2023-2024 FSGP AND ASC SOLAR CAR COMPETITIONS

MULTI-OCCUPANT VEHICLE SCORING, PRACTICALITY, AND STRATEGY



IEF Solar Car Conference, 01/14/23





Scoring Practicality Strategy **Open Discussion, Q&A**

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MOV AGENDA TOPICS

THIS CONTENT IS INTENDED TO SUPPLEMENT THE **REGULATIONS BUT DOES NOT SUPERSEDE THEM**





- practicality while driving at or above the Target Average Speed for the Event
- Multi-Occupant vehicle teams are ranked by S value as described below highest score is best 1
 - $\mathbf{S} = (\mathbf{D} / \mathbf{E}) \times \mathbf{C} \times \mathbf{T} \times \mathbf{P}$
 - D is the Total Person-Mile Distance higher values are better 1
 - ▶ <u>E is the Total External Energy Usage</u> lower values are better ↓
 - C is the Completion Factor higher values are better 1
 - T is the Target Speed Derate higher values are better 1
 - P is the Practicality Score higher values are better 1 (Practicality is not a factor for scoring FSGP Track Events)
 - MOV teams so Stages are simply ranked by $D \times C \times T$ higher values are better \uparrow
 - > The MOV scoring formula presents a challenging multivariable optimization problem make a <u>strategy</u>!
 - Having a <u>reliable</u> vehicle is especially critical to being successful in the MOV class!
- shall remain intact throughout the duration of the American Solar Challenge Tour

> Any team that fails to complete the Base Route of the American Solar Challenge Tour will automatically be ranked below all teams that successfully complete it (Reg 12.2.A) - completing the Base Route is the primary goal for all SOV and MOV teams in the event

> The general objective for Multi-Occupant vehicles is to efficiently transport people along a predefined route with considerations for

> External Energy Usage (E) and Practicality Score (P) are excluded in the Stage performance evaluation of American Solar Challenge

> Multi-Occupant vehicles shall remain in the same Scrutineered configuration throughout the duration of the Event - all practicality features

Person-Mile Distance (D)

- ASC Segments Base Legs between Checkpoints/Stage Stops + Optional Loops
 - Each Segment of the Event will yield a Person-Mile Distance calculated as
 - (Tour Distance driven in Miles) x (Min occupied solar car seats)
 - Note: Dropping an occupant on a loop will impact the entire Segment
 - Similar to the SOV class, MOV teams can drive optional loops to increase distance travelled
- FSGP Laps (Reg 14.2.B)
 - Each valid completed Lap will yield a Person-Mile Distance calculated as
 - (Lap Distance driven in Miles) x (Min occupied solar car seats)
 - MOV teams can invalidate a slower than desired lap by notifying Timing Officials prior to the completion of the lap, but invalidated laps won't count towards team/driver qualification for the ASC Tour
- The summation of these Segment/Lap Person-Mile Distances will yield a Total Person-Mile Distance for the team.

- External Energy Usage (E)
 - Calculated as
 - ▶ (n+1) x Q + M
 - **n** is the number of times the battery is charged from unmetered external energy
 - > Multiple unmetered charging sessions will be counted as a single unmetered charge as long as the solar car is not driven in the Event between the charging sessions
 - > **Q** is the energy capacity of the battery in kWh calculated at Electrical Scrutineering
 - **M** is the total metered external energy in kWh used to charge the battery
- Metered vs. Unmetered External Energy
 - > Metering enables the flexibility of partial battery charges to optimize race strategy (teams need to record kWh reading at the beginning and end of each metered charge via a photo with time stamp)
 - Metered charging incentives MOV teams to still perform morning/evening solar charging
 - Metered charging is impacted by the conversion efficiency of the onboard vehicle charger
 - > A more efficient charging system will help your score!
 - > Unmetered charging is available to teams who are unable to implement J1772/onboard charging and get certified in Scrutineering
 - > If for any reason an external charge isn't properly metered and recorded, it will count as unmetered

Completion Factor (C)

- Calculated as
 - (Driving Distance Penalties) / (Highest Driving Distance of Any MOV)
- Penalties could become the deciding factor for winning an ASC stage if more than one team completes the same person mile distance
- Note: Your score is impacted by the performance of the furthest driving MOV team





- Target Speed Derate (T)
 - **V** is the Target Average Speed which is equal to
 - ▶ 35 MPH for ASC
 - ▶ 30 MPH for FSGP
 - > Va is the team's Overall Average Speed which is calculated as
 - ASC: Total Tour Distance driven divided by the total Official Elapsed Time, in MPH
 - FSGP: Average speed of all valid laps completed during the event, in MPH
 - \blacktriangleright If Va \ge V then the target speed has been met and the Target Speed Derate is

▶ T=1

- If Va < V then the target speed has not been met and the Target Speed Derate is</p>
 - T=0.6^((V-Va)^0.4) New formula for 2023-2024
 - For reference the previous formula from 2019-2022 was T=0.4^(V-Va)
- There is a high incentive for teams to average above the Target Average Speed!



2019-2022

Practicality Score (P)

- of the car for publication through social media on the morning of judging.
- ranging from 0-100%.
 - the judging.
- Judging Rubric evaluation of their vehicle.
 - until the ASC Awards Ceremony at the conclusion of the Event.

The Practicality Score for a Multi-Occupant vehicle team will be determined by a panel of judges appointed by the ASC Organizers. It will be based on a mix of subjective and objective evaluations.

> Teams will be required to prepare a "window sticker" for their solar car which describes the attributes

Practicality judging will be conducted on the solar cars during the rest day prior to the start of the Tour. The score from each judge will be averaged into the overall Practicality Score for the solar car

> The MOV Practicality Judging Rubric will not be released to judges or teams until the morning of

Prior to the start of ASC, Officials will review and compile the Practicality Scores for all MOV teams and each team will be provided with their own score along with a copy of each judge's MOV Practicality

> In order to maintain an element of surprise, the practicality Scores of all teams will not be made public



ASC MOV COMPARISON TO WSC CRUISER CLASS DESIGN (NON COMPREHENSIVE LIST)

- Both MOVs and Cruisers must be designed to carry more than 1 occupant
- Both MOVs and Cruisers can't exceed 5m^2 of solar array area
- > Neither MOVs or Cruisers are limited by battery weight
- MOVs must have exactly 4 wheels while Cruisers must have at least 4 wheels
- > Both MOVs and Cruisers must contain an onboard AC-DC charger and be capable of using the SAE J1772 signaling protocol
 - MOVs must have the J1772 Type 1 charging inlet (or another standard EV charging inlet with an adapter to J1772 Type 1 carried onboard)
 - Cruisers must have the IEC 62196-2 Type 2 charging inlet
- > Both MOV and Cruiser occupant mass will be ballasted to 80kg and ballast must be carried within 300mm of the occupant's hip point
- > Must be able to egress a Cruiser in less than 15 seconds while MOVs must egress in no more than 10 seconds for the primary direction and no more than 15 seconds for the secondary direction
- > Both MOV and Cruiser vehicles must feature redundant service brake systems capable of stopping the fully laden solar car
 - > MOVs don't require rear wheel brakes if the front brakes are redundant while Cruisers must have braking on all road wheels
 - > MOVs must repeatedly stop on wetted level pavement from 50km/h or greater exceeding 4.72m/s^2 while Cruisers must be able to stop on dry level pavement within $0.1v + 0.006v^2$ meters from any speed v, in km/h
 - From 50km/h an MOV must stop repeatedly on wet pavement within 2.94s while a Cruiser must stop from the same speed on dry pavement within 1.44s
- > The parking brake must hold a fully laden MOV on dry level ground under either a forward or rearward force equal to 10% of the car's weight while it must hold a fully laden Cruiser on a 20% incline or decline
- > ASC is notorious for being more rigorous than WSC for Scrutineering inspections of solar vehicles

ASC MOV COMPARISON TO WSC CRUISER CLASS SCORING (NON COMPREHENSIVE LIST)

- Person-Distance Energy Efficiency
 - > Both events evaluate driving efficiency with a multiplier for the number of occupants carried in the vehicle
 - min occupants on a leg between consecutive control stops
 - > MOV distance evaluation is in miles while Cruiser distance is in kilometers
 - Both events meter external energy usage in kWh (including onboard charger losses)
 - densities depending on battery chemistry
- Vehicle Reliability and Operational Efficiency is Key to Success in Both Events

 - available driving hours while averaging above the event target speed (optional loops are available to achieve greater distance)
 - - > ASC derates based on overall average speed while WSC derates based on time to complete a fixed distance

> MOV person-distance is calculated based on min occupants on a segment (base leg+loops) while Cruiser person-distance is calculated based on

> MOV battery capacity is assessed based on the supplier data sheet while Cruiser battery capacity is assessed based on standardized gravimetric

> MOVs can externally charge from their own EVSE at any time/location (observer/officials must be notified of MOV unmetered charging) while Cruisers can only externally charge during specified hours using WSC provided EVSE (with built in metering) at two predetermined control stops

> Both MOVs and Cruisers that fail to complete the entire base route of the tour are automatically ranked below teams that successfully complete it

> The first time a Cruiser misses a control stop the team is automatically ranked below teams that successfully complete through the next control stop while MOVs that fail to complete the base route are credited for all segments they successfully complete without regard for the segment sequence

> ASC requires precise navigation of a pre determined tour route through cities and along highways compared to a relatively simple WSC route

Cruisers are attempting to travel a fixed event distance in as short an elapsed time as possible while MOVs are trying to as far as possible within the

> Both MOVs and Cruisers are severely derated for failing to drive fast enough during the event (necessary in order to fairly evaluate vehicle efficiency)



ASC MOV COMPARISON TO WSC CRUISER CLASS SCORING (NON COMPREHENSIVE LIST)

- > MOVs are evaluated by official mileage credited compared to the highest distance driven of any team (completion factor)
 - > This helps provide some additional incentive for MOVs to complete loops if they can
- Both MOV and Cruiser Teams Can be Issued Technical and/or Operational Penalties
 - SASC penalties are applied as mileage deducted from the team's official distance for their completion factor while WSC demerits for regulation infractions reduce the team's final score by 1% each
 - WSC teams are excluded from the remainder of the event if they are issued 3 or more demerits while ASC mileage penalties are not limited and can range from warnings up to full disqualification
- In Both Events Practicality is a 0-100% Score Multiplier which is Evaluated by a Panel of Judges
 - MOV practicality is judged/scored before the tour while Cruiser practicality is judged/scored after
 - MOV practicality features must remain in place for the duration of the tour
 - MOV practicality is based on a combination of objective and subjective evaluation but the specific rubric is not announced in advance of the event while Cruiser practicality is based on subjective evaluation of 8 pre-announced categories
 - Category weighting for MOVs is determined by the organizers while it is up to the judges for Cruisers
 - MOV teams prepare a "window sticker" for their solar car which describes the attributes of the car while Cruiser teams prepare a 3-minute video and a brochure that describes their car, how it will be used, and how it addresses sustainability, mobility and energy resilience



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- The following is an example list of areas that may be considered for practicality scoring
 - Driver and Occupant Amenities
 - Quality of Features
 - Infotainment System
 - Phone Connectivity
 - Ease of Operation
 - Internal and External Styling Fit & Finish
 - Watertight Cabin
 - Visibility
 - Seats
 - Doors
 - Cargo Space
 - Spare Tire Kit
- scoring



> This list is not intended to be comprehensive, additional items may be considered, and not all items may be included in the final

Example Practicality Scoring Rubrics (From ASC 2021 and ASC 2022)

ASC 2021 Multi-Occupant Vehicle Practicality Judging		Judge's	Name	Team #	School	А	SC 2022 Multi-Occupant Vehicle Practicality Judging	Judge's	Name	Team #	School
Control & Operation							ol & Operation				
Info	otainment System	Grading	Perfect Score	Judge's Mark	Judge's Comments	Inf	fotainment System	Grading	Perfect Score	Judge's Mark	Judge's Comments
	Audio Quality	0-10	10				Audio Quality	0-10	10		
	Navigation System	Yes/No	Yes				Navigation System	Yes/No	Yes		
	Useful Features	1-10	10				Phone Connectivity	Yes/No	Yes		
	Recognizes Voice Commands	Yes/No	Yes				Recognizes Voice Commands	Yes/No	Yes		
	Ease of Use	0-10	10				Ease of Use	0-10	10		
Eas	e of Operation	Grading	Perfect Score	Judge's Mark	Judge's Comments	Ea	se of Operation	Grading	Perfect Score	Judge's Mark	Judge's Comments
	Simplicity of Charging	0-10	10				Simplicity of Charging	0-10	10		
	Ergonomic Cabin Controls	0-10	10				Useful Steering Wheel Controls	0-10	10		
Interio	r Prior Aesthetics	Grading	Perfect Score	ludge's Mark	ludge's Comments		Ergonomic Cabin Controls	0-10	10		
inte			10	Sunde a mark		Interio	or				
	Fit & Finish Quality	0-10	10			Int	terior Aesthetics	Grading	Perfect Score	Judge's Mark	Judge's Comments
	Interior Styling	0-10	10				Fit & Finish Quality	0-10	10		
Sea	ts	Grading	Perfect Score	Judge's Mark	Judge's Comments		Interior Styling	0-10	10		
	# of Occupant Seats	#	4			Se	ats	Grading	Perfect Score	Judge's Mark	Judge's Comments
	Seat Quality	0-10	10				# of Occupant Seats	#	4		
Occ	supant Amenities	Grading	Perfect Score	Judge's Mark	Judge's Comments		Seat Comfort	0-10	10		
	One Cup Holder Per Occupant	Yes/No	Yes					0 10	10		
·	One USB Charging Port Per Occupant	Yes/No	Yes				One Cup Holder Per Occupant	Grading Yes/No	Perfect Score	Judge's Mark	Ludge's Comments
	Overall Quality of Driver Amenities	0-10	10				Cabin Clock	Yes/No	Yes		
Car	go Space	Grading	Perfect Score	Judge's Mark	Judge's Comments		Overall Quality of Passenger Amenities	0-10	10		
	Dedicated door/hatch for cargo access	Yes/No	Yes					Crading	Dorfoct Score	ludgo's Mork	ludge's Comments
·	Organization & Layout of Vehicle Storage Locations	0-10	10				Dedicated Door/Hatch for Cargo Access	Yes/No	Yes	Judge S Mark	
Exterio	sr										
Exterior Aesthetics Grading Perfect Score Judge's Mark Judge's Comments							Organization & Layout of Vehicle Storage Locations	0-10	10		
	Fit & Finish Quality	0-10	10			Exteri	ior				
		0-10	10			Ex	terior Aesthetics	Grading	Perfect Score	Judge's Mark	Judge's Comments
	Exterior Styling	0-10	10				Fit & Finish Quality	0-10	10		
Oco	Eupant Doors	Grading	Perfect Score	Judge's Mark	Judge's Comments		Exterior Styling	0-10	10		
		0-10	10			Oc	ccupant Doors	Grading	Perfect Score	Judge's Mark	Judge's Comments
Cofoty	Ease of Entry	0-10	10				Ease of Opening/Closing	0-10	10		
Visibility Grading Perfect Score Judge's Mark Judge's Comments				/ Judge's Comments		Ease of Entry/Exit	0-10	10			
		0.40	10			Safety	/	•	.	1 	
		0-10	10			Vi	sibility	Grading	Perfect Score	Judge's Mark	Judge's Comments
	Side Visibility	0-10	10				Driver Visibility	0-10	10		
0	Quality of Rear View Camera/Mirror	0-10	10				Quality of Rear View Camera/Mirror	0-10	10		
Overall Vehicle Desirability Grading Perfect Score Judge's Mark Judge's Comments Overall Vehicle Desirability Grading Perfect Score Judge's Mark Judge's Comments								Perfect Score	ludge's Mark	ludge's Comments	
000		Grauing	renect score	Judge S Mark				Grauing	renect score	Judge S Widrk	i sudge a commenta
	Judge's Overall Vehicle Desirability Rating	0-10	10				Judge's Overall Vehicle Desirability Rating	0-10	10		

Guidance for 0-10 Grading

10 Entrant is clearly top notch and deserving extra points for excellence in this category

8 Entrant exceeds expectations in this category

5 Entrant meets expectations in this category

2 Entrant is below expectations in this category

0 Entrant has none of the characteristics necessary to judge this category or performed so poorly as to deserve a particularly harsh assessment

10 Entrant is clearly top notch and deserving extra points for excellence in this category

Practicality rubrics and scoring results from past ASC events can be downloaded from the American Solar Challenge website for reference

Guidance for 0-10 Grading

8 Entrant exceeds expectations in this category 5 Entrant meets expectations in this category

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0 Entrant has none of the characteristics necessary to judge this category or performed so poorly as to deserve a particularly harsh assessment





MOV pack capacity is unlimited - how to choose optimal size?

Ideally it should be large enough to avoid the need for external energy charging during the racing day

- > Plan to start every day with a full pack except possibly the last day for the ceremonial finish where you may want to end the event with your pack nearly depleted
- Consider the length of the racing day (typically 8 hours for FSGP and 9 hours for ASC but ASC 2022 had one 10 hour day) - take into account checkpoint/stage stop Hold Time for ASC (typically 45 min)
- Consider elevation gain (some ASC stages and FSGP tracks can contain significant uphill sections)
- Plan for the unexpected (need to go faster to correct for wrong turns, make up for break downs/lost time, etc)
- If your pack capacity is way larger than necessary then you are just carrying extra weight which will hurt your efficiency
- How many seats to include in the vehicle design? MOV class requires at least two seats
 - > How much vehicle weight can your tire ratings accommodate? Designing in additional seats may not be worth it unless you are confident they can be used
 - Carrying extra people is beneficial if you are able to maintain the target speed and as long as each extra person doesn't require more than 1kWh of energy per mile driven
 - > Keep in mind that you can run with less occupants than seats available if there is a particularly challenging stage or you you need to go faster to make up lost time



- How to determine target speed?
 - (especially early on in the event)
 - Known factors can include route, distances, speed limits, elevations, pavement conditions, etc.
 - breaks, poor weather, etc
 - the clock during the event (unfortunately during ASC down time on a base leg hurts your average speed)
 - Utilize your scout vehicle as much as possible to relay conditions ahead and adjust strategy accordingly
 - if possible
- Maximizing distance travelled should you run loops or not?
 - your D/E value for the loops will be greater than 1

 - penalties hurt your completion factor

> Average segment speed is impacted by both known and unknown factors so it is recommended to leave yourself a safe buffer

Unknown factors can include traffic, being stuck waiting for a train or construction pilot car, accidents, breakdowns, bathroom

> Perform lots of pre-event competition practice to help ensure vehicle reliability and effective teamwork to minimize down time on

> Run your own average speed calculations and ask ASC timing officials to verify your average speed at checkpoints and stage stops

> Yes, if you can maintain the target speed, have the energy available to start running loops immediately after serving hold time, and

> It is recommended to have your Scout drive loops in advance to help determine how feasible it will be to maintain the target speed > Do your best to eliminate penalties by fully complying with the regulations and the rules of the road throughout the event since



- > The strategy for winning a stage is counterproductive to winning the overall event should you try to win a stage?
 - > If you are trying to win the overall event focus on the long game and don't worry too much about winning individual stages
 - battery capacity to successfully finish the stage
 - about finishing safely/efficiently than going fast
- Charging Strategy

 - Get certified for Metered charging in order to take advantage of opportunity charging during the event (partial top offs)

 - (be sure to test this before the event)
 - MOV from that at night
 - charger inefficiency is included)

> If your team doesn't think you have the ability to win the overall event you could focus on trying to win a stage instead (generally this consists of getting as many person miles as possible without worrying about energy efficiency) - if you do this, you still need to make sure you have enough

> The final stage of the event can be a good one for teams trying to pick up a stage win since it is short and the event leader(s) may be more worried

> Bring as powerful a solar array as you can (within 5m^2 limit) and maximize solar charging during the event to minimize your external energy usage > Attempt to predict how much solar charging you'll be able to get in the morning and leave some energy capacity left in the pack to utilize this

Scope out commercial EV charging stations along the route that could be used (many campgrounds have NEMA 14-50 RV hookups for RVs)

> We recommend having a portable generator that is capable of charging your vehicle if at any point you are unable to find another means of charging

Sustainability/innovation idea: install solar panels on your vehicle trailer and use them to charge up a battery during the race day then charge your

> Have a good understanding of the efficiency of your onboard vehicle charger (if utilizing metered external charging, energy lost due to onboard

> If your battery pack is dead at the end of the competition day is there is minimal opportunity for solar charging that evening/next morning there may be a scenario where it makes more sense to do an unmetered charge so you don't take the efficiency hit from your onboard vehicle charger









How to prioritize the practicality of your vehicle design

- Generally you want to do as well as you can in practicality scoring
- by how little energy they consume
- practicality scoring
- Doing very well in practicality can help make up for an otherwise less efficient/ optimized vehicle
- Consider ergonomics and ease of use for the driver/occupants in the vehicle
- Review past ASC practicality rubrics for inspiration

Teams looking to maximize vehicle efficiency may want to prioritize practicality features

Recommend focusing on fit/finish of the vehicle which can help both on efficiency and

Spend time developing a compelling "window sticker" for your vehicle instead of quickly throwing this together last minute (be sure to highlight cool/innovative features)



