SAE Australasia Student Series

Formula SAE Australasia 2018
Cost Report Information & Training for Competitors

Presenter Information

- David Ford (SAE Australasia, Ford Motor Company [retired])
  - FSAE-A – Cost Judge (2004-present)
- Norbert Drage (Curtin University)
  - FSAE-A – Cost Judge (2015-present)
  - Curtin Motorsport Team (2012-2014)
    - Financial Controller (2014)
    - Cost Report Coordinator (2013, 2014)

Acknowledgements

- SAE Australasia
  - Mario Cappola (Ford Motor Company)

- SAE Detroit Section
  - Bill Riley – SpaceX, Cornell University
  - Michael Royce – Albion Associates LLC, Detroit Region SCCA

M. Cappola

B. Riley

M. Royce

FSAE-A 2018 CR Info & Training

- Overview
  - General Information
  - Rules, Tables & Templates
  - Where to Find Cost Materials
  - List of Published Cost Materials
- Cost Report Essentials
  - The Cost Report Itself
  - Published
  - Cost Templates
  - Cost Tables
- Further CR Information
  - Making vs. Buying
  - Add Item Requests
- Cost Report Example
  - A-Arm Case Study
  - Part Manufacture
  - Parts & Tooling

FSAE-A 2018 CR Info & Training

- At the Competition
  - Addenda
  - FSAE-A Cost Event
    - Overall Judging Process
    - Check-in & Introductions
    - Visual Inspection
    - Visual Inspection - Penalties
  - Real Case Scenario
- In Closing
  - Dos and Don'ts
  - Questions & Answers

Cost Event Overview

General Information

Rules, Tables & Templates

Where to Find Cost Materials

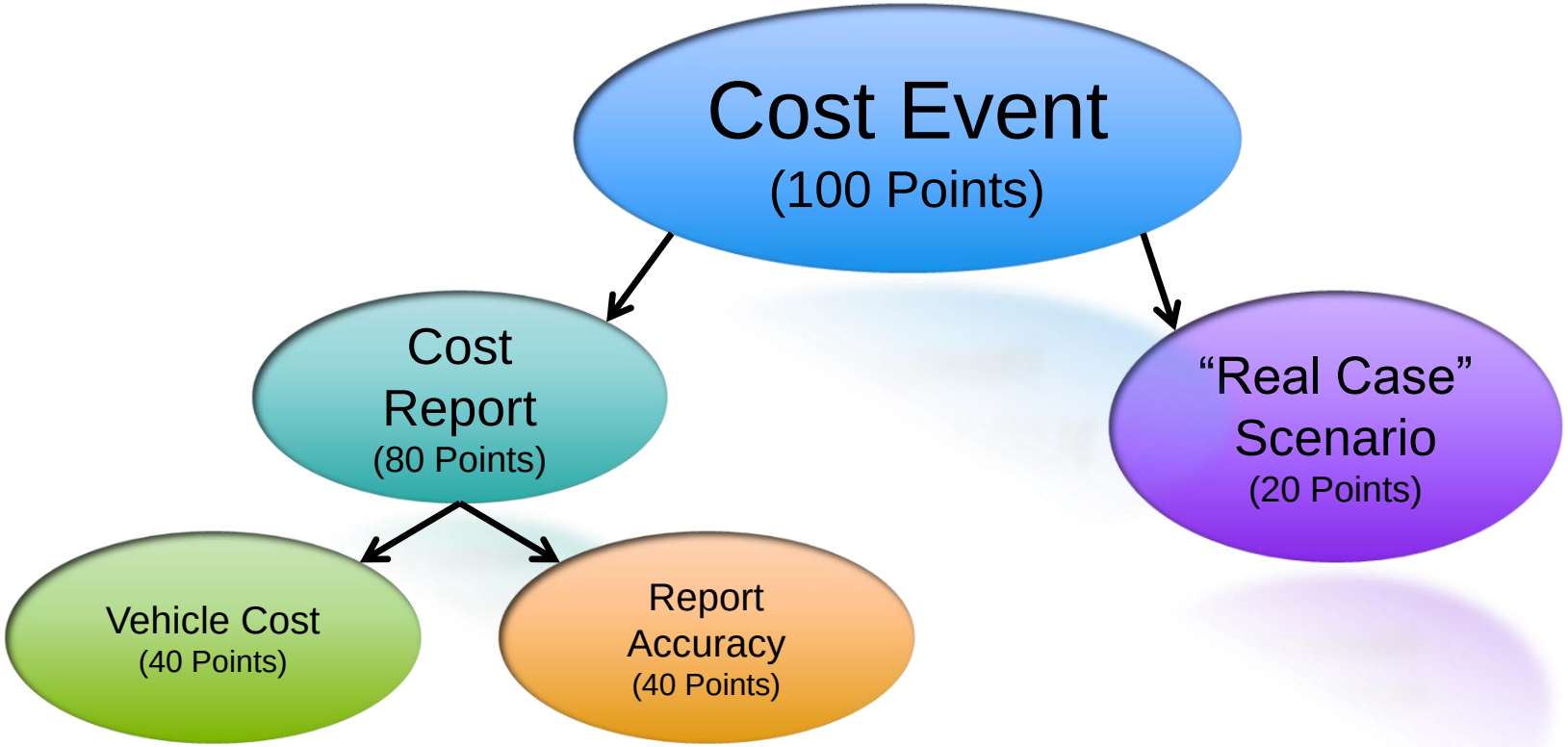
General Information

"Formula SAE is an automotive-themed engineering design competition; it exists to prepare student engineers for the real world."

Real world engineering is:

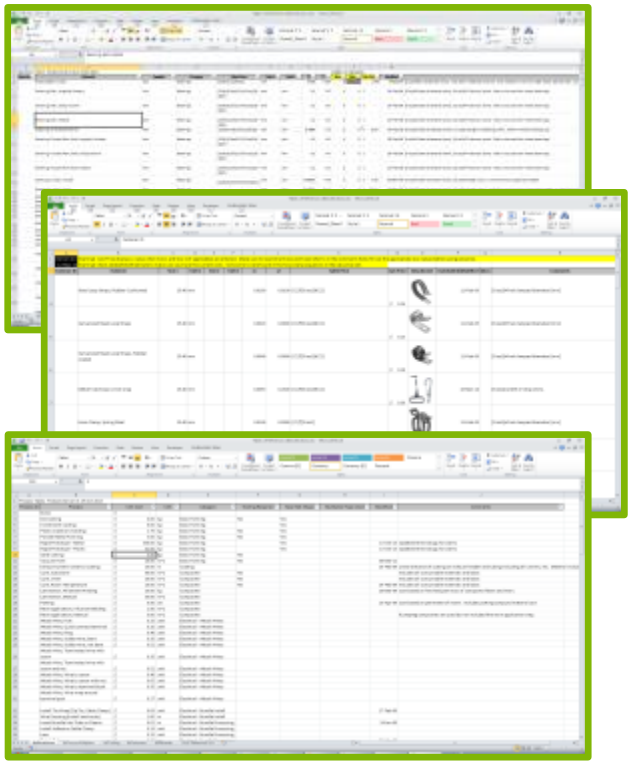
- recognising that cost and budgeting are critical in the real world
- organising costing data to assist in the decision-making process
- making trade-off decisions between functional advantage and cost
- justifying design decisions with respect to cost

General Information



Rules, Tables & Templates

- Standardised across all FS/FSAE competitions worldwide
  - Same baseline rules
  - Same cost tables
  - Same part/assembly templates
- FSAE-A-specific additions on http://www.saea.com.au/formulasae; the car design drives final cost
  - Engineering design is about trade-off analysis



Where to Find Cost Materials

The SAE-I site's Formula section is the prime location for all forms and templates

https://www.fsaeonline.com/cdsweb/gen/DocumentResources.aspx

- FSAE Rules
  Cost Event in Article S4
  (p.132 2017/2018 Rules)
- Standard Tables
- Templates
- Appendices
- Forms

List of Published Cost Materials

- Standard Tables
  - Materials
  - Processes
  - Process Multipliers
  - Fasteners
  - Tooling
- Add Item Request Form
- Templates
  - Assembly
  - Part
- Appendices
  - S1: Cost Models & Methodology
  - S2: Standard Part Numbering
  - S3: Systems & Assemblies List for IC Cars
  - EV3: Systems & Assemblies for EV cars at http://www.saea.com.au/fsaerulesdownloads/
  - S4: Power Tool Package Envelopes

Cost Report Essentials

The Report

Report Structure

BOM (Bill of Materials) Structure

Cost Templates

Cost Tables

The Report

Hard Copy

- 3- or 4- ring binder (2-rings tend to break in transit!)
  - Spiral/comb binders do **NOT** count as ring binders!!
- Tabs separating each system, clearly labelled
- Easy-to-read Table of Contents
- Page numbering
- Ensure text size is readable for all ages
- Ensure legibility of all content – limit excessive background colouring

Easy details that are ‘gimme’ marks!!!

The Report

Soft Copy

- Excel Format
  - One file only
  - Use templates available from SAE-I

AND

- PDF Format

Electronic copies are important for report validation!

Report Structure

Suggested ‘Baseline’ for Hard Copy

Overall Report:

- Cover Page
- Table of Contents
- Supplementary material *(as required)*
  - Part number decoding
  - Blurb/s about manufacturing, etc.
- Full Bill of Material
  - Every system, assembly and part listed
  - Full costings
- All system breakdowns (see right)

Breakdown per System:

- Clearly marked tab!
- System Bill of Material
- System Costing
  - Must follow BOM structure
  - Parts to follow parent assembly
- System Supplementary Material
  - Must follow BOM structure, each drawing/photo clearly identifiable by part number and description

Report Structure
Explanations/Clarity

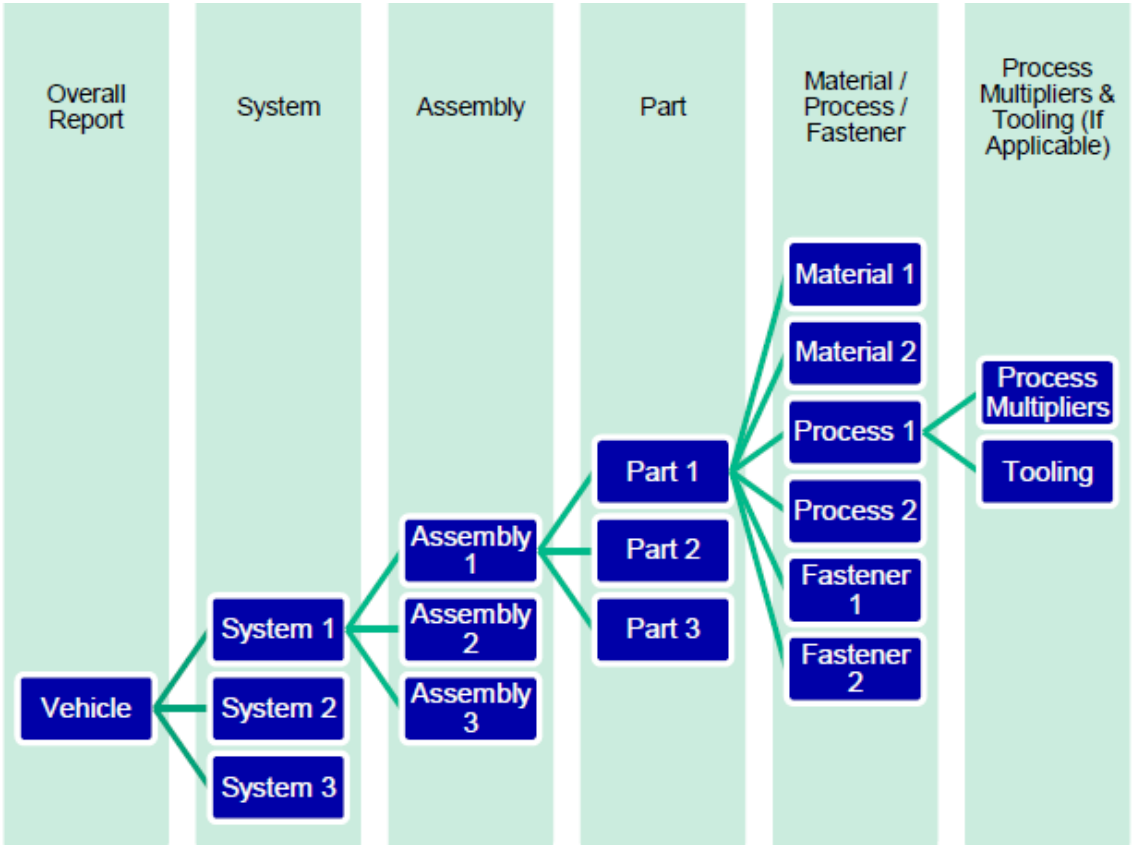
Clarity of reports presented varies **significantly** between teams

- Break down each line in the material/process/fastener/tooling sections as much as possible
  - Covered later in the presentation
- Number all pages logically and clearly; this will help both your own tracking and the judges
- Utilise the “use” column as much as possible
  - Just a few words in each line helps to follow along!

When reading down a page, each step should flow in a logical manner

BOM Structure

- Some teams struggle with a clear BOM breakdown
- MUST follow parent “Systems” as specified in Appendix S-3 or EV-3
- Issues present at the assembly level, and cascade down



BOM Structure

- Suggest using Appendix S-3 assembly list as a ‘baseline’ BOM breakdown
  - Provides an appropriate level of breakdown at the assembly level
  - Where an assembly is bundled into one costed elsewhere, **DO NOT DELETE THE LINE ITEM!** Use description column to direct judge to new location
  - Some concessions will be made to suit individual vehicle applications

FORMULA SAE SAE International

APPENDIX C-3
ORGANIZED LIST OF SYSTEMS & ASSEMBLIES

The Cost Report must follow the organized list of systems and assemblies/parts outlined below. Any questions as to the correct location of the specific items **must be submitted to the rules committee by March 1 of the competition year.**

The two letter abbreviation after each system name is to be used in the part number.

1) Brake System - BR
Brake Fluid
Brake Master Cylinder
Fasteners
Brake Lines
Brake Discs
Brake Pads
Balance Bar
Calipers
Proportioning Valve

2) Engine and Drivetrain – EN
Air Filter
Axles
Carburetor
Chain / Belt
Coolant
Coolant Lines
CV Joints/U Joints
Differential
Differential Bearings
Differential Mounts
Engine
Engine Mounts
Engine/Diff Oil
Exhaust Manifold
Fuel Filter
Fuel Injectors
Fuel Lines/Rails
Fuel Pressure Reg.
Fuel Pump

BOM Structure

Example Only!

Area of Commodi	Asm/Prt	Rev. Lv	Asm	Component	Description
Suspension	A0001	AA		Bell Cranks	1x Vehicle Set of Bell Cranks per P/N
Suspension	P1001	AA	A0001	LHF Bell Crank	1x Complete LHF Bell Crank per P/N
Suspension	P1002	AA	A0001	LHR Bell Crank	1x Complete LHR Bell Crank per P/N
Suspension	P1003	AA	A0001	RHF Bell Crank	1x Complete RHF Bell Crank per P/N
Suspension	P1004	AA	A0001	RHR Bell Crank	1x Complete RHR Bell Crank per P/N
Suspension	A0002	AA		Front A-Arms	1x Set of Front A-arms (4 arms for SLA) per P/N
Suspension	P2001	AA	A0002	LHF Upper A-Arm	1x Complete LHF Upper A-Arm per P/N
Suspension	P2002	AA	A0002	LHF Lower A-Arm	1x Complete LHF Lower A-Arm per P/N
Suspension	P2003	AA	A0002	RHF Upper A-Arm	1x Complete RHF Upper A-Arm per P/N
Suspension	P2004	AA	A0002	RHF Lower A-Arm	1x Complete RHF Lower A-Arm per P/N
Suspension	A0003	AA		Front Uprights	1x Front Upright Assembly per P/N
Suspension		Insert Child parts here			
Suspension	A0004	AA		Pushrods/Pullrods	1x Pushrod per P/N,
Suspension		Insert Child parts here			
Suspension	A0005	AA		Rear A/Arms or Equivalent	1x Set of Rear A-arms (4 arms for SLA) per P/N
Suspension		Insert Child parts here			
Suspension	A0006	AA		Rear Uprights	1x Rear Upright Assembly per P/N
Suspension		Insert Child parts here			
Suspension	A0007	AA		Rod Ends	Not used, costed in respective Pushrod, A-Arm Assemblies
Suspension	A0008	AA		Shocks Front & Rear	1x Coilover Shock Assembly per P/N (incl spring)
Suspension		Insert Child parts here			

7) Suspension System – SU

Bell Cranks
Front A/Arms or Equivalent
Front Uprights
Pushrods/Pullrods
Rear A/Arms or Equivalent
Rear Uprights
Rod Ends
Shocks Front
Springs
Suspension Mechanism

- Suspension Used as an example (excerpt from S-3 included to the right)
- Custom part numbering used, for operator's clarity, would require 'decoding' page at start of report

BOM Structure
Explanations/Clarity

Drawings and other supplementary ‘visual’ materials provide the judge with a method to piece together the car, as they review the material presented to them.

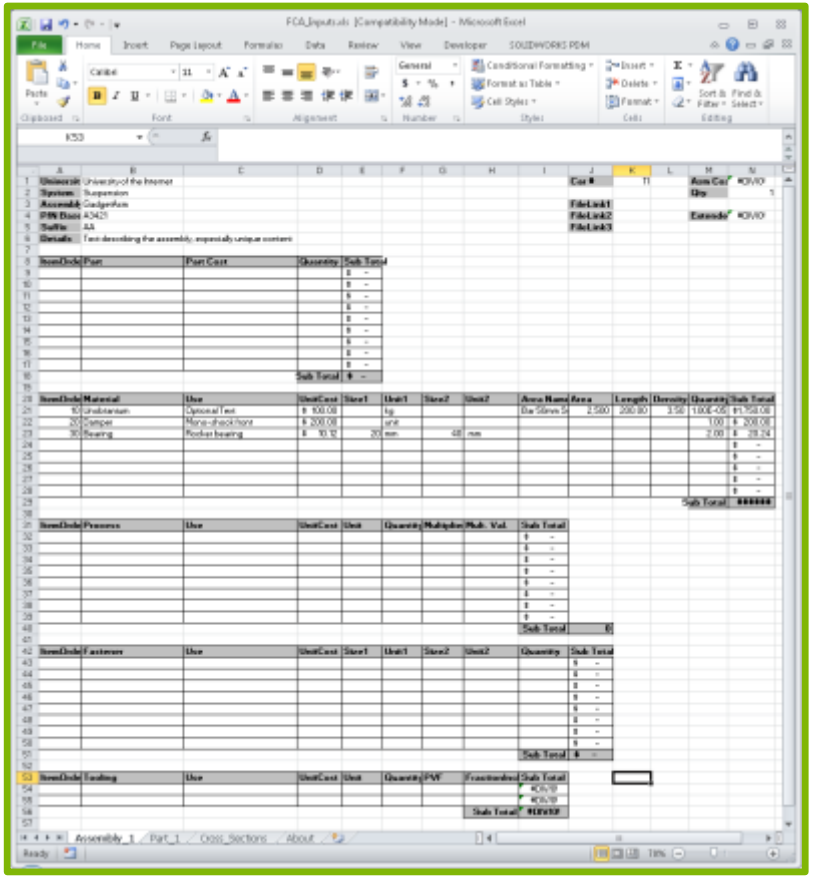
In lieu of full engineering drawing/data pack, consider the following:

- Parts: 2D third-angle-projection drawing, dimensioning the overall envelope space and any key features
- Assemblies: 3D exploded-view of assembly, with BOM
- Where photo(s) are used, place a ruler with the part/assembly (to give a sense of scale)

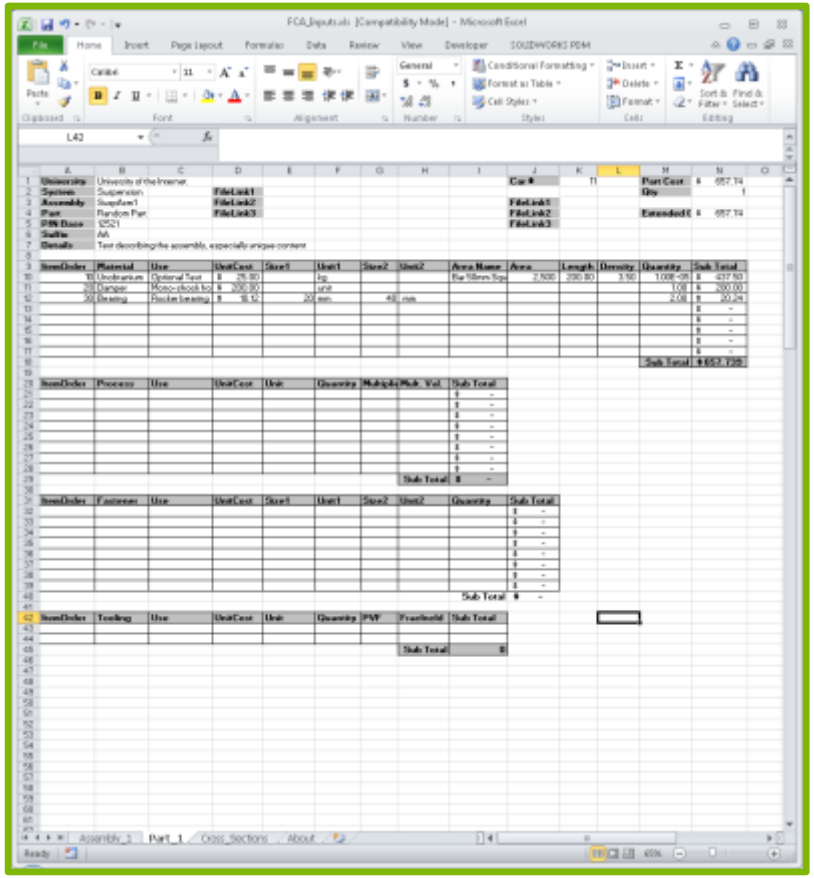
Think of what the judges would need, in order to visualise the part/assembly/system/vehicle coming together in their head when reviewing the report!

Cost Report Templates

Assembly Template



Part Template



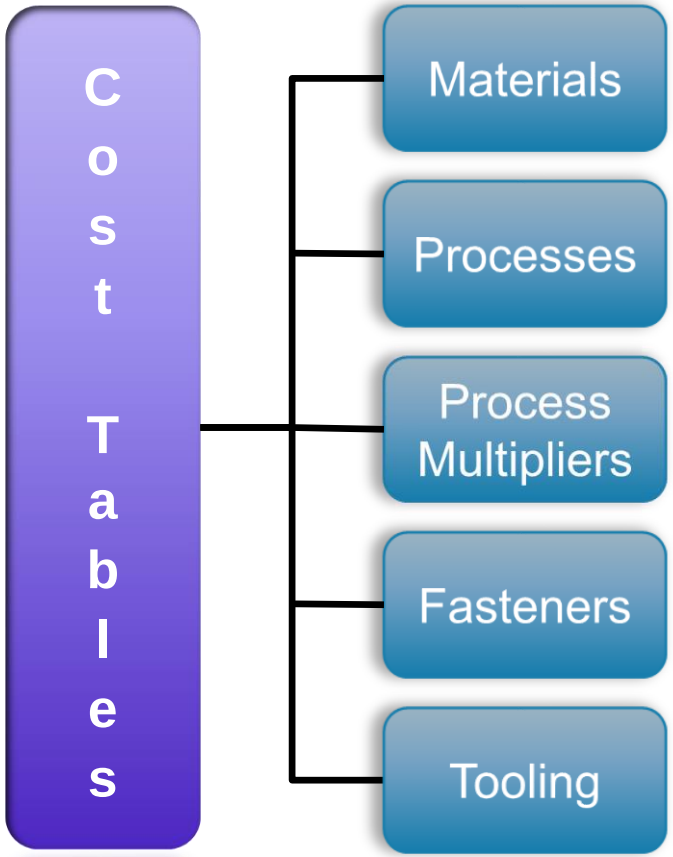
Cost Tables

- Cost Tables previously available on the SAE-I website, but format has changed for SAE North America events.
  - Each tables' items have been put into online catalogues
  - Old tables have been removed

- Notice sent to FSAE-A teams (http://www.saea.com.au/resources/Documents/FSAE-A%202018%20Cost%20Event%20Update.pdf) approving the use of 2017 cost tables for this year; updated parts/materials/processes/fasteners (as listed in the 2018 online catalogue) can be used as needed though.

Cost Tables

- **Materials** - the list of purchasable 'finished parts' and 'raw materials' used by teams to construct the car
- **Process** - operations that alter the form of the materials
- **Process Multipliers** - modifiers that alter the standard cost of various operations to account for physical differences (i.e. material used, geometric size)
- **Fasteners** - various components that are used to fasten components (i.e. bolts, nuts, washers, rivets, hose clamps, safety wire)
- **Tooling** - the rigging/infrastructure required for processes to be achievable (i.e. die for die casting, welding fixtures for welding, etc.)



Cost Tables – Materials

- General categories:

Bearings	Brake System	Chassis	Composite
Control Module	Controls	Damper	Drivetrain
Electronics	Engine	EV – CM/Elec/TD	Fluid
Miscellaneous	Raw Material	Safety	Sensors
Springs	Steering	Tire	Wheel

- Examples include:
  - Raw Material – Steel, Aluminium, Titanium
  - Composite – Carbon Fibre (include material weight!), Foam
  - Engine – Dry Sump Pump, Overflow Bottle
  - Control Module – ECU, Datalogger

Cost Tables – Process

- General categories:

Basic Forming	Composite	Electrical – Attach Wires
Electrical – Bundle Install	Electrical – Bundle Processing	Electrical – Connections
Electrical – Layout	Electrical – Prep	Electrical – Wire in Connector
Fasteners	Joining	Labour
Material Removal	Sheet Materials	Tubing

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

Cost Tables – Process Multipliers

- General categories:

Assembly	Fastener Installation
Drill, Tap	Machining

- Examples include:
  - Assembly – Length, Disassemble
  - Fastener Installation – Engagement Length
  - Drill, Tap – Hole Length
  - Machining – Material Type (e.g. Foam is easier to machine than Aluminium, therefore 0.33x multiplication factor)

Cost Tables – Fasteners

- General categories:

Bolts	Dzus Fasteners	Hose Clamps
Loop Straps	Nuts	Pins
Retaining Rings	Studs	Washers

- Points to note:
  - Many fasteners are equation-driven
  - Only required for components on the vehicle, not for fixtures/jigging

Further CR Information

Making vs. Buying

Add Item Requests

Making vs. Buying

- Car components are classified as either purchased or made
- Bought parts appear in tables
  - Typically organised by: 1) part type, 2) manufacturer, and 3) model
  - Can be modified as the team requires
- Made parts can appear in tables
  - Parts designated as ‘Student Built’ must be ‘made’ within the CR
  - Unlisted parts must be ‘made’ or an ‘add item request’ is needed

Making vs. Buying

Made Parts

- Start as raw materials (Steel, Alloy; Aluminium, Normal; Iron; etc.)
- Undergo various processes (Machining; Spinning, Metal; Tube cut; etc.)
- May require subassembly (Assemble, 1kg, Loose; Weld; Hand - Start Only)
- Examples: oil tank, uprights, A-arms

Bought Parts

- Purchased in ready state
- *Can* be modified as per team requirements
- Examples: suspension dampers, engine control units, brake master cylinders

Rule Covering 'Made vs. Bought'

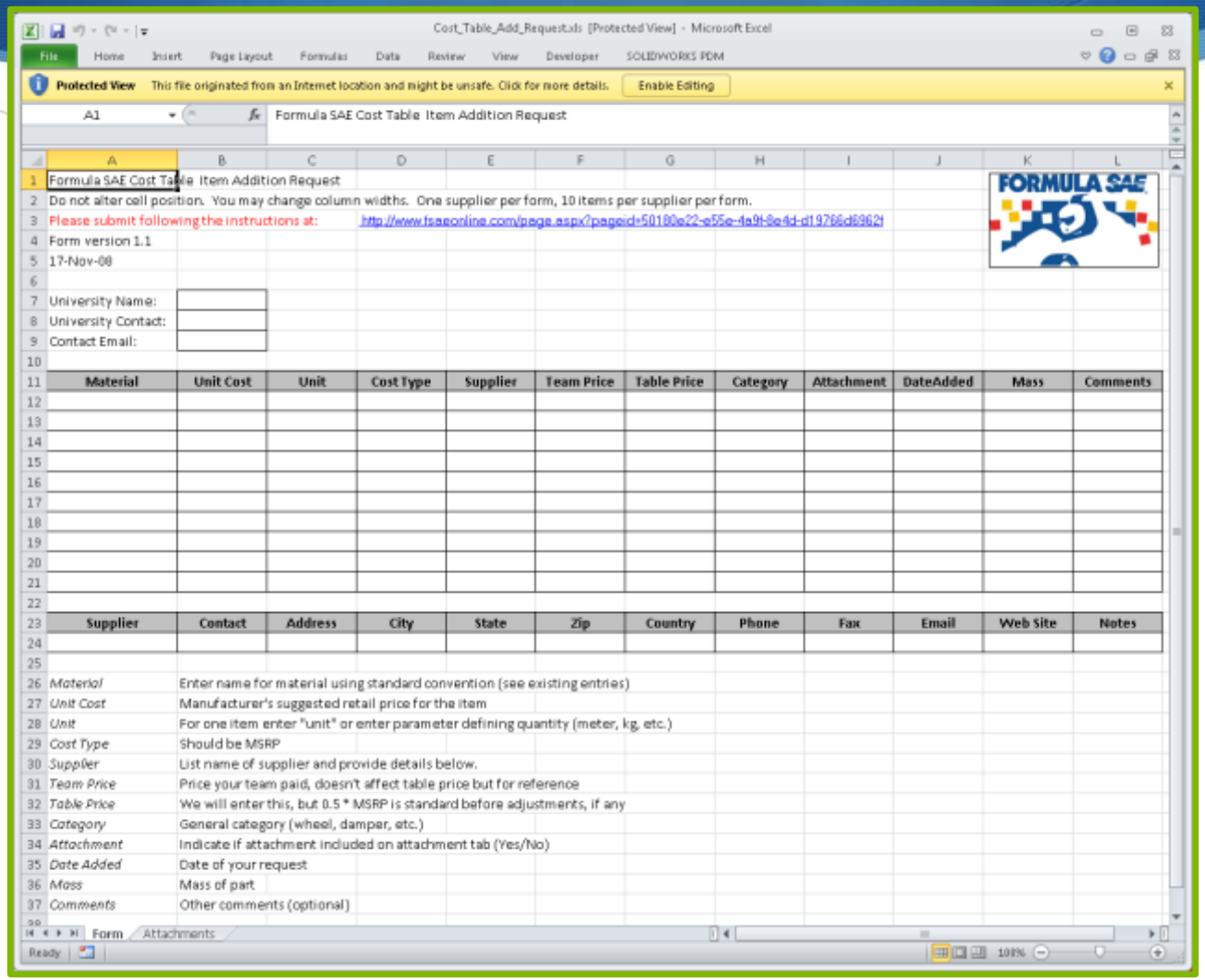
	How Team Actually Acquired the Part	
How Cost Table Lists Part	**Team Made**	**Team Bought**
Table lists the part as "Made", or the part is not listed in the Tables	Cost as "Made"	Cost as "Made"
Table lists the part as "Bought"	1) "Made" option is NOT in table; cost as "Bought" 2) "Made" option is in table; team can choose either "Bought or "Made"	Cost as "Bought"

2018 Formula SAE Rules, S4.13.3 (p.138)

Add Item Requests

- Non-existent items that teams want to see in future cost tables
  - Details in ‘Add Item Request Online’ on fsaeonline.com
  - Past AIR viewable in ‘Master Table/Committee Decision’
- Use the ‘Excel format AIR’ and e-mail to formulasae@sae-a.com.au
  - Don’t forget to provide the item’s/items’ critical details

Add Item Requests



Cost_Table_Add_Request.xls [Protected View] - Microsoft Excel

Protected View This file originated from an Internet location and might be unsafe. Click for more details. Enable Editing

A1: Formula SAE Cost Table Item Addition Request

1	Formula SAE Cost Table Item Addition Request
2	Do not alter cell position. You may change column widths. One supplier per form, 10 items per supplier per form.
3	Please submit following the instructions at: http://www.fsaeonline.com/page.aspx?pageid=50180e22-e55e-4a9f-8e4d-d19766d6962f
4	Form version 1.1
5	17-Nov-08
7	University Name:
8	University Contact:
9	Contact Email:

Material	Unit Cost	Unit	Cost Type	Supplier	Team Price	Table Price	Category	Attachment	DateAdded	Mass	Comments

Supplier	Contact	Address	City	State	Zip	Country	Phone	Fax	Email	Web Site	Notes

Material	Enter name for material using standard convention (see existing entries)
Unit Cost	Manufacturer's suggested retail price for the item
Unit	For one item enter "unit" or enter parameter defining quantity (meter, kg, etc.)
Cost Type	Should be MSRP
Supplier	List name of supplier and provide details below.
Team Price	Price your team paid, doesn't affect table price but for reference
Table Price	We will enter this, but 0.5 * MSRP is standard before adjustments, if any
Category	General category (wheel, damper, etc.)
Attachment	Indicate if attachment included on attachment tab (Yes/No)
Date Added	Date of your request
Mass	Mass of part
Comments	Other comments (optional)

Form | Attachments

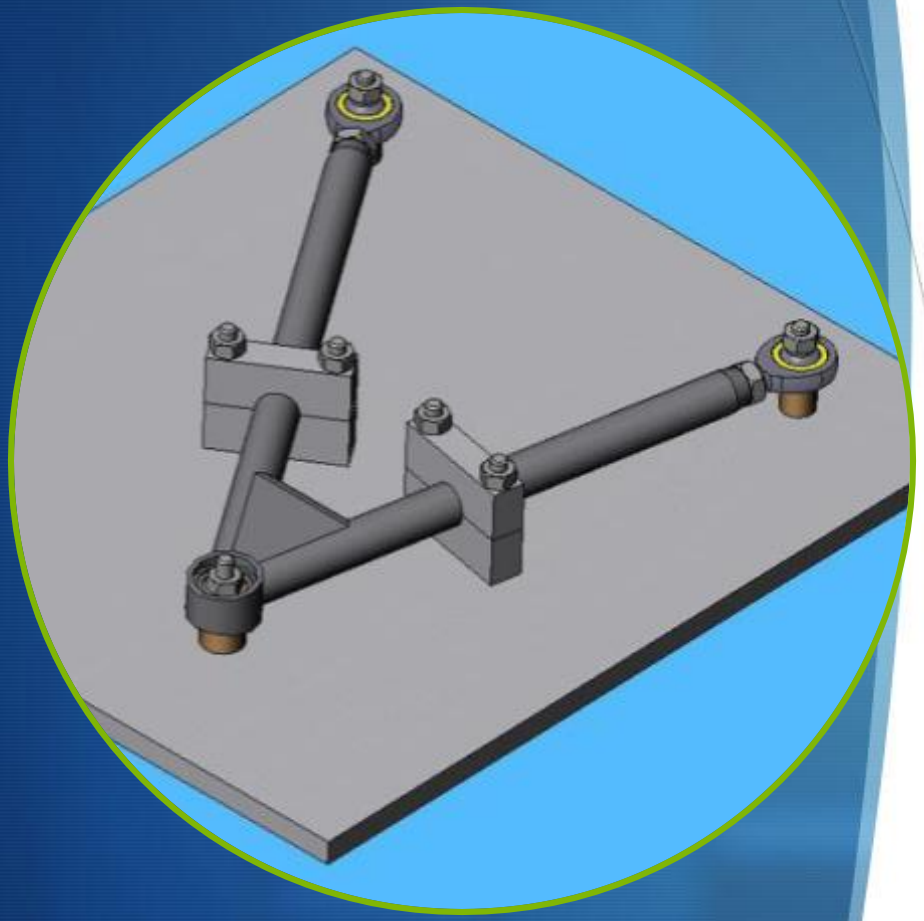
Ready

Cost Report Example

A-Arm Case Study

Part Manufacture

Parts & Tooling



Introduction

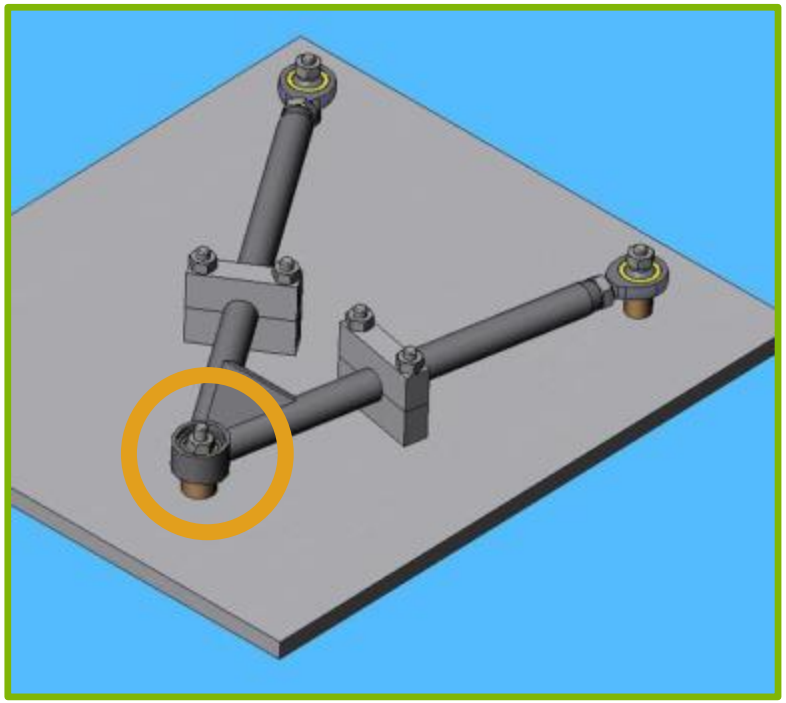
A-Arm Case Study

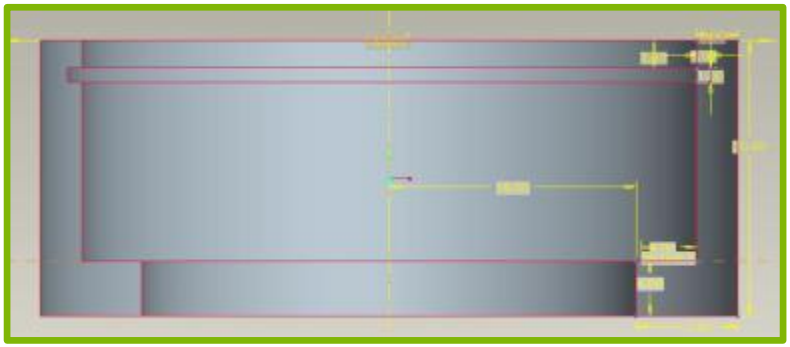
This example covers

- Individual Part Manufacture
- Assembly Manufacture
- Fasteners & Tooling

Based on the example created by Bill Riley (mentioned at the start of the presentation)

Cost Report Example
Part Manufacture





- Example in case is the spherical bearing cup
  - Manufactured from steel round bar
  - ***ALL*** processes to be stepped

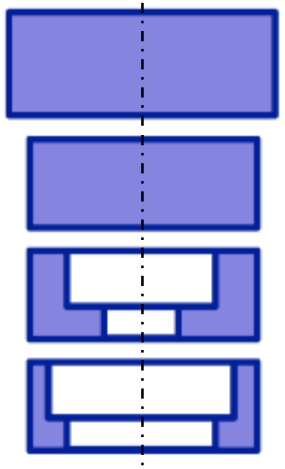
Cost Report Example
Part Manufacture

Process Steps

Working from initial steel round bar

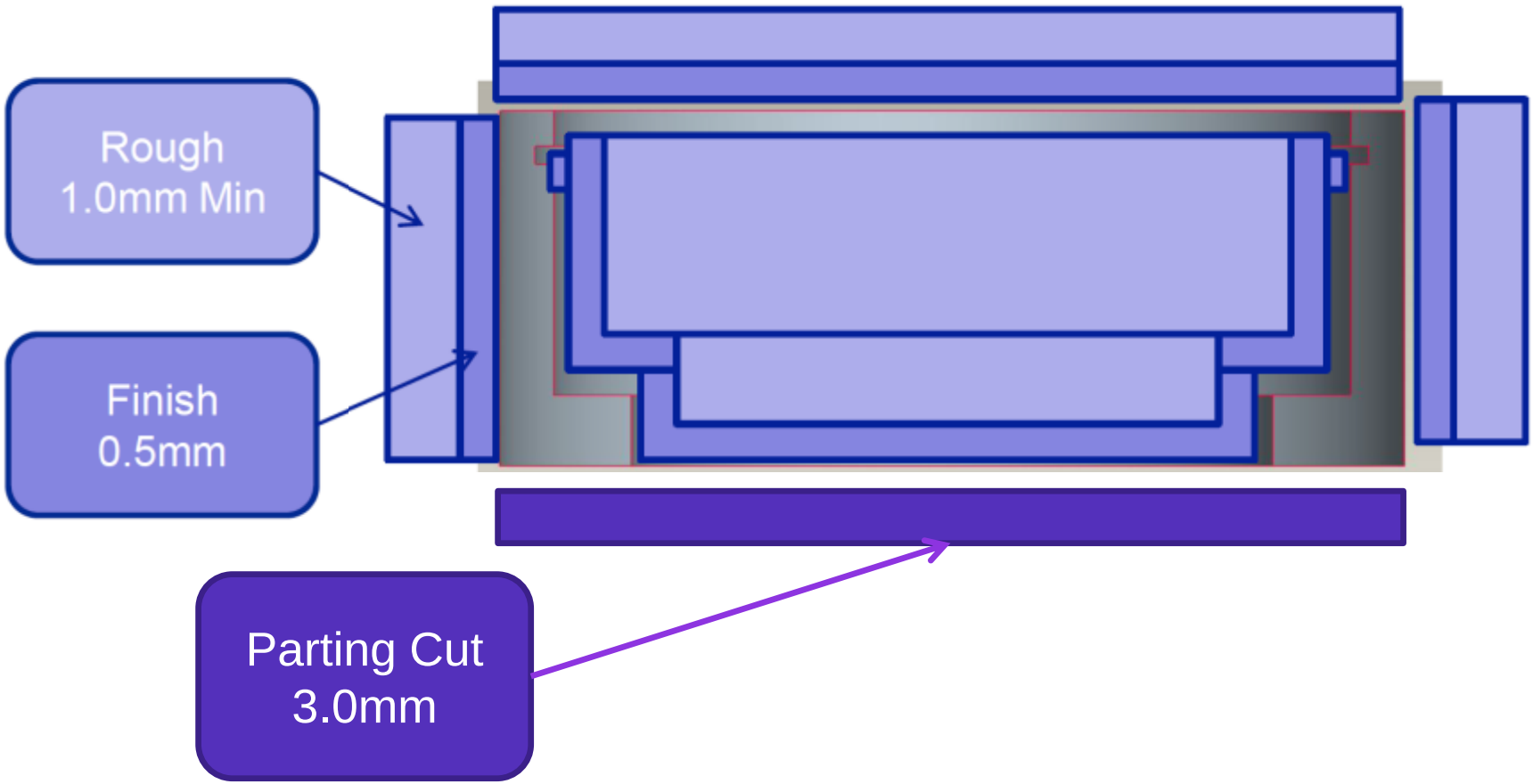
- Rough machine outside
- Finish machine outside
- Rough machine inside
- Finish machine inside
- Part material from round bar

Visualisation



Cost Report Example

Part Manufacture



Cost Report Example

Part Manufacture

Part Cost

Part Name	A-Arm Bearing Cup		Car #	27	Part Cost $ 13.25
System	Suspension				
P/N Base	000099				
DLS	A		Full P/N	FSAEM – 08 – 027 – SU – 00099 – AA	
PLS	A		University	University of the Internet	
Comment	Upper Left A-Arm				

Design/Process Rev. Level (Optional)

Material

MID	Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
1	Steel, Alloy	Spherical Bearing Cup - Bar	$ 2.25	kg	506.0	20	7.80E-06	$ 0.178
								$ -
							Sub Total	$ 0.178

Process

PID	Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
1	Lathe - Turn, Rough	Bearing Cup OD	$ 0.04	cm^3	15.96	Mtl - Steel	3	$ 1.92
2	Lathe - Turn, Finish	Bearing Cup OD	$ 0.04	cm^3	7.98	Mtl - Steel	3	$ 0.96
3	Lathe - Face, Rough	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
4	Lathe - Face, Finish	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
5	Lathe - Turn, Rough	Bearing Cup ID	$ 0.04	cm^3	7.79	Mtl - Steel	3	$ 0.93
6	Lathe - Turn, Finish	Bearing Cup ID	$ 0.04	cm^3	4.4	Mtl - Steel		$ 0.18
7	Assemble, 1 kg, Interference	Bearing into Bore	$ 0.19	unit	1			$ 0.19
8	Assemble, 1 kg, Interference	Retaining Ring	$ 0.19	unit	1			$ 0.19
							Sub Total	$ 6.79

Fastener

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity	__	Sub Total
3	Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
4	Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
								$ -
								$ -
							Sub Total	$ 6.28

Tooling

TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF	__	Sub Total
							Sub Total	$ -

Subtotals

Cost Report Example

Part Manufacture

Part Name	A-Arm Bearing Cup	Car #	27	Part Cost	$ 13.25
System	Suspension				
P/N Base	000099				
DLS	A	Full P/N	FSAEM – 08 – 027 – SU – 00099 – AA		
PLS	A	University	University of the Internet		
Comment	Upper Left A-Arm				

MID	Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
1	Steel, Alloy	Spherical Bearing Cup - Bar	$ 2.25	kg	506.0	20	7.80E-06	$ 0.178
								$ -
							Sub Total	$ 0.178

PID	Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
1	Lathe - Turn, Rough	Bearing Cup OD	$ 0.04	cm^3	15.96	Mtl - Steel	3	$ 1.92
2	Lathe - Turn, Finish	Bearing Cup OD	$ 0.04	cm^3	7.98	Mtl - Steel	3	$ 0.96
3	Lathe - Face, Rough	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
4	Lathe - Face, Finish	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
5	Lathe - Turn, Rough	Bearing Cup ID	$ 0.04	cm^3	7.79	Mtl - Steel	3	$ 0.93
6	Lathe - Turn, Finish	Bearing Cup ID	$ 0.04	cm^3	4.4	Mtl - Steel		$ 0.18
7	Assemble, 1 kg, Interference	Bearing into Bore	$ 0.19	unit	1			$ 0.19
8	Assemble, 1 kg, Interference	Retaining Ring	$ 0.19	unit	1			$ 0.19
							Sub Total	$ 6.79

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity	__	Sub Total
3	Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
4	Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
								$ -
								$ -
							Sub Total	$ 6.28

TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF	__	Sub Total
							Sub Total	$ -

Cost Report Example

Part Manufacture

Part Name	A-Arm Bearing Cup	Car #	27	Part Cost	$ 13.25
System	Suspension				
P/N Base	000099				
DLS	A	Full P/N	FSAEM – 08 – 027 – SU – 00099 – AA		
PLS	A	University	University of the Internet		
Comment	Upper Left A-Arm				

MID	Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
1	Steel, Alloy	Spherical Bearing Cup - Bar	$ 2.25	kg	506.0	20	7.80E-06	$ 0.178
								$ -
							Sub Total	$ 0.178

PID	Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
1	Lathe - Turn, Rough	Bearing Cup OD	$ 0.04	cm^3	15.96	Mtl - Steel	3	$ 1.92
2	Lathe - Turn, Finish	Bearing Cup OD	$ 0.04	cm^3	7.98	Mtl - Steel	3	$ 0.96
3	Lathe - Face, Rough	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
4	Lathe - Face, Finish	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
5	Lathe - Turn, Rough	Bearing Cup ID	$ 0.04	cm^3	7.79	Mtl - Steel	3	$ 0.93
6	Lathe - Turn, Finish	Bearing Cup ID	$ 0.04	cm^3	4.4	Mtl - Steel		$ 0.18
7	Assemble, 1 kg, Interference	Bearing into Bore	$ 0.19	unit	1			$ 0.19
8	Assemble, 1 kg, Interference	Retaining Ring	$ 0.19	unit	1			$ 0.19
							Sub Total	$ 6.79

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity	__	Sub Total
3	Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
4	Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
								$ -
								$ -
							Sub Total	$ 6.28

TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF	__	Sub Total
							Sub Total	$ -

Missing Steel Multiplier

Cost Report Example

Part Manufacture

Part Name	A-Arm Bearing Cup	Car #	27	Part Cost	$ 13.25
System	Suspension				
P/N Base	000099				
DLS	A	Full P/N	FSAEM – 08 – 027 – SU – 00099 – AA		
PLS	A	University	University of the Internet		
Comment	Upper Left A-Arm				

MID	Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
1	Steel, Alloy	Spherical Bearing Cup - Bar	$ 2.25	kg	506.0	20	7.80E-06	$ 0.178
								$ -
							Sub Total	$ 0.178

PID	Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
1	Lathe - Turn, Rough	Bearing Cup OD	$ 0.04	cm^3	15.96	Mtl - Steel	3	$ 1.92
2	Lathe - Turn, Finish	Bearing Cup OD	$ 0.04	cm^3	7.98	Mtl - Steel	3	$ 0.96
3	Lathe - Face, Rough	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
4	Lathe - Face, Finish	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
5	Lathe - Turn, Rough	Bearing Cup ID	$ 0.04	cm^3	7.79	Mtl - Steel	3	$ 0.93
6	Lathe - Turn, Finish	Bearing Cup ID	$ 0.04	cm^3	4.4	Mtl - Steel		$ 0.18
7	Assemble, 1 kg, Interference	Bearing into Bore	$ 0.19	unit	1			$ 0.19
8	Assemble, 1 kg, Interference	Retaining Ring	$ 0.19	unit	1			$ 0.19
							Sub Total	$ 6.79

No Parting Operation

Missing Steel Multiplier

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity	__	Sub Total
3	Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
4	Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
								$ -
								$ -
							Sub Total	$ 6.28

TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF	__	Sub Total
							Sub Total	$ -

Cost Report Example

Part Manufacture

Part Name	A-Arm Bearing Cup	Car #	27	Part Cost	$ 13.25
System	Suspension				
P/N Base	000099				
DLS	A	Full P/N	FSAEM – 08 – 027 – SU – 00099 – AA		
PLS	A	University	University of the Internet		
Comment	Upper Left A-Arm				

MID	Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
1	Steel, Alloy	Spherical Bearing Cup - Bar	$ 2.25	kg	506.0	20	7.80E-06	$ 0.178
								$ -
							Sub Total	$ 0.178

No Machining – Install/Setup/Remove

	Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
1	Lathe - Turn, Rough	Bearing Cup OD	$ 0.04	cm^3	15.96	Mtl - Steel	3	$ 1.92
2	Lathe - Turn, Finish	Bearing Cup OD	$ 0.04	cm^3	7.98	Mtl - Steel	3	$ 0.96
3	Lathe - Face, Rough	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
4	Lathe - Face, Finish	Bearing Cup Top	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
5	Lathe - Turn, Rough	Bearing Cup ID	$ 0.04	cm^3	7.79	Mtl - Steel	3	$ 0.93
6	Lathe - Turn, Finish	Bearing Cup ID	$ 0.04	cm^3	4.4	Mtl - Steel		$ 0.18
7	Assemble, 1 kg, Interference	Bearing into Bore	$ 0.19	unit	1			$ 0.19
8	Assemble, 1 kg, Interference	Retaining Ring	$ 0.19	unit	1			$ 0.19
							Sub Total	$ 6.79

No Parting Operation

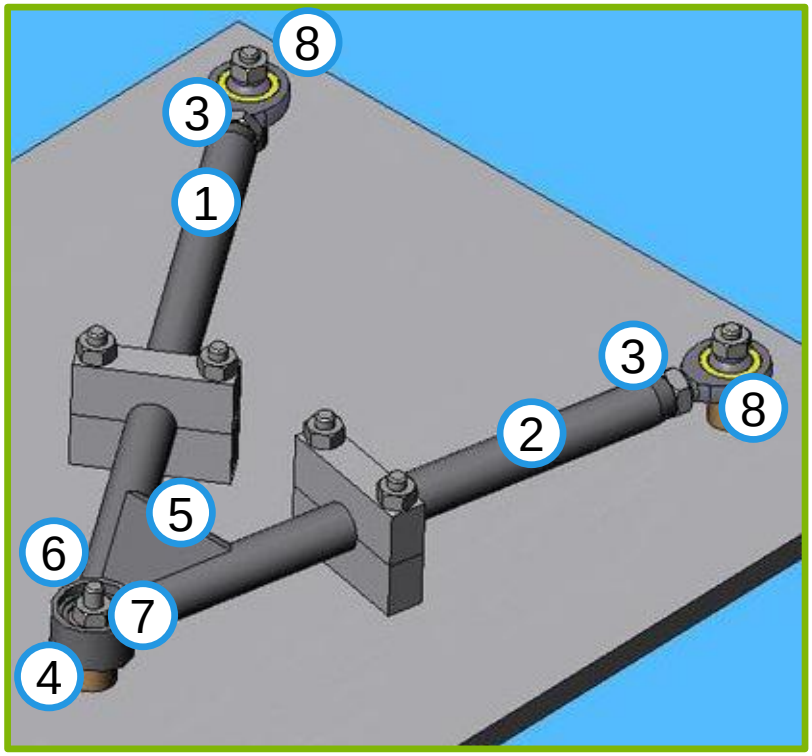
Missing Steel Multiplier

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity	__	Sub Total
3	Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
4	Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
								$ -
								$ -
							Sub Total	$ 6.28

TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF	__	Sub Total
							Sub Total	$ -

Cost Report Example
Parts & Tooling

Assembly Layout



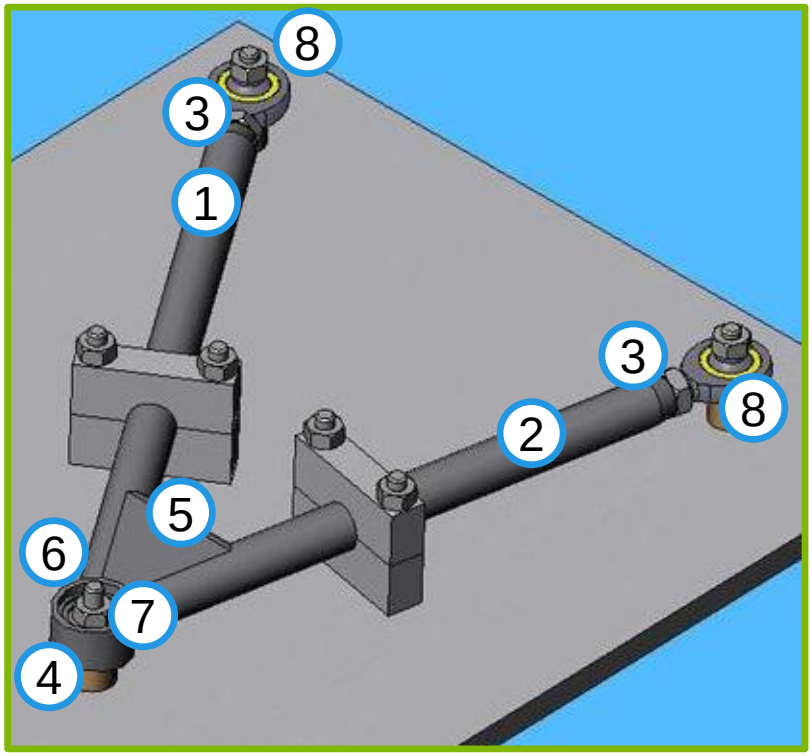
Assembly Parts

- Leg 1 Tube
- Leg 2 Tube
- Tube Inserts (machined & tapped)
- Spherical Bearing Cup
- Sheet Metal Gusset
- Spherical Bearing
- C-clip-type Retaining Ring
- Rod End w/Jam Nut

Cost Report Example

Parts & Tooling

Assembly Layout

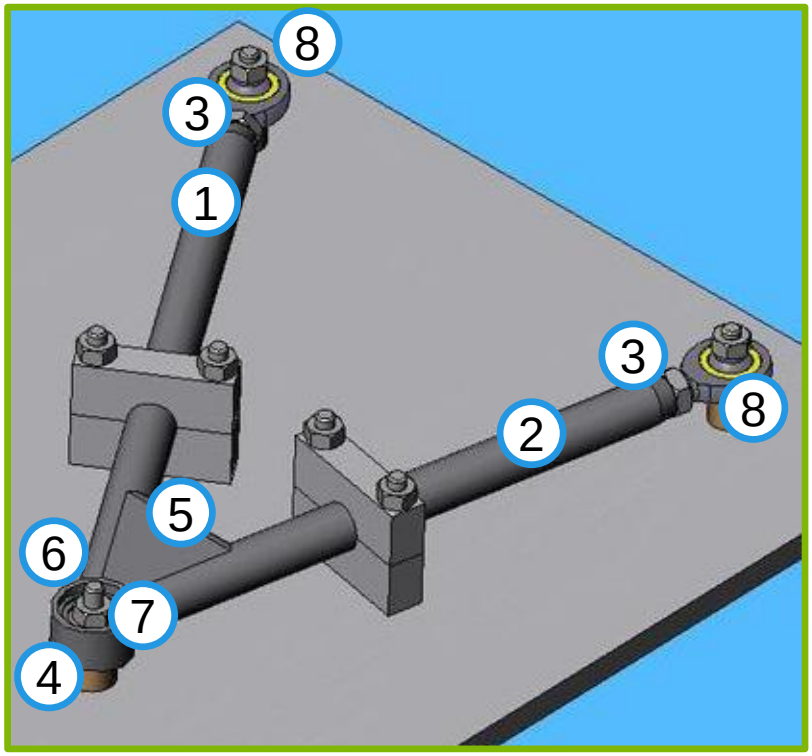


Cost Report

Cost Report Example

Parts & Tooling

Assembly Layout



Assembly Report – Materials

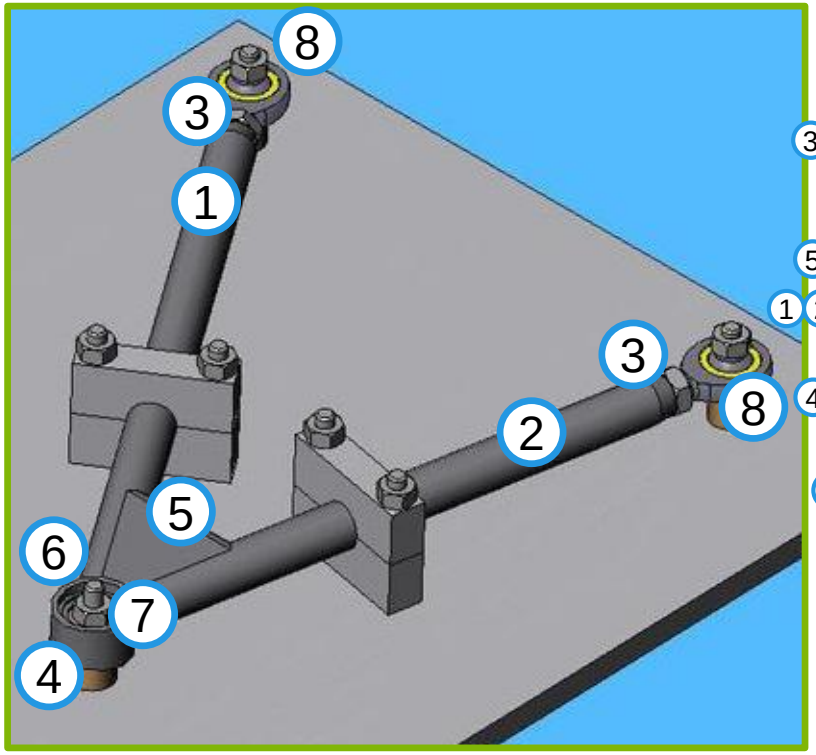
Part Name	A-Arm			Car #	27	Part Cost	$	43.54
System	Suspension							
P/N Base	00001							
DLS	A			Full P/N	FSAEM – 08 – 027 – SU – 00001 – AA			
PLS	A			University	University of the Internet			
Comment	Upper Left A-Arm							

MID		Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
1	1	Steel, Alloy	Tubing-5/8" x 0.035"	$ 2.25	kg	41.9	250	7.80E-06	$ 0.184
2	2	Steel, Alloy	Tubing-5/8" x 0.035"	$ 2.25	kg	41.9	250	7.80E-06	$ 0.184
3	3	Steel, Alloy	Threaded Insert - Bar Stock	$ 2.25	kg	229.6	20	7.80E-06	$ 0.081
3	4	Steel, Alloy	Threaded Insert - Bar Stock	$ 2.25	kg	203.5	20	7.80E-06	$ 0.071
5	5	Steel, Alloy	Gusset - Sheet	$ 2.25	kg	450.0	1	7.80E-06	$ 0.008
4	6	Steel, Alloy	Spherical Bearing Cup - Bar	$ 2.25	kg	506.0	20	7.80E-06	$ 0.178
									$ -
									$ -
									$ -
								Sub Total	$ 0.705

Cost Report Example

Parts & Tooling

Assembly Layout



Assembly Report – Processes

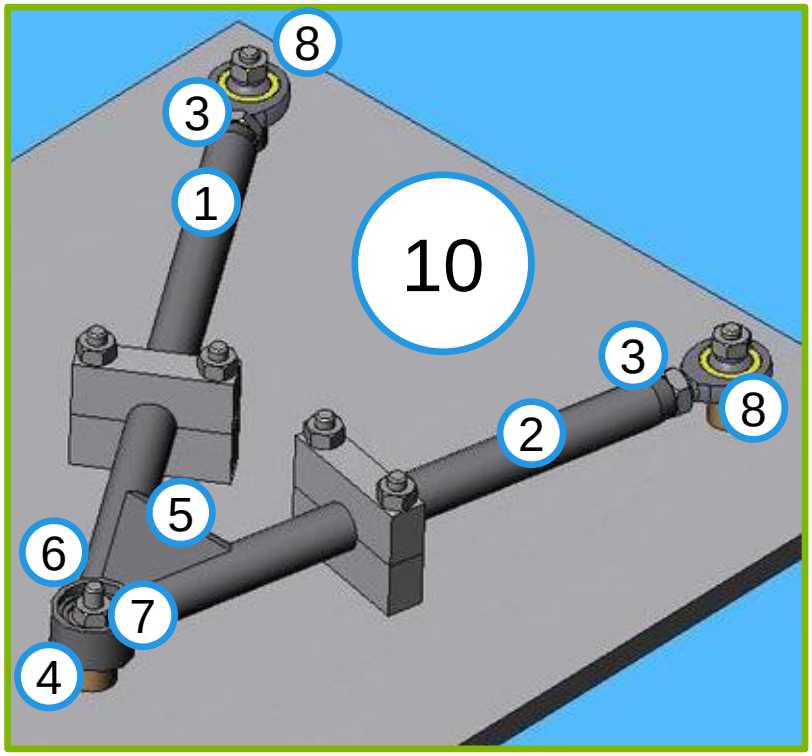
PID	Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
1	Lathe - Turn, Rough	Insert, OD	$ 0.04	cm^3	10.74	Mtl - Steel	3	$ 1.29
2	Lathe - Turn, Finish	Insert, OD	$ 0.04	cm^3	5.37	Mtl - Steel	3	$ 0.64
3	Lathe - Face, Rough	Insert, Tapped Face	$ 0.04	cm^3	2.30	Mtl - Steel	3	$ 0.28
4	Drilled holes < 25.4" dia.	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
5	Tapping holes	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
6	Lathe - Turn, Rough	Insert, OD	$ 0.04	cm^3	10.74	Mtl - Steel	3	$ 1.29
7	Lathe - Turn, Finish	Insert, OD	$ 0.04	cm^3	5.37	Mtl - Steel	3	$ 0.64
8	Lathe - Face, Rough	Insert, Tapped Face	$ 0.04	cm^3	2.30	Mtl - Steel	3	$ 0.28
9	Drilled holes < 25.4" dia.	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
10	Tapping holes	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
11	Sheet Metal Stamping	Gusset	$ 0.03	cm^2	4.5			$ 0.14
12	Sheet Metal Bend	Gusset	$ 0.25	unit	1			$ 0.25
13	Tube Cut	Tubing	$ 0.03	cm	1.587			$ 0.05
14	Tube Cut	Tubing	$ 0.03	cm	1.587			$ 0.05
15	Tube End Prep for Weld	Tubing	$ 0.75	end	4			$ 3.00
16	Lathe - Turn, Rough	Bearing Cup OD	$ 0.04	cm^3	15.96	Mtl - Steel	3	$ 1.92
17	Lathe - Turn, Finish	Bearing Cup OD	$ 0.04	cm^3	7.98	Mtl - Steel	3	$ 0.96
18	Lathe - Face, Rough	Bearing Cup Top & Bottom	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
19	Lathe - Face, Finish	Bearing Cup Top & Bottom	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
20	Lathe - Turn, Rough	Bearing Cup ID	$ 0.04	cm^3	7.79	Mtl - Steel	3	$ 0.93
21	Lathe - Turn, Finish	Bearing Cup ID	$ 0.04	cm^3	4.4	Mtl - Steel		$ 0.18
22	Weld - Round Tubing	Tube	$ 0.19	cm	2.54			$ 0.47
23	Weld - Round Tubing	Tube	$ 0.19	cm	2.54			$ 0.47
24	Weld - Round Tubing	Bearing Cup to Tube 1	$ 0.19	cm	2.54			$ 0.48
25	Weld - Round Tubing	Bearing Cup to Tube 2	$ 0.18	cm	2.54			$ 0.46
26	Weld	Gusset	$ 0.15	cm	7			$ 1.05
							Sub Total	$ 21.44

3 · 5 · 1 2 · 4 · 1 3 · 2 3 · 1 4 · 2 4 · 5

Cost Report Example

Parts & Tooling

Assembly Layout



Assembly Report – Fasteners/Tooling

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity		Sub Total
8	1 Rod End, Precison (Aircraft)	Inboard Front	6.35	mm	$ 7.02	1		$ 7.02
8	2 Rod End, Precison (Aircraft)	Inboard Rear	6.35	mm	$ 7.02	1		$ 7.02
6	3 Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
7	4 Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
8	Nut, AN	Jam Nut	6.35	mm	$ 0.12	2		$ 0.24
								$ -
								$ -
							Sub Total	$ 20.56

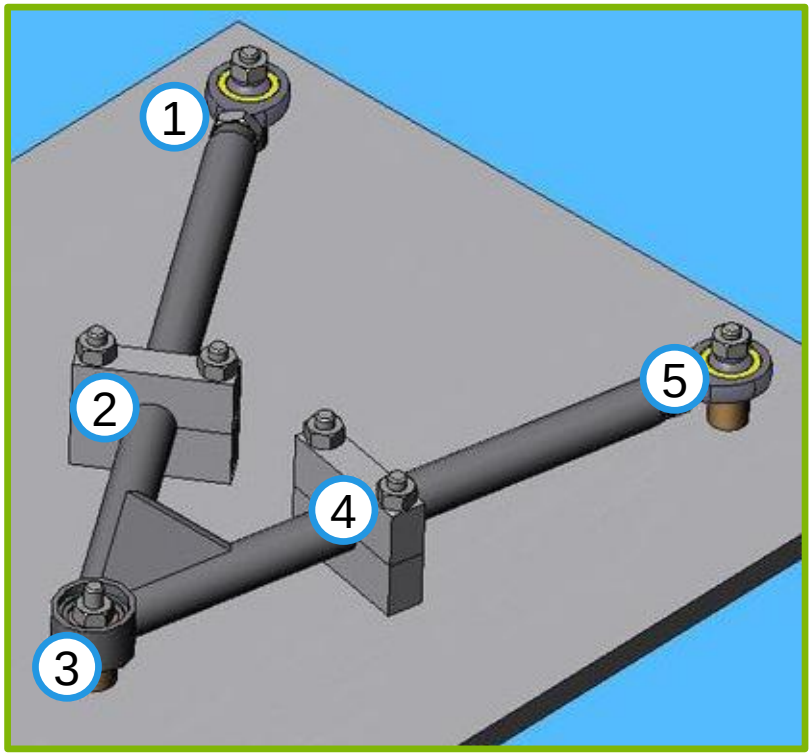
TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF		Sub Total
	Welding Fixture	Welding A-arm	$ 500.00	point(s)	5	3000		$ 0.83
							Sub Total	$ 0.83

10

Cost Report Example

Parts & Tooling

Assembly Layout



Assembly Report – Fasteners/Tooling

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity		Sub Total
1	Rod End, Precison (Aircraft)	Inboard Front	6.35	mm	$ 7.02	1		$ 7.02
2	Rod End, Precison (Aircraft)	Inboard Rear	6.35	mm	$ 7.02	1		$ 7.02
3	Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
4	Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
	Nut, AN	Jam Nut	6.35	mm	$ 0.12	2		$ 0.24
								$ -
								$ -
							Sub Total	$ 20.56

TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF		Sub Total
	Welding Fixture	Welding A-arm	$ 500.00	point(s)	5	3000		$ 0.83
							Sub Total	$ 0.83

Cost Report Example

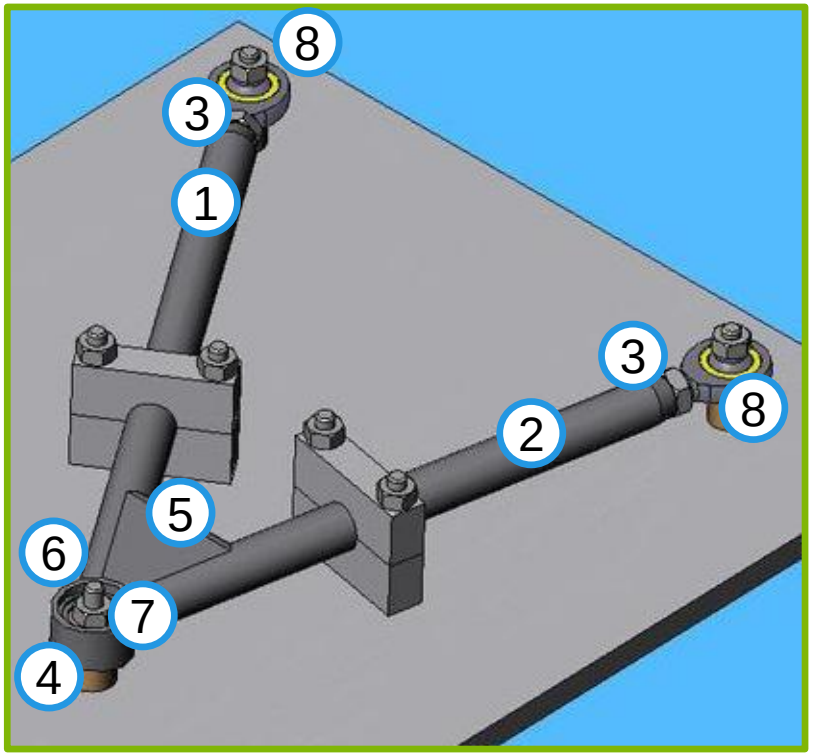
Part Name	A-Arm		Car #	27	Part Cost	$ 43.54
System	Suspension					
P/N Base	00001					
DLS	A		Full P/N	FSAEM – 08 – 027 – SU – 00001 – AA		
PLS	A		University	University of the Internet		
Comment	Upper Left A-Arm					

MID	Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
1	Steel, Alloy	Tubing-5/8" x 0.035"	$ 2.25	kg	41.9	250	7.80E-06	$ 0.184
2	Steel, Alloy	Tubing-5/8" x 0.035"	$ 2.25	kg	41.9	250	7.80E-06	$ 0.184
3	Steel, Alloy	Threaded Insert - Bar Stock	$ 2.25	kg	229.6	20	7.80E-06	$ 0.081
4	Steel, Alloy	Threaded Insert - Bar Stock	$ 2.25	kg	203.5	20	7.80E-06	$ 0.071
5	Steel, Alloy	Gusset - Sheet	$ 2.25	kg	450.0	1	7.80E-06	$ 0.008
6	Steel, Alloy	Spherical Bearing Cup - Bar	$ 2.25	kg	506.0	20	7.80E-06	$ 0.178
								$ -
								$ -
								$ -
							Sub Total	$ 0.705

PID	Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
1	Lathe - Turn, Rough	Insert, OD	$ 0.04	cm^3	10.74	Mtl - Steel	3	$ 1.29
2	Lathe - Turn, Finish	Insert, OD	$ 0.04	cm^3	5.37	Mtl - Steel	3	$ 0.64
3	Lathe - Face, Rough	Insert, Tapped Face	$ 0.04	cm^3	2.30	Mtl - Steel	3	$ 0.28
4	Drilled holes < 25.4" dia.	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
5	Tapping holes	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
6	Lathe - Turn, Rough	Insert, OD	$ 0.04	cm^3	10.74	Mtl - Steel	3	$ 1.29
7	Lathe - Turn, Finish	Insert, OD	$ 0.04	cm^3	5.37	Mtl - Steel	3	$ 0.64
8	Lathe - Face, Rough	Insert, Tapped Face	$ 0.04	cm^3	2.30	Mtl - Steel	3	$ 0.28
9	Drilled holes < 25.4" dia.	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
10	Tapping holes	Threaded Insert	$ 0.35	unit	1	Mtl - Steel	3	$ 1.05
11	Sheet Metal Stamping	Gusset	$ 0.03	cm^2	4.5			$ 0.14
12	Sheet Metal Bend	Gusset	$ 0.25	unit	1			$ 0.25
13	Tube Cut	Tubing	$ 0.03	cm	1.587			$ 0.05
14	Tube Cut	Tubing	$ 0.03	cm	1.587			$ 0.05
15	Tube End Prep for Weld	Tubing	$ 0.75	end	4			$ 3.00
16	Lathe - Turn, Rough	Bearing Cup OD	$ 0.04	cm^3	15.96	Mtl - Steel	3	$ 1.92
17	Lathe - Turn, Finish	Bearing Cup OD	$ 0.04	cm^3	7.98	Mtl - Steel	3	$ 0.96
18	Lathe - Face, Rough	Bearing Cup Top & Bottom	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
19	Lathe - Face, Finish	Bearing Cup Top & Bottom	$ 0.04	cm^3	10.13	Mtl - Steel	3	$ 1.22
20	Lathe - Turn, Rough	Bearing Cup ID	$ 0.04	cm^3	7.79	Mtl - Steel	3	$ 0.93
21	Lathe - Turn, Finish	Bearing Cup ID	$ 0.04	cm^3	4.4	Mtl - Steel		$ 0.18
22	Weld - Round Tubing	Tube	$ 0.19	cm	2.54			$ 0.47
23	Weld - Round Tubing	Tube	$ 0.19	cm	2.54			$ 0.47
24	Weld - Round Tubing	Bearing Cup to Tube 1	$ 0.19	cm	2.54			$ 0.48
25	Weld - Round Tubing	Bearing Cup to Tube 2	$ 0.18	cm	2.54			$ 0.46
26	Weld	Gusset	$ 0.15	cm	7			$ 1.05
							Sub Total	$ 21.44

FID	Fastener	Use	Size	Unit	Unit Cost	Quantity		Sub Total
1	Rod End, Precison (Aircraft)	Inboard Front	6.35	mm	$ 7.02	1		$ 7.02
2	Rod End, Precison (Aircraft)	Inboard Rear	6.35	mm	$ 7.02	1		$ 7.02
3	Spherical Bearing	Outboard	6.35	mm	$ 6.21	1		$ 6.21
4	Retaining Ring	Spherical Bearing	17	mm	$ 0.07	1		$ 0.07
	Nut, AN	Jam Nut	6.35	mm	$ 0.12	2		$ 0.24
								$ -
								$ -
							Sub Total	$ 20.56

TID	Tooling	Use	Unit Cost	Unit	Quantity	PVF		Sub Total
	Welding Fixture	Welding A-arm	$ 500.00	point(s)		$ 3000		$ 0.83
							Sub Total	$ 0.83

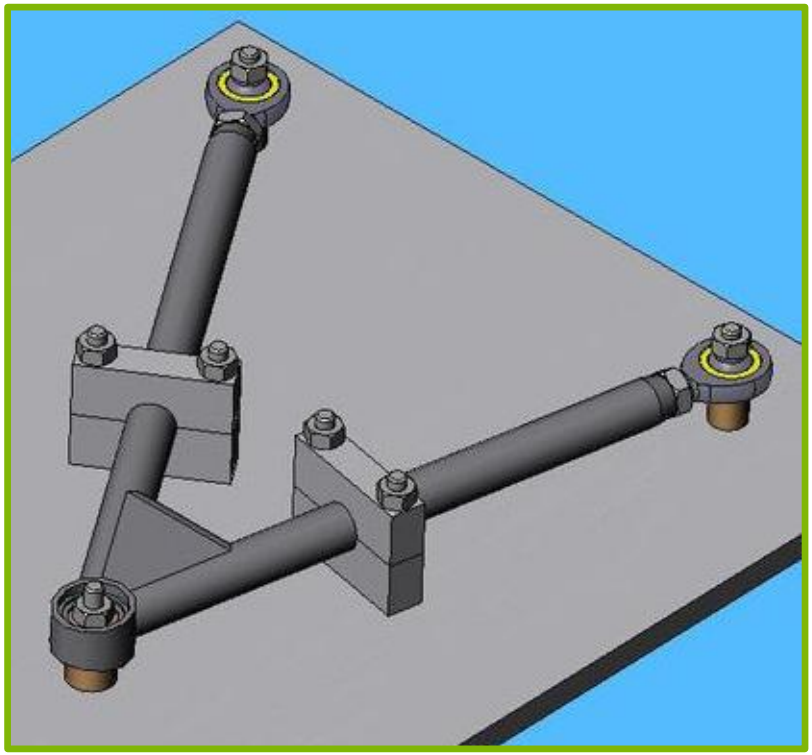


A-arm is complete, removed from fixture, but not yet installed onto the vehicle

Cost Report Example

Parts & Tooling

Completed Assembly



Assembly Report

Part Name	A-Arm			Car #	27	Part Cost	$	2.06
System	Suspension							
P/N Base	00001							
DLS	A			Full P/N	FSAEM – 08 – 027 – SU – 00001 – AA			
PLS	A			University	University of the Internet			
Comment	Upper Left A-Arm							

MID	Material	Use	Unit Cost	Unit	Area	Length	Density	Sub Total
								$ -
								$ -
							Sub Total	$ -

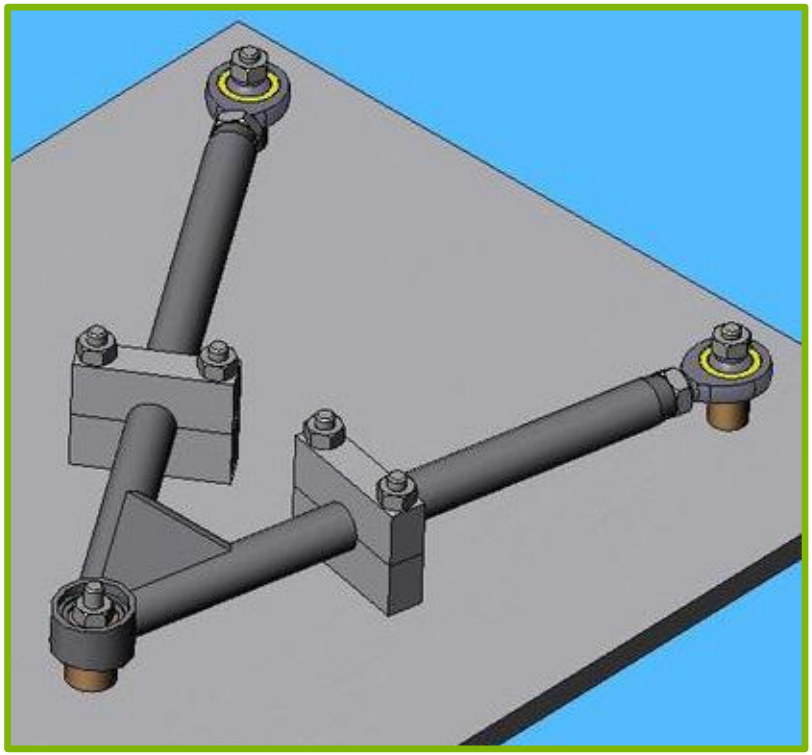
PID		Process	Use	Unit Cost	Unit	Quantity	Multiplier	Mult. Val.	Sub Total
	1	Assemble, 1 kg, Line-on-Line	Inboard rod ends	$ 0.13	unit	2.00			$ 0.26
	2	Power Tool <= 0.25"	Inboard bolts	$ 0.25	unit	2.00			$ 0.50
	3	Reaction Tool <= 0.25"	Inboard bolt nuts	$ 0.25	unit	2.00			$ 0.50
			Outboard bolt included with upright						$ -
									$ -
									$ -
								Sub Total	$ 1.26

FID		Fastener	Use	Size 1	Size 2	Unit Cost	Unit	Quantity	Sub Total
	1	Bolt, AN	Inboard Rod Ends	6.35	28.575	$ 0.27	unit	2	$ 0.54
	2	Nut, AN	Inboard Rod Ends	6.35		$ 0.13	unit	2	$ 0.26
									$ -
									$ -
								Sub Total	$ 0.80

TID		Tooling	Use	Unit Cost	Unit	Quantity	PVF		Sub Total
								Sub Total	$ -

Cost Report Example
Parts & Tooling

Completed Assembly

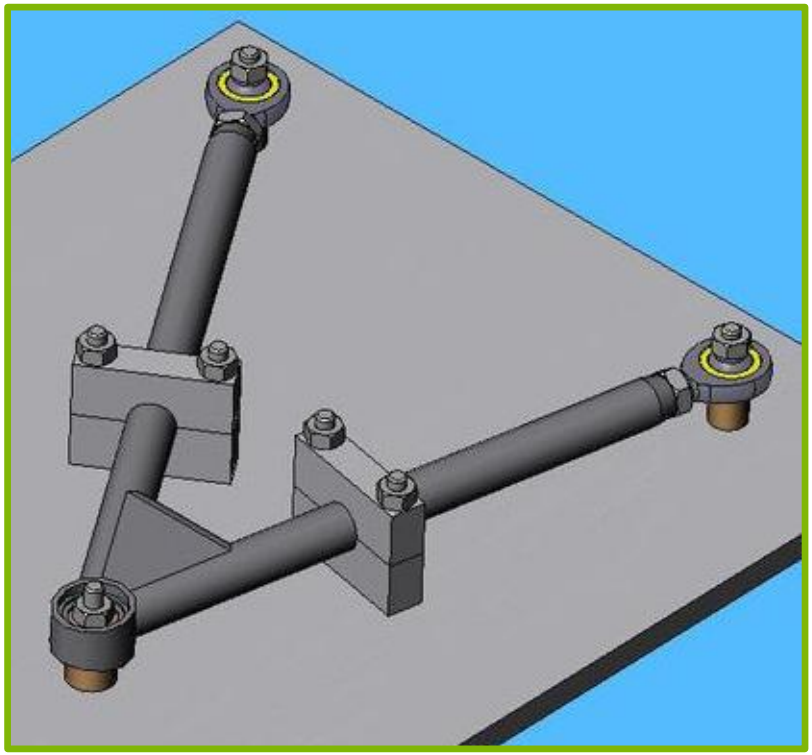


Errors in the Costed Assembly

- Jam nuts do not include installation steps
  - Hand – Start Only
  - Hand, Loose <=6.35 mm
  - Ratchet <=6.35 mm
- Bearing cup and threaded inserts require setup costs for the machining operations
  - Machining Setup, Install and remove
- If continuous feed is used (a-la-machining centre), this needs to be included as a note

Cost Report Example
Parts & Tooling

Completed Assembly



Review Points

- Are the materials, processes, multipliers, tooling, etc. correct?
- Were any elements forgotten?
- What assumptions have been made?
  - Do we have these written down to backup/explain the flow?
- Can any further evidence (visual or otherwise) complement our work?
  - Engineering drawings, photos, sketches

At the Competition

Addenda

FSAE-A Cost Event

Overall Judging Process

Check-in & Introductions

Visual Inspection

Visual Inspection - Penalties

Real Case Scenario

Addenda

Addenda to the report can be taken into consideration to cover any necessary changes made to the car.

These addenda:

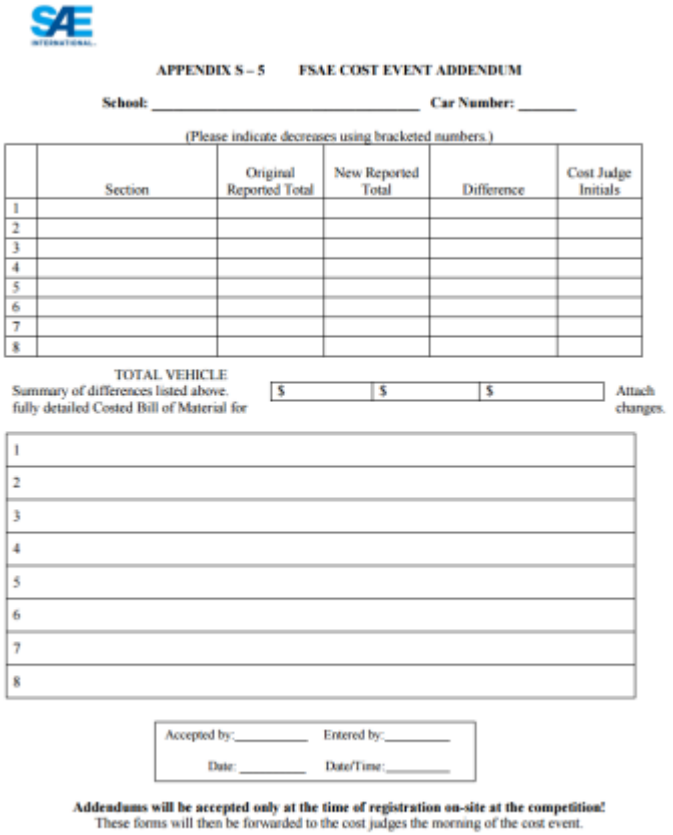
- **MUST** be logged in at the same time as the team's event registration
  - **DO NOT SUBMIT** at time of judging!!!
- **MUST** be in the format prescribed by the rules (Appendix S-5)
- **MUST** have supporting evidence for all amended costs attached

Judges reserve the right to refuse any addenda which do not comply with the terms above.

Addenda

Key considerations:

- Items added to the Cost Report via addenda will be costed at 1.25 times the tabulated cost
- Items removed from the Cost Report via addenda will be credited at 0.75 times the tabulated cost
- Judges will make the above calculations as required, after net cost change being verified at the event (Visual Inspection)



APPENDIX S – 5 FSAE COST EVENT ADDENDUM

School: _____ **Car Number:** _____

(Please indicate decreases using bracketed numbers.)

	Section	Original Reported Total	New Reported Total	Difference	Cost Judge Initials
1					
2					
3					
4					
5					
6					
7					
8					

TOTAL VEHICLE
Summary of differences listed above. fully detailed Costed Bill of Material for

$	$	$

Attach changes.

1
2
3
4
5
6
7
8

Accepted by:_____ Entered by:_____

Date: _____ Date/Time:_____

Addendums will be accepted only at the time of registration on-site at the competition!
These forms will then be forwarded to the cost judges the morning of the cost event.

FSAE-A Cost Event
Overall Judging Process

FSAE-A Cost Event
Check-in & Introductions

Duration – 5 minutes

Introduce the team and the car, mentioning any noteworthy features that may be of interest to the judges in the following areas:

- Trade-offs between content and cost based on performance of parts/assemblies
- Design for Manufacture and Assembly
- Lean Manufacturing
- Minimum Constraint Design
- Any other special actions taken affecting the Cost Report

The introduction should only cover key notes; consider this an ‘ice breaker’ activity

FSAE-A Cost Event
Visual Inspection

Duration – 10 minutes

The judges have reviewed the submitted cost report prior to the event

- Any issues and/or feedback for the teams will be presented at this point
- This review is done to make sure that parts on the vehicle are correlate with the cost report and that nothing has been added or changed since the cost report's publication

Key considerations:

- The quality in which you conduct yourself and respond to questions counts. Be professional!
- Use the Cost Report as submitted to SAE-A
  - Will be provisionally provided by the judges for the Visual Inspection, before being returned on a permanent basis on Saturday/Sunday
- Be open to feedback and discussion on areas for improvement

FSAE-A Cost Event
Visual Inspection

- The secret is to know your cost report and your car well
  - Treat this as an explanation/justification exercise
  - Avoid flicking between pages!!
  - Practice before the event if necessary!

"So it is said if you know the tables and know your car, you will do well in Cost.
If you know your car, but not the tables, you may or may not do well.
If you know neither your car nor the tables, you will do quite badly."

Adapted from Sun Tzu's 'The Art of War'

FSAE-A Cost Event
Visual Inspection - Penalties

- Penalties regarding report ‘errors’ are not applied until after they are verified at the visual inspection
- Two methods to calculate penalties
  - Fixed Point
  - Adjusted Cost
- No penalty applied when values are over-estimated
  - Self-penalising!
- In addition to the penalty process, correlation between the Cost Report and the vehicle presented may be extended to an overall evaluation
- Judges will use discretion when applying penalties, which will largely depend on the magnitude of error made

FSAE-A Cost Event
Visual Inspection - Penalties

FIXED POINT PENALTIES:

- Points deducted from Accuracy score
- Most penalties will be of the Fixed Point method

Description	Penalty Value
Missing/Inaccurate Material, Process, Fastener, Tooling	1 point each
Missing/Inaccurate Part	3 points each
Missing/Inaccurate Assembly	5 points each

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.

FSAE-A Cost Event
Visual Inspection - Penalties

ADJUSTED COST PENALTIES:

- An adjusted 'penalty' cost added to total cost of vehicle
- Used where the Fixed Point Penalty would not penalise teams enough for missing bigger items or distort other teams' cost relationships and their points allocation
  - i.e. Teams are actively discouraged from 'forgetting' whole assemblies and systems, copping a fixed point penalty
- Where a table cost cannot be determined in a timely manner, a judge may use the table cost of a similar vehicle into the penalty formula

Formula:

Penalty Method B – Adjusted Cost Deductions
The alternative penalty will be calculated using the following equation:

Penalty = 2 x (Table Cost – Team Reported Cost)

FSAE-A Cost Event
Real Case Scenario

Duration – 10 minutes

Students are to respond to a challenge relating to the cost and/or manufacture of the car. The challenge will be advised in the lead up to the event via email to team leaders and a copy uploaded to the SAE-A website.

Key considerations:

- Weighted trade-off tables are often a powerful tool to choose between design proposals
- Consider the flow-on effects to interacting parts/assemblies
- Consider the flow-on effects of vehicle attributes as a result of the change
  - Marketability
  - Performance – subjective & objective
- The final recommendation from this task may not be the same as what is fitted to the vehicle at competition – there is no ‘right’ or ‘wrong’ answer
- Use as many (realistic) assumptions as required, to right-size the amount of effort to complete the task

FSAE-A Cost Event
Real Case Scenario

Note

- The Real Case Scenario is not a discretionary low-value activity
  - It should be regarded as an integral and major part of the event
  - It is an opportunity for teams to demonstrate their critical thinking abilities and approach to cost minimisation or other special activity

Additionally, it provides an insight to real problems you'll encounter in industry, ***including what management will expect you to consider when making a recommendation****!*

FORMULA SAE AUSTRALASIA

In Closing

Dos and Don'ts

Questions & Answers

Dos and Don'ts

DO

- Consider the legibility of the report
- Know the published materials (rules, supp. regs., cost tables, templates)
- Break down every step as far as possible
- Consider your BOM breakdown and how it cascades at each step
- Include as many supplementary 'visual' aids as possible
- Submit addenda at on-site registration

DON'T

- Lose track of submission deadlines
- **Use comb binders!**
- Oversimplify steps in part/assembly breakdown
- Forget to use Process Multipliers, Machining Install/Remove, etc.

And Last But Not Least

DO START EARLY!

There is *BARELY* enough time for cost report if you start early!

SAE Australasia Student Series

Questions & Answers