

Cost Event Overview and Tutorial for 2012 Rules

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Agenda

- Event Objectives & Overview
- Changes for 2010
- The Cost Report
 - Format
 - BOM Structure
 - Make versus Buy
 - Published Materials
 - AIR's
 - Part Numbering System & Part Names
- Addenda
- Penalties
- "Real Case"
- Do's and Don't's

Cost Event - Event Objectives

C.3.1 Event Objective

- The objectives of the Cost and Manufacturing Event are:
 - a. To teach the participants that cost and budget are significant factors that must be considered in any engineering exercise.
 - b. For teams to make trade off decisions between content and cost based on the performance advantage of each part and assembly.
 - c. To gain experience with creating and maintaining a Bill of Material (BOM).
 - d. For the participants to learn and understand the principles of Design for Manufacture and Assembly, lean manufacturing and Minimum Constraint Design.

Event Overview

- Event comprised of three parts
 - Cost Report
 - Cost Report/Vehicle Review at Competition
 - “Real Case” Scenario
- Cost Report and review remain fundamentally same as previous years (up to 2009) except now all costs come from SAE Cost Tables
- Real Case scenario similar to 2010 and 2011
 - Will vary year to year
 - More information available closer to competition
 - No design work is necessary, but
- Possible Cost Audit

Cost Event Changes in 2010

- Same Rules as 2010
- Content drives Cost → Tradeoff analysis very important
- Costs the same world over
- No receipts
- All costs from tables
- Tooling costs included
- No maximum cost - accuracy is focus
- “Real Case” added
- Costs missing from tables will be added after students submit an Add Item Request (AIR) Form – now done electronically at fsaeonline.com

Scoring

- Same Scoring Method and point allocation

3.7 Scoring

The points for the Cost and Manufacturing Event will be broken down as follows:

$\frac{40 \times [(P_{max}) / (P_{your}) - 1]}{[(P_{max}) / (P_{min}) - 1]}$	40 Points	Lowest cost - each of the participating schools will be ranked by total adjusted cost from the BOM and given 0-40 points based on the formula on the left.
	40 Points	Accuracy, Clarity & Event Day/Visual Inspection - The cars will be reviewed for part content, manufacturing feasibility and accuracy of the cost information. Supporting documentation will be assessed based on its quality, accuracy and thoroughness. The range for the score is 0-40 points.
	20 Points	Event Day/Manufacturing Processes - The teams must be prepared to discuss in detail the "real case" scenario distributed prior to the competition. The materials will include more specifics about the goal and scoring of the scenario. The range for the score is 0-20 points.
Total	100 Points	

Where:

P_{your} is the adjusted cost of your car (with penalties) in dollars.

P_{min} is the adjusted cost of the lowest cost car in dollars.

P_{max} is the cost of the highest cost car in dollars.

- Rephrased three categories are: **Cost, Accuracy and "Real Case"**
- The actual Cost and Cost Accuracy determine majority of points

Cost Report

MUST

- Include **EVERY part on the car**, except....
- Use the “**actual manufacturing technique used on the prototype**”
- Include **tooling** costs for processes that require it.
- Have a cover sheet
- Have a Cost Summary page, listing each section’s cost and total, vehicle cost
- Use the eight commodity report sections per Appendix C-3.
- Have tabs for each section.
- **Use the part numbering system per Appendix C-2.**

Cost Report - Cont'd

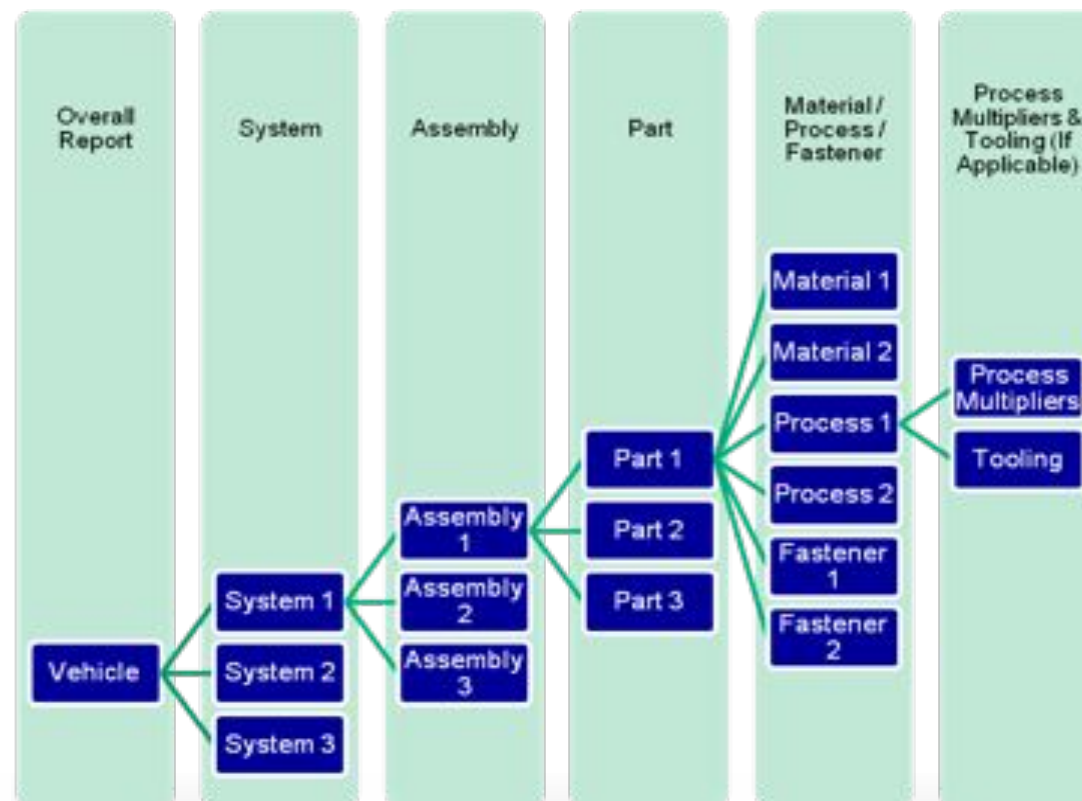
- **Include** in the Cost Report
 - **Data Acquisition systems** including display screens, sensors and wiring
 - **Preservative finishes** to “preserve the appearance or function” of a part, e.g. anodizing and paint for basic protection
- **Do NOT** include in the Cost Report
 - “Rain” tires (and wheels)
 - Extra sets of “dry” tires
 - Paint or polish for “beautifying” the car
 - On-board fire systems
 - Transponders
 - Video and radio systems

Cost Report Format

- There is currently no rule defining report format but a sample format is listed on fsaeonline.com
- BUT it **must be accurate and easy to understand**, i.e. logical
- Hard copy will be very similar to previous years with exception of
 - No receipts
 - No length limit
- **Regardless of submission format you will need good, clear supporting documentation for your designs to justify the cost data submitted**

Cost Report – BOM Structure

- The Cost Report is a costed Bill of Material (BOM)
- Hierarchy: System → Assembly → Part → Material/Process/Fastener → Tooling



Cost Report – BOM Structure - Cont'd

- Eight Systems:
 - Brakes
 - Engine & Drivetrain
 - Frame & Body
 - Electrical
 - Misc. & Finish
 - Steering
 - Suspension
 - Wheels, Bearings & Tires
- **This structure is required**

See Appendix C-3 for
more details

Cost Report – BOM Structure - Cont'd

- Sample BOM from rules:

3.9.2 An example BOM structure is shown below:

- Engine & Drivetrain.....System
 - Engine.....Assembly
 - Differential.....Assembly
 - Housing.....Part
 - Aluminum.....Material
 - Needle Bearing.....Material
 - Sand cast.....Process
 - Die & Core Package #4.....Tooling
 - Machining-Turn.....Process
 - Weld.....Process
 - M6x1.25 Grade 8.8.....Fastener
 - Internals.....Part
 - End Cap.....Part

Make vs. Buy

- Designation of “Made” or “Bought” is applied to each part on the car
- Determines how Cost is calculated
 - “Made” parts are those that start with raw materials (aluminum, etc.), have operations performed on them and may have subassembly
 - Examples: pedals, differential housing, brake discs
 - “Bought” parts come right off the tables and get assembled to vehicle
 - “Bought” parts can have operations if the team modifies the standard parts
 - Examples: dampers, engines, safety harness
- “Bought” parts appear in tables by manufacturer and model (generally)
- “Made” parts are designated as “Student Built”

Make vs. Buy - Cont'd

- Table from rule C.3.12.3

How Table Lists Part	How Team Actually Acquired the Part	
	Team Made	Team Bought
Table Lists Part as "Made", or Part is not Listed in the Tables	Cost as "Made"	Cost as "Made"
Table Lists Part as "Bought"	Team made option NOT in table cost as "Bought". If team made option in table team can choose either "Bought" or "Made"	Cost as "Bought"

Make vs. Buy - Cont'd

Explanation

- Table lists a part as “Bought” but team actually made the part:
 - If the Table lists “Team Made” as an option, then team can choose to cost the part as “Bought” or “Made”.
 - If the table does NOT list “Team Made” as an option, then the cost MUST be taken as “Bought” from the Tables

Some Items - All “Cost as Made”

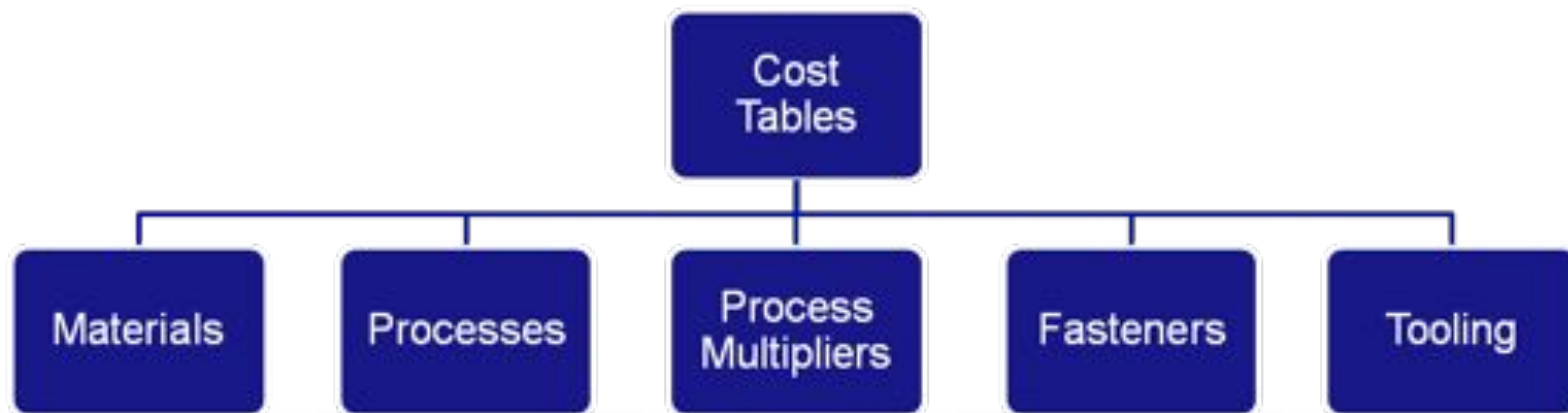
- Axle
- Brake Rotor/Disc
- Composite tubing
- Differential Housing
- Pulley
- Sprocket or gear
- Fuel Rail
- Heat Exchanger Fan Shroud
- Muffler
- Mirror, Rear View, Housing
- Seat
- Steering Pinion
- Steering Rack Housing
- Steering Rack
- Steering Wheel, Quick Release
- Steering Wheel
- Throttle Body

Published Cost Materials

- Formula SAE Rules, Part C – Article 3
- Appendix C-1 Cost Models and Cost Methodology
- Appendix C-2 Standard Part Numbering
- Appendix C-3 Organized List of Systems and Assemblies
- Appendix C-4 Power Tool Package Envelopes
- Table: Materials
- Table: Process
- Table: Process Multipliers
- Table: Fasteners
- Table: Tooling

Cost Tables

- Materials - Lists the **costs for raw materials** used to manufacture parts built by the teams and also of **finished parts purchased** by the teams.
- Process - **Operations which modify materials** such as cutting, joining, assembling, etc.
- Process Multipliers - Modify the standard costs of different operations to account for **material and geometric differences in the part**
- Fasteners - Consists of not only traditional fasteners such as bolts, nuts and rivets **but also adhesives, hose clamps and retaining rings**
- Tooling - The **production tooling** associated with processes that are **specific to the part geometry**



Materials

- General Categories (for ease of searching)

Bearings	Drivetrain	Safety
Brake System	Electronics	Sensors
Composites	Engine	Springs
Control Modules	Fluids	Steering
Controls	Misc.	Tires
Dampers	Raw Materials	Wheels

- Some Examples:
 - Raw Materials – Steel, Aluminum, Titanium
 - Composites – Carbon Fiber, Honeycomb, Foam
 - Tires – 13” Hoosier, 10” Hoosier, 13” Goodyear
 - Wheels – BBS, Keizer, JongBloed

Processes

- General Categories (for ease of searching):

Basic Forming	Electrical - Connections	Joining
Composites	Electrical - Layout	Labor
Electrical - Attach Wires	Electrical - Prep	Material Removal
Electrical - Bundle Install	Electrical - Wire in Connector	Sheet Materials
Electrical - Bundle Processing	Fasteners	Tubing

- Some Examples:
 - Basic Forming – Die Casting, Sand Casting, Powder Metal
 - Composite – Lamination, Oven Cure, Autoclave Cure
 - Joining – Sewing, Welding
 - Material Removal – Turning, Facing, Milling, EDM, Cutting

Process Multipliers





- General Categories (for ease of searching):

Assembly
Fastener Installation
Drill, Tap
Machining

- Some Examples:
 - Assembly – Length, Disassemble
 - Fastener Installation – Engagement Length
 - Drill, Tap – Hole Length
 - Machining – Material Type → Similar to machinability index for different materials

Fasteners & Plumbing

- Plumbing generally comes from Aeroquip catalog but many other suppliers listed
- Plumbing fittings are listed in the Materials Table
- Fasteners costed by:
 - Grade
 - Nominal thread size
 - Length

FSAE Plumbing - Low Pressure	
	Adapter, Bulkhead Male Connector, , Steel,
	Adapter, Bulkhead Run Tee, , Aluminum, Anodized
	Adapter, Bulkhead Tee, , Aluminum, Anodized
	Adapter, Bulkhead Union, 45 deg., Aluminum, Anodized
	Adapter, Bulkhead Union, 90 deg., Aluminum, Anodized

Tools versus Tooling

Tools

- Tools refer to **hand or power tools used to assemble the vehicle.**
- The costs of these tools **are not included** in the Cost Report.
 - The effect of the tools used for assembly are captured in the process tables for labor as different costs are given based on the tools used for assembly.

Tooling

- Is the production tooling **associated with processes** that are specific to the part geometry.
 - Examples
 - The dies to stamp a chassis bracket.
 - The dies for die casting or injection molding
 - The dies AND patterns (cores) for sand casting
 - The jigs for welding or brazing
 - The tools (molds) for lamination

Note: The press used to stamp the bracket is not to be included, and is considered production equipment which is not part of the Cost Event.

- The costs of **Tooling must be included** in the Cost Report.

Tooling

- General Categories:

Die Casting
Lamination
Plastic Injection Molding
Powder Metal Forming
Sand Casting
Welding, Brazing

- Tooling is process specific and goes only with the processes that require it.
- Column “F” in Process Table labeled “Tooling Required” will have “Yes” if needed. Blank means “No”.

Cost Tables - AIR's

- Add Item Request (AIR) can be done electronically at fsaeonline.com
 - Note: all information input into form is viewable by all teams.
- Items considered extremely proprietary may have AIR's submitted to katklauz@aol.com in an Excel format, but final results will always be published to the public tables.
- **Providing all required information will speed up the cost verification process**
- Status of the AIR can be seen in
 - “View eAIR Master Table & Committee Decision”.
 - “Final Cost” column has official results which can be used in the Cost Reports.

Part Numbering System - Appendix C-2

All assemblies and parts in the BOM **must** have a part number using the following convention:

- Competition Code – Date Code - Car Number – System Designation – Base Number – Suffix
- Competition Code – A code for the competition entered. Refer to A2.6.
- Date Code – Last two digits of the year of the event.
- Car Number – A three (3) digit number assigned to the car for the specific event
- **System Designation** – A two (2) letter code for the system under which the part is associated. These can be found in **Appendix C-3**.
- **Base Number** – Five (5) digit numbers assigned at the student's discretion. For assemblies this becomes a four (4) digit number with preceding character of "A".
- Suffix – Two character code showing part change history. These are provided for student use only so if desired all can be "AA".
- For example, a part entered into the chassis section for car number 27 competing at an event with code "FSAEM" that the students have decided is part one would be:

FSAEM – 12 – 027 – **CH** – 00001 – AA

Part Numbering System - Cont'd

- In the **Hard Copy** version of the Cost Report **the competition code, date and car number fields** of the part numbers **do not need to be printed**.
- In the **Electronic Version** of the Cost Report they **DO need to be included** in the digital files submitted.
- The event code and car numbers are for SAE use when the different digital files are combined into the master database.
- **All fasteners in the BOM must have a part number using the same convention as parts.**
- **All fasteners use system code "FS"** even though they are included in the BOM under the part and assembly where they are used.

Part Naming

- Typical automotive convention
 - Part noun name - 1 or 2 words
 - Description
 - Application
- Examples
 - Wishbone Assy - Left, Front, Upper
 - Bolt - M8x25LG, Grade 9.8 - Left Front Upper Wishbone Attach.
 - Tooling - Upper Wishbone Welding
 - Padding - Main Hoop
 - Tie-Wrap - Main Hoop Padding Attach.
 - Clamp - 37 mm - Radiator Upper Hose/Radiator

Note: This part naming convention is **not** a requirement

Addenda

- A unique addendum is permitted for every competition entered
- Allows teams to change design and content between events
- A cost modifier is used for all changes to the BOM made through addenda
 - Items added in an addendum have 125% of the table cost
 - Items removed in an addendum are credited 75% of the table cost
 - Limits teams submitting entire Cost Report as an addendum
- Do not want length limits since accuracy is scored
- From Rule C.3.16.3:

Note: Late changes to designs impact costs in the real world. Contracts need to be altered, commodity costs can change, cancellation fees may be incurred and information needs to be transmitted to suppliers. The scaling factors for the addenda capture this as well as encourage teams to submit full and accurate information with the initial Cost Report.

Penalties

The penalty system seems complex - but is simple at the Competition

Two tier system

- Method A – Fixed Point Deductions
- Most errors will be penalized using Method A

3.18 Penalty Method A- Fixed Point Deductions

3.18.1 From the Bill of Material, the cost judges will determine if all parts and processes have been included in the analysis. In the case of any omission or error the judges will add a penalty proportional to the BOM level of the error. The following standard points deductions will apply:

- Missing/inaccurate material, process, fastener..... 1 pt.
- Missing/inaccurate part..... 3 pt.
- Missing/inaccurate assembly..... 5 pt.

Note: Each of the penalties listed above supersedes the previous penalty. If a 5 point deduction is given for a missing assembly the missing parts are ignored for Method A. Method B would include the cost of the missing parts in the calculation.

- Examples
 - Five M6 fasteners listed, six used – 1 pt.
 - Three kilograms of steel listed, 4.4 used – 1 pt.
 - Bearing carrier face machined, mill operation not included – 1 pt.
 - Installation labor for steering wheel missing – 1 pt.
 - Upright cost as cast but actual part billet machined – 3 pt.
 - Pneumatic shifter not included on BOM – 5 pt.
- Applied to Accuracy Score

Penalties - Cont'd

- Method B – Adjusted Cost Deductions

3.19 Penalty Method B – Adjusted Cost Deductions

The alternative penalty will be calculated using the following equation:

$$\text{Penalty} = 2 \times (\text{Table Cost} - \text{Team Reported Cost})$$

- Intended to stop “big errors” that would not be penalized enough with Method A
- Applied to Adjusted Cost of vehicle
- Without Method B teams could “forget” systems and take fixed point penalty
- No penalty is applied when values are over estimated
 - Be conservative and estimate high when part geometry is complicated
 - Or when time is short and the Report is due

“Real Case”

- Event specific
 - Could be cost reduction
 - Could be weight reduction
 - Could be
- Usually published 3-4 weeks before the event.
- Michigan
 - Has been 3 possible cost reduction exercises & team gets 1 at random at the Event
- California
 - In 2011 three Scenarios, team choose one before Event
- Lincoln - ??????
- Time limit (5 or 10 minutes)
- Flip charts optional
- No hand outs or use of electronic devices
- Must be based on the system on your car

“Real Case” - Cont’d

- Presentation will be evaluated on:
 - The process or methodology(ies) used to develop the proposal(s)
 - The alternatives presented
 - The credibility of the proposals
- Proposals could include
 - Reduced “content”
 - Simplify
 - Change manufacturing process, e.g. machined from billet to cast and machined.

Do's & Don'ts

- Do start your BOM **NOW!**
 - Distribute the work
- Do ask questions early
- When in doubt be conservative
- Don't miss any parts OR processes from your Cost Report
- Don't submit your Cost Report late
- Do prepare for the Real Case.
- Don't miss your assigned time at the Event

Do's & Don't's - Cont'd

- Don't forget:
 - Wheel weights
 - Brake bleeding
 - Suspension alignment/set-up
 - Safety wiring
 - Paint
 - Welding jig tooling
 - Tie wraps/Zip ties

Questions?