COST EVENT (FROM BAJA SAE RULES 2019)

C.4.1 - OBJECTIVE

The purpose of the Cost Event is to provide teams an opportunity to show the cost/benefit design decisions used in their prototype vehicle. The Cost Event aims to represent a comparable model for each team to be measured against. Revisions in the Cost Event implemented for the 2018 Competition Season are an effort to streamline the costing and evaluation processes and provide a more comparable and fair costing model.

C.4.2 - COST REPORT

The Cost Report will be summarized in a PDF format where teams should complete their overall BOM (Bill of Materials) with material, processes and fasteners costs.

C.4.2.1 - COSTING SHEETS

The core of the report is the series of costing sheets. Implemented in Mexico competition 2019, the format of these sheets will follow the **BSAE_Cost_eBOM_Template..xls** for the BOM and the **BSAE_Cost_System_Template.xls** for every system.

C.4.2.2 - COST DOCUMENTATION

Cost Documentation is not required. The material, process and fasteners costs will come from a common database of material and component costs **BSAE_Cost_Catalogs_MX2019.xlsm**. These items may be very specific, or may be generalized into a cost category of material/components. If a team's purchased material/components are not in the common database, the team may request an "Add Item Request" for their specific material or component for approval by sending an email to **cost@bajasaemexico.com** Once submitted and approved, that material will be updated and will be available for all teams to use in their BOM.

C.4.2.3 - COST ADJUSTMENT FORM

The purpose of the cost adjustment form is to make additions to a previously submitted report. Items may be deleted, but the total adjustment for the individual component categories must be positive (cost will not be subtracted). This gives the team the chance to add items that were not previously planned. **It is not an opportunity to redo the entire report**. **The total amount of adjustments may not exceed 10% of the total cost of the vehicle previously submitted. If the adjustment exceeds 10%, the additional amount will be added with a multiplier of 3 times (3x). If the adjustment exceeds 25% the report will be considered incomplete and will not be graded.**

C.4.3 - ON SITE EVALUATION

Teams may be required to meet with a cost auditor during the competition to ensure that the vehicle presented at the competition matches with the BOM submitted during in the Cost Report

C.4.3.1 - COST AUDIT

The judges may increase costs and/or fabrication cost if they believe that the figures submitted are below current prices for the item, source, or process involved. **Prices that are higher than the judge expects will not be corrected. Mathematical errors will be penalized. Reports that are highly inaccurate, highly incomplete, or in which the costs cannot be substantiated, may be rejected in their entirety and scored accordingly.** Teams that are required to bring their car to on-site cost judging must do so by their

scheduled appointment. Failure to report by the scheduled appointment time will result in an automatic zero for the event. If teams need to reschedule their appointment, it must be done prior to their appointment. Teams selected for cost audits will be notified by the competition organizers.

C.4.3.2 - Additional Team Review

The judges reserve the right to review with any team during the competition the accuracy of their BOM relative to the vehicle brought to competition. This includes teams who were chosen for audits as well as teams who were not originally chosen and notified.

C.4.4 - Scoring

Cost Event scoring for the 2019 Competition Season will be consistent with past events.

C.4.4.1 - Cost Report Score

The Cost Report score is a maximum of 15 points and is associated with completion of the Cost Report.

C.4.4.2 - Prototype Cost

The Prototype Cost score is a maximum of 85 points and is based upon the Prototype Cost, as adjusted by the judging process, as compared with other vehicles at the competition.
Prototype Cost score will be calculated as follows:

$S_{cs} = 85 \times \frac{C_{max} - C_{team}}{C_{max} - C_{min}}$	Where: C_{team} Vehicle cost, as corrected C_{min} lowest vehicle cost, as corrected C_{max} highest vehicle cost, as corrected

A.7.1.4 - Deadline

Submissions must be received by the due date listed on the Action Deadlines on sae.org. Submission will be acknowledged on the submission website with a visual indicator. Teams should have a printed copy of this acknowledgement available at the competition as proof of submission in the event of discrepancy.

A.7.1.5 - Late Submission / Non-Submission Penalty

Late submission or failure to submit the Design Report and/or Cost Report will be penalized ten (10) points per day. If either report is received more than five (5) days late it will be classified as “Not Submitted” and your team’s registration will be cancelled.

A.7.1.6 - Unsatisfactory Submission

At the discretion of the judges, teams who submit any report that, in the opinion of the judges, does not represent a serious effort to comply with the requirements as listed in these rules will also not compete in the design and/or event, but may at the design judges’ discretion receive between five (5) and twenty (20) points for their efforts.

COST REPORT CONTENT

CM - COST MODEL AND METHODOLOGY

The Cost Models are the underlying methodology and equations that relate the final cost of a part to the different operations and goods used in that part.

CM.1 COST TABLES

CM.1.1 TABLE LIST

All costs in the Cost Report must come from the standardized Cost Tables **BSAE_Cost_Catalogs_MX2019.xlsm :**

- Materials
- Processes
- Fasteners
- Tooling * (cost not included for this year)

CM.1.2 BASES

a. All Cost Tables are presented using metric units. The tables do not differentiate between parts designed in metric and US systems of measure.
b. The tables represent cost based on specific parameters.

- Most items have a cost expressed as a function of one parameter
- When more than one parameter is necessary, additional categories are indicated on the file.

c. Certain types of parts are supplier specific and other types are generic, as specified in the table entry
d. The comment section for each Material, Process or Fastener may refer to the specific part by actual local designation.
Example - a 6.35mm bolt is cost but the comments would say "1/4 inch A-arm bolt"

CS - COST REPORT SPECIFIC ITEMS

CS.1 ENGINE

CS.1.1 ENGINE COST

Engine cost includes: All components necessary to run including spark plugs, coils, wires, oil filter, etc.

CS.1.2 SEPARATE ENGINE ITEMS

The following are not part of the engine cost and must be included separately:

- Air induction (air cleaner by rules) and fuel system components (fuel Cap, Fuel Tank, by rules)
- Any driveline component downstream of the transmission output gear/shaft
- If covers or other parts are removed disassembly labor must be included in labor cost.

CS.2 WELDING PROCESS

Every welded part requires at least **"tube end preparation for welding** operation. It covers all processes except for saw cutting a tube to length and the welding.
Each weld joint on the frame should have this included.

CS.3 DATA ACQUISITION

Data acquisition systems and instrumentation providing live feedback to the driver or telemetry data to the team must be included in the cost report. Data acquisition systems not providing live data to the driver and/or telemetry data to the team may be excluded from the cost report.
All RF data communications systems and associated equipment shall be included in the cost report. RF Voice communication systems and equipment may be excluded from the cost report.

CS.4 FINISHES

a. Any finishes (paint, polish, etc) that are only used to beautify are not costed.
b. Preservative finishes intended to protect the appearance or function of a part for an extended period of time must be costed.

CS.5 EXCLUDED ITEMS

Items that do not need to be included in the Cost Report, if installed:

- Seat Belts
- Fire Extinguishers
- Kill Switches
- Rotating Guards
- Fuel Spill Pan
- Transponder

All the items on the above list are excluded but if there are other components that a team feels is only safety related, please submit a rules question to see if should or should not be included in the cost report.

CL - COST REPORT SYSTEMS AND ASSEMBLIES

CL.1 SYSTEMS AND ASSEMBLY LIST

1 BRAKE SYSTEM – BR: Brake Fluid, Brake Master Cylinder, Brake Lines, Fittings, Brake Discs, Brake Pads, Balance Bar, Calipers, Proportioning Valve, Brake Pedal

2 ENGINE & DRIVETRAIN – EN

Engine: Engine, Choke, Accelerator, Pedal Cables, Fuel Tank, Splash shields, Fuel Cap, Air Filter
Transmission: Gearbox, Hydraulic Clutches, Torque Conv., Shift Mechanisms, Throttle Controls
Drive Train: Belts, Gears, Chains, Drive Shafts, Bearings, Sprockets, pulleys, Axles, Chain guards

3 FRAME & BODY - FR

Body: Outer Covering, Fenders, Skid Plates
Frame: Structural Members/ Frame Tubes, Roll Cage, Mounts Integral to Frame, Firewall, Seat, Floor Pan, Tube End Preps, Tubes Cuts / Bends

4 INSTRUMENTS, WIRING & ACCESSORIES – EL: Battery, Cables, Wire Harness / Connectors, Lights, Bulbs, Dash Panel, Displays, Fuses, Gages (any), Relays, Instrumentation and data acquisition, Switches / Buttons / Controls

5 MISCELLANEOUS, FINISH AND ASSEMBLY – MS: Paint, Trim, Headrest / Restraints, Seats, Shields.

6 STEERING SYSTEM – ST: Steering Wheel, Bearings, Shafts, Tie Rods, Bushings, Rack, Pinion, Gears, Rod Ends / Clevis

7 SUSPENSION & SHOCKS – SU: Springs, Spindles, Shocks / Dampers, Rod Ends, Ball Joints, A-Arms or Equivalent, Uprights, Pushrods / Pullrods, Bell Cranks, Suspension Mechanism
8 WHEELS, WHEEL BEARINGS &TIRES – WT**:** Hubs, Lug Nuts, Tires, Valve Stems. Wheel Bearings, Wheel Studs, Wheel Weights, Wheels

CL.2 ASSEMBLY AND PART NUMBERING

Each Assembly and Part in the BOM must have a Part Number using the following convention:
a. Base Number (for each Part) – Five digit numbers assigned at Team discretion (example "00001")
b. Base Number (for each Assembly) – A four-digit number with preceding character of "A" (example "A0001")
c. Suffix – Two-character code showing part change history. These are provided for team use only so if desired all can be "AA"

CL.3 FASTENERS

a. All Fasteners are included in the BOM under the Assembly and Part where they are used.

CR - COST REPORT IMPLEMENTATION

CR.1 MATERIALS

CR.1.1 DEFINITIONS

a. **Raw Material** - the stocks used to produce parts from scratch, such as billet steel for machining or aluminum ingot for casting.
b. **Gross Weight** - the weight of the raw material, including all machining stock
c. **Net Weight** - the weight of the finish machined part

CR.1.2 BASES

a. Bar, sheet and tube stock are purchased using Raw Material costs.
b. Material costs are based on part **Gross Weight.**
Example - a steel hub is machined from solid bar. The interior is removed by boring. The cost of the bar must include this interior material.
c. Any parts that are manufactured by removing material should be reported as Raw material (per size).
Example – machining, water jet, laser cut
d. Any parts that are manufactured forming the geometry should be reported as **Raw material (per kg).**
Example – casting, rapid prototype (3D printing), Plastic Injection.
In the case of casting and plastic injection the cost report should include the cost of the mold or matrix used to generate the part (material, fasteners and process).

CR.2 MAKE VERSUS BUY

CR.2.1 MADE OR BOUGHT

Every part may be classified as Made or Bought.

- This designation does not necessarily refer to whether a team actually purchased or fabricated a part but defines how the part must be cost from the Cost Tables.
- The Made versus Bought designation enables certain parts to be simplified to a relatively few number of entries.

CR.2.2 MADE PARTS

Made (or manufactured) Parts must be cost as if the company manufacturing the vehicle was going to make the part internally. That is by purchasing raw materials and processing them into a finished product. **Parts that must be Made do not appear explicitly in the Cost Tables or appear with a "Cost as Made" option.**

CR.2.3 BOUGHT PARTS

Bought Parts must be cost as if the company manufacturing the vehicle was going to outsource the fabrication of that part. These parts would be received by the vehicle manufacturer in a relatively finished state. **Teams costing Bought parts as Made parts will be penalized.**

CR.2.4 MADE PARTS LISTED AS BOUGHT

CR.2.4.1 If a team genuinely Makes a part which is listed in the Cost Table as a Bought part, they may alternatively cost it as a Made part only if a placeholder entry is listed in the Cost Tables enabling them to do so.

Example - in the category of dampers a "student built" entry is included. The team must create a new component named "Damper, Student built" and cost the damper they actually designed and built.

CR.2.4.2 Any part which is normally purchased that is optionally shown as a Made part must have supporting documentation submitted to prove team manufacture.

Documentation may include engineering drawings, pictures of machining, etc.

CR.3 ASSEMBLY LABOR

CR.3.1 MASS

The mass of the part influences the time and effort it takes the operator to assemble the part to the assembly or vehicle. **The actual part mass must be equal to or less than the value selected.**

Example - a 300 g part would have an assembly labor category of 1 kg

CR.3.2 INTERFACES

Each interface that a part has with surroundings parts must be costed

CR.3.3 FIT TYPE

The ease with which a part can be assembled is described by the fit. There are three categories of fits:

FIT TYPE	**Loose**	**Line on Line**	**Interference**
Description	the part assembles with **no force**	the part is designed **to have a close fit** to the surrounding parts and some buildup of force is required to get the part started.	significant **force is required to insert the part** and mechanical assistance may be necessary.
Example	-Quick release (steer. wheel) the steer. shaft -Bracket bolted to a monocoque.	-A rod end inserted between two tabs in double shear -A splined axle shaft into the differential gear	-A rubber hose onto a barbed fitting - A ball bearing into a bore.

CR.4 MACHINING

CR.4.1 MACHINING BASIS

Costs for machining operations are based on the volume of material removed. All processes require a minimum of 1 mm (approx 0.040 in) of machining stock to be removed from each surface of the part with machining, regardless of the actual amount removed.

CR.4.2 Machining Type

The actual machine used, whether mill, lathe or otherwise, is the same unless a specific line item is included for that machine, such as gear hob.

CR.4.4 Machining Stock

When costing the raw materials that go into making machined parts the machine stock must be included in the purchased material mass, even though this material is machined away to produce the final part.
Example - an upright bore is machined into a piece of billet aluminum. The interior material that is milled away must be included in the billet mass and hence cost. The same feature machined into a casting need only include 1 mm of machine stock of the machined away material

CR.4.5 Fixturing

Machining requires labor operations to fixture the part onto the machine.
CR.4.5.1 **Every machined part requires at least a 'Machining Setup, Install and Remove' operation.**
This is the time it takes to pick up the work piece, fixture on the machine, and remove it when the machining is complete.
CR.4.5.2 For a part that requires an intermediate change in position, such as to machine the back of the part which would not be accessible in a single fixturing setup, the labor step of **'Machining Setup, Change'** is also required.
Example - an upright that requires three different orientations on a mill to fully machine would require two of the 'Machining Setup, Change' and the 'Machining Setup, Install and Remove' labor operations.

CR.4.6 Fixturing – Special Case

It may be possible to fixture a work piece of raw material and machine more than one part out of it.
a. Fixturing for this case may be distributed among the quantity of resulting parts that could reasonably be handled as one.
b. This assumption must be clearly noted in the Cost Report, with enough details for the Cost Judges to verify the part geometry is appropriate for the machine being used.
Example - a self-feeding lathe could machine 10 suspension inserts out of a single piece of bar stock. These 10 pieces are small enough to be handled together. In this case the quantity of the 'Machining Setup, Install and Remove' may be set to 0.1. This represents the 10 parts that can be machined per setup.

CR.5 TOOLING & FIXTURING

It does not apply

CR.6 FASTENER INSTALLATION

CR.6.1 Installation Basis

The cost to tighten or loosen Fasteners is based on:

- The tool (or motion) needed to turn it
- The diameter and length of the Fastener
- Whether the Fastener requires a secondary tool for reacting the torque (such as a wrench on a nut)

CR.6.2 Installation Types

CR.6.2.1 Hand

No tool is necessary for tightening, such as quick release fasteners or hand tightened nuts
a. Loose operations are those accomplished by using the fingers of the hand.
b. If the entire hand is moving to rotate the fastener the tight category should be used.

CR.6.2.2 Screwdriver

A tool that can be held in the hand and turned with the wrist. Any type of bit can be fitted such as straight, Philips, Torx, etc.

CR.6.2.3 Wrench

An open end or box wrench or similar tool requiring motion of the hand. After a turn the wrench may have to be removed and repositioned for the next turn.

CR.6.2.4 Ratchet

A tool with internal clutch that allows the hand to be moved and returned to the starting position without removal of the tool. Compatible with any bolt head style such as 6-point hex, 12-point hex, Torx or other.

CR.6.2.5 Power Tool

An electric, pneumatic or other power assisted tool for running down fasteners.
To qualify for power tool use, a Fastener must meet the following requirements:
a. A socket of the size needed to drive the fastener must fit in the fully secured position
b. An extension may be used to fit the power tool but it may not exceed 0.35 m in length.
c. One power tool must fit onto the socket.
Any power tool may be used. There are no restrictions on size or shape.

CR.6.2.6 Reaction Tool

Where the Fastener is not being attached into the part but requires a nut or other separate threaded piece, a reaction tool will be required.
This will appear as a separate line item and should appear whenever a nut is used on a bolt.

CR.7 COMPOSITES

CR.7.1 Composite Manufacturing

CR.7.1.1 Lamination

Used to build the laminate one ply at a time. A ply is a single layer of the laminate consisting of a single sheet of material, regardless of material or thickness. A ply may consist of woven carbon, unidirectional glass, adhesive film or honeycomb core, for example.

CR.7.1.2 Resin Application

Used to apply resin to non prepreg materials.

CR.7.1.3 Curing Operations

Used to take a laminate and convert it to a finished composite structure.
a. All curing operations include vacuum bagging, peel ply, breather cloth and other consumable materials and labor
b. Costs also include part removal from the mold

CR.7.1.4 Cure Types

a. **Room Temperature** – ambient temperature curing resin systems at one atmosphere of external pressure or less
b. **Oven** – increased temperature cure cycles for composites at one atmosphere of external pressure or less
c. **Autoclave** – high temperature and pressure composites curing

CR.7.2 Composite Material Cost

CR.7.2.1 Fiber and Resin

The composite material must be the cost of both the fiber and resin together. This is true for both prepreg and dry fiber systems and is further stated in the Materials Table.

CR.7.2.2 HYBRID WEAVES

a. If hybrid weaves are used the cost should reflect the ratio of the materials in the ply.
Example - a 50% carbon fiber, 50% glass woven ply may use the average cost of the carbon and glass materials.
b. If the actual fiber ratio is not used, then the cost of the ply must be the cost of the highest cost material present.

CR.7.3 COMPOSITE MASS

CR.7.3.1 MASS COMPARISON

a. When costing composite materials, the total mass of the part in the Cost Report must match the actual mass of the part as presented on the vehicle for Cost Judging.
b. The mass of each ply may be adjusted to make the finished part mass match the Cost Report.
c. Parts may be weighed during the event. The Cost Report mass must be equal to or greater than the actual mass of the part

CR.7.3.2 MASS INCLUDES THE FINISH

Actual mass of the Part includes clear coat, paint and other finishes. *The paint and finish mass is included to eliminate questions about how much weight the paint (or clear coat) has added.* The cost of the paint and paint application is not included if it is solely for cosmetic purposes but the mass of paint must be included in the composite cost.

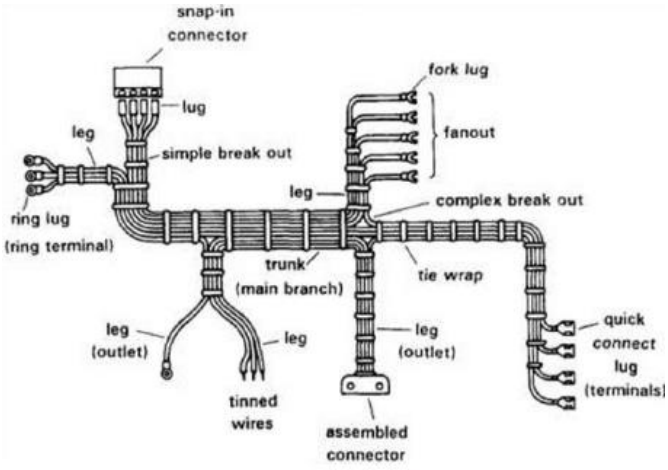
CR.8 ELECTRONICS AND WIRING

The wiring harness is cost as a number of connectors of a certain style, each interconnected by a number of wires of a certain type.

CR.8.1 WIRING TYPES

The electrical system is composed of three wiring types.
a. **Signals** – Inputs to the control system such as wheel speed, mass airflow or the position of a driver toggle switch.
b. **Controls** – Control system outputs. These can be digital signals, pulse width modulated or voltage outputs.
c. **Power** – Wires carrying current for vehicle distribution or actuators. These include vehicle power from the battery, engine starter, solenoids, motors etc.

CR.8.2 WIRING HARNESS TERMS



From "Product Design for Manufacture & Assembly" by Geoffrey Boothroyd, 1994

CR.8.3 ELECTRONICS

This update will include cost for:

- PCBs
- Electrical Components (i.e. resistors, capacitors, inductors)
- Wire
- Connectors
- Process Charges

Due to the custom nature of electronics and the goal of cost event to provide an accurate and consistent prototype cost, we have developed a formula that should be used by teams when adding PCBs and the components mounted on them.

The formula is **$5 per square inch for a 2-layer PCB and $10 per square inch for a 4-layer PCB**.
For the electrical components mounted, the cost is $4 per square inch.
Example, a 2-layer PCB that is 4 square inches would have a total prototype cost of $36 for the material.

Process cost will be $0.05 for each soldered connection on the board.
The cost of wire will be charged in the number for segments. The cost of each segment of wire is $1.00.
That will include the end preparation for insert it into a connector.

Connectors will be $1.00, regardless of the number of wires or pins on the connector.
Example, a wire harness with 8 wires and a connector on each end will have a material cost of $10. The length of the harness will not affect the cost of the harness.
Process cost has been uploaded to the catalog and is based on style of connector.
It is for common and simple electrical components. Microcontrollers, screens/displays and other components should be submitted for addition to the cost catalog using the add item request process.