for #3 would be more expensive with 8 to 12 progressive stations.

Type of operations?
1. Plate and blank with a coin on the tip
2. Plate and blank with a coin or form on the tip
3. Plate, blank, progressive roll in the die

Cost to manufacture?
1. Low (assumes solid blade)
2. Low
3. Moderate

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)
1. Good – some edge burr issues possible, flatness of the blade also a possible issue (easily addressed in female design)
2. Excellent – Pin straightness is the only issue, but this should more consistent that blade. (The pin dimensional control is much better than the blade if a post plate process is used)
3. Fair – Diameter control and seam protrusion are possible issues.

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width)

Ability to attach to internal battery conductors?

Cost to assemble?

Alignment stability in the battery housing?
1. In the narrow dimension the blade is much more susceptible to bending (smaller moment of inertia)
2. The best from a bending prevention stand point
3. Second best depending on the material thickness and diameter needed to meet the current.

Ease of “fingerproofing”? (ability to pass a test that would not provide finger access for a small child)
1. Blade terminals need to be wider, but narrower than their pin counterpart. As a result no significant difference exists.

2. No significant difference exists compared to blade.
3. A hollow pin will require a larger size to carry the necessary current. This increases the potential for problem.

Serviceability? (bent pin vs. blade)
1. In the narrow dimension the blade is much more susceptible to bending (smaller moment of inertia)
2. The best from a bending prevention stand point
3. Second best depending on the material thickness and diameter needed to meet the current.

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
The female terminal would follow similar operations. Plate, blank, and form.
Number of operations?
The blade box is slightly more difficult to form depending on the allowable corner radii on the box.
Type of operations?
In line plating and progressive die.

Cost to manufacture?
The blade box is likely to be more expensive due to material usage and a slight increase in difficulty.

Dimensional stability?
The pin cylindrical terminal will be marginally more stable.

Questions regarding **wiring harness assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector?
The box progression on the reel may be larger and would result in a slight decrease in crimping rate (assumes that the box drive progression and not the crimp wings). The cylindrical terminal would not require orientation and would allow for a slight increase in assembly rate ~2-5%.

Alignment stability in the harness connector?
The blade connector will be lower and longer. This may drive a slight decrease in system alignment stability. This is heavily housing design dependent.

Retention within the harness connector?
No significant difference.

Capability to seal?
No significant difference.

Serviceability?
No significant difference.

Questions regarding **vehicle assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly? (assume the same alignment features in the plastic connector for all three approaches)
No significant difference.

Cost of assembly?
The blade would likely be more expensive as a total system. This is driven by component cost (material and component / harness assembly).

Performance of contact surface?
No significant difference. Multiple contact beams / points should be used to reduce contact resistance and increase stability in all female terminal designs. Plating type and normal force will have the biggest impact for each interface. With thick, soft plating the pin system would perform better assuming little or no moment at the interface.

Durability of contact surface?
If both the pin and blade systems had the same normal force and plating thickness and the blade did not use a dimple or tight radius in the contact area, it would wear better in durability cycle testing.

Battery cable – directional orientation?
No significant difference.

Size of connection system?
The solid pin system would be 20 – 30% smaller.

Reliability / Warranty history?
The biggest issue in connector warranty is the crimp and base material supporting the crimp. It is generally independent from the male terminal shape.

Competitive product availability?

Serviceability / repairability?

- **Bobby Kim – Yazaki – North America – Connection systems manufac**turer

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following: **Yazaki has experience with all three choices listed. Ranking would be choice #1, 2 and 3 (best to worst).**

Manufacturing operations? Number of operations? Type of operations? **Blade and formed pin design utilizes a progressive die process whereas a solid pin is milled.**

Cost to manufacture? **Progressive die for blade or pin is more cost effective than milled pin.**

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.) **Choice #1 and 2 have good dimensional stability. Choice #3 has more tolerance stack-up depending on cut and bending process involved in forming a pin (concentricity of pin not as accurate as solid pin).**

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width) **Pin design would require less surface area on battery.**

Ability to attach to internal battery conductors? **Ability to attach to battery does not affect terminal design choice.**

Cost to assemble? **All terminal designs have same cost to assemble.**

Alignment stability in the battery housing? **Choice # 2 is more alignment stable since there are less dimensions to control. Ranking (best to worst) 2, 1, and 3.**

Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child) **Pin or blade on the battery side will be designed with a shroud for protection. But to protect the tip against "fingerproofing" some type of conductive material should be incorporated to the tip of the male terminal.**

Serviceability? (bent pin vs. blade) **A solid machined pin has superior bending resistance (similar to existing battery post).**

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following: **Yazaki has experience with all three choices listed but prefers choice #1.**

Manufacturing operations? Number of operations? Type of operations? **Both female box and sleeve can be manufactured using a progressive die. But formed sleeve design may require multiple operations (i.e. 2-piece design requires assembly).**

Cost to manufacture? **Progressive die for female box or sleeve is more cost effective than milled sleeve. The sleeve design's ease of manufacturability is contingent on 1-piece or 2-piece sleeve design which effects reliability and cost.**

Dimensional stability? **Milled sleeve has excellent dimensional stability. The female box design is comparably stable to he milled sleeve. However, the formed sleeve has more dimensional tolerance stack-up (1-piece or 2-piece).**

Questions regarding **wiring harness assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector? **All terminal design have the same cost of assembly.**

Alignment stability in the harness connector? **All choices have similarly good alignment stability since the primary alignment feature is the shroud and not the terminals.**

Retention within the harness connector? **All choices have the good retention.**

Capability to seal? **All choices have capability to seal.**

Serviceability? **All choices have same serviceability.**

Questions regarding **vehicle assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly? (assume the same alignment features in the plastic connector for all three approaches) **Pin or blade design can have the same connector assembly process. Therefore, ease of assembly is not a factor in design direction.**

Cost of assembly? **Since this committee is not determining the method of mating (mechanically assisted), there will be no cost impact for assembly since all connector will be hand mated.**

Performance of contact surface? **All choices have good contact surface.**

Durability of contact surface? **All choices have good durability.**

Battery cable – directional orientation? **Pin design gives better directional freedom.**

Size of connection system? **The pin design is smaller packaging requirements than the blade design.**

Reliability / Warranty history? **Blade or pin is reliable but a solid machined pin is reliable (most similar to existing battery post).**

Competitive product availability? **Yes, many different companies have capability to manufacture either pin/blade design.**

Serviceability / repairability? **Serviceablity is not effected by the choice of terminal design.**

- **Dell Crouch – Delphi Automotive – Battery manufacturer**

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations?
    Number of operations?
    Type of operations?
A ROUND PIN HAS NO ROTATIONAL ORIENTATION WITH RESPECT TO SURROUNDING PLASTIC. BEST CHOICE IS A SOLID ROUND PIN
Cost to manufacture?

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width)
SIMILAR TO THREADED TERMINAL ON MARINE BATTERIES.
Ability to attach to internal battery conductors?

Cost to assemble?

Alignment stability in the battery housing?
ROUND PIN HAS NO ROTATIONAL ORIENTATION WITH RESPECT TO SURROUNDING PLASTIC
Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child)

Serviceability? (bent pin vs. blade)
BENT PIN? HOW DO WE ASSEMBLE AND HEAT SEAL COVER AT ~6 SECONDS PER BATTERY?

- **Wolf-Dieter Blauensteiner – DaimlerChrysler – Vehicle manufacturer**

after a long internal discussions we came to following statements:

1. For packaging reasons the connection must not exceed the total height of the battery.

2. For production and service reasons a single two pole connector is of best practice.

3. For the cabeling people flexibility regarding the cabeling takeoff direction would be of most importance.

4. We prefer round contacts in any case.

Taking into consideration all aspects we would prefer as our first choice the Hoppecke design.
If no consensus could be found on that we certainly would get the utmost standardisation at widest freedom by threaded bolts.

- **Rudolf Andraschko – Cannon Weinstadt - C**

After several technical meetings and evaluations at Cannon Weinstadt, we came to following conclusion.

A highly reliable battery link should consider:

Round male contacts (brass) which are fixed onto the lead (Pb) terminals. Diameter of those depends on max. current flow, and should be between 8 and 10 mm max.

Both poles should be arranged parallel. Poles should be protected by a plastic cover,(at least for transportation). The protection of these poles can be incorporated to the connector design as well.

The mating half should have 2 Socket contacts with crimp termination. 4 slots on the contact protected by a stainless steel spring, guarantee, that 4 contact points touching the male contact on the Battery. Both contacts are fixed in a one piece part plug. (Will be cheaper than 2 separate plugs)

Contacts must be easy to insert by hand. If requested socket contacts can be replaceable by a simple hand tool, not destroying the connector,(just in case of repair). The design of the contacts will allow also a 90° crimp termination, if required. The plug must have a polarization to avoid wrong mating. The final design has to be determined together with the battery manufacturer. Engaging force should be less than 70 N. A technical advantage would be a hand lever that guarantees a smooth and determent mating and disengaging of the plug. The contact resistance should be less than 1 mOhm. If desired by the automotive a fuse can be integrated. (Disadvantage, cost will increase).

- **Fred Feres – Exide – Battery manufacturer**

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width) SOME EXPERIENCE BUT WE HAVE NO DATA. Our preferred system would be the round pin based on that experience.

Ability to attach to internal battery conductors? SOME EXPERIENCE, NO DATA Same as above round based on our current experience.

Cost to assemble? SOME EXPERIENCE, NO DATA. All the operations require secondary operations for inserts.

Alignment stability in the battery housing? NO DATA AT THE MOMENT Until complete designs are available and analyzed this is a significant concern

Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child) NO EXPERIENCE, NO DATA

Serviceability? (bent pin vs. blade) PREFERENCES IN ORDER GIVEN BELOW:
INTENDED AS A STYATEMENT :1.- AS BATTERY MANUFACTURERS WE ARE INCLINED TO SAY THAT THE MOST RELIABLE SYSTEM FOR A BATTERY WILL BE A **THREADED SS STUD**.
THIS STATEMENT DERIVES FROM ITS PROVEN DESIGN AND STABILITY UNDER VARIOUS CODITIONS OF VIBRATION, THERMAL CYCLES, CORROSION, ETC.
2.- A SOLID PIN IS OUR SECOND CHOICE (Choice 2 -if the Stud is not adopted).
BENT PIN DESIGNS CAN LEAD TO SERIOUS CONTACT PROBLEMS.
3.- FLAT BLADE IS OUR LAST CHOICE GIVEN THE POSSIBLE VARIATIONS IN MATING AFTER THE BLADE IS MOLDED IN THE BATTERY CONTAINER/COVER.

- **Various – DaimlerChrysler – Vehicle manufacturer**

DC votes for a round pin, no matter if formed or solid though both systems can be made to work for our requirements. Flat designs have some drawbacks but might be slightly cheaper.

There are inputs included from DC Connectors Group/Specialists in Auburn Hills and Stuttgart!

Questions regarding the **male terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? *1 step plus plating /both cases*
Number of operations?
Type of operations? *Pin can be produced in different ways, either are not expensive.*
Cost to manufacture? *Below .50 US$*

Dimensional stability (flatness of blade, concentricity of pin, taper on the edge, etc.)
Depends on tool.
Depending on female layout the pin is self-centering, this easens the requirements, but no longitudinal or wounded sharp edges are allowed. Diameter has to be accurate to at least +/- 0.05mm for optimum performance – this is valid for radsok-design of the female and depends on the length of the contact surface. Definitely no problem with a single flat die for a blade, as long as tool is sharp!

Questions regarding **installing the male terminal in the battery**

For the three choices above, do you have any experience/data that would assist in answering the following:

Dimensional preferences on battery surface area needed for the connector?
(blade = low height / large width, pin = average height / width)
A pin should have 8mm diameter, if it is formed, we recommend the use of a 10mm diameter. To go to 8mm and for ultimate proof a thermal simulation is required!

Ability to attach to internal battery conductors?
Easy and with costs as low as today's studs.

Cost to assemble?
Comparable to today's studs

Alignment stability in the battery housing? *Depends on layout of the lead anchor, the pin is inserted in. Should not create problems. But: The smaller the pin, the harder it is, to accomplish mechanical stability.*

Ease of "fingerproofing"? (ability to pass a test that would not provide finger access for a small child) *Is possible but pin has to be recessed pretty far or clip on protector is needed. Blade needs more space in one direction and less in the other, thus might be done in a way, that recess does not have to be that deep.*

Serviceability? (bent pin vs. blade)
A solid pin at 8mm is pretty strong, of it is shorter than 18mm. Since it is recessed, should not create a problem. A small deformation in a radsok pin is not really a problem as long as insertion is still possible. A bent blade is ugly, since you cannot really even it out.

Questions regarding the **female terminal**

For the three choices above, do you have any experience/data that would assist in answering the following:

Manufacturing operations? *All cage designs end up in a multistep production effort*
Number of operations? *Probably the same for all three designs*
Type of operations? *Stamping and tube production, several bending operations in all three cases, tubes are needed only for the round design, these can be formed or bought ready for use. Should not create a difference.*

Cost to manufacture?
Below 1.50 US$ for a silvercoated 10 mm, 8 mm copper tinned is about .90US$ or less.

Dimensional stability?
More robust than femals for blades cause tubecovered, internal is springloaded...a cheap female for a blade is always an open design.

Questions regarding **wiring harness assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Cost to assemble a female terminal in the harness connector?
Needs to be figured, crimping ends are available.

Alignment stability in the harness connector? *Easy since selfcentering can be achived*

Retention within the harness connector? *Done with plastic parts! No decisive elements.*

Capability to seal? *No difference between approaches, but sealing around a round pin is much easier than on a blade.*

Serviceability? *Since crimping is available, should not be a difference in all three cases.*

Questions regarding **vehicle assembly**

For the three choices above, do you have any experience/data that would assist in answering the following:

Ease of assembly? (assume the same alignment features in the plastic connector for all three approaches)

Cost of assembly? *Low in all cases cause of reduced time for mating in the assembly*

Performance of contact surface?
No difference?!
Durability of contact surface?
No difference?!

Battery cable – directional orientation?
No difference?!

Size of connection system?
No difference?!

Reliability / Warranty history?
No difference?!

Competitive product availability?
For pins several approaches around, for blades also, but are more expensive.

Serviceability / repairability?
Equal!