

# ESTIMATED RANGE

Requests for the estimated range on driver and center display

# MOTIVATION

- Many drivers do not see any benefit in the current solution.
- The estimated range displayed in the cockpit is redundant to the battery's state of charge; it does not contain any other useful information (4 km/%).
- Many people are confused, due to lack of information, that the estimated range of the range assistant app and in the cockpit differs.
- The range displayed by the range assistant is pretty useless since the calculation basis is unknown.
- The same applies to the displayed values of minimum and maximum range, which are useless without knowing the calculation background.
- Many drivers want an estimated range that reflects their driving style and the current traffic situation.
- In addition, the estimated range should reflect long- and short-term trips.
- The range estimate must be flexible enough to allow drivers to adjust the displays to meet their information needs.

# FEATURES OF RANGE ESTIMATION

- Eight main features of range estimation w/o considering a specific route have been identified.
- This features will allow a comparison of different solutions

Main Features Range Display & Calculation	
Short Name	Explanation
Battery Degradation	The battery degradation which occur over life time is considered in range calculation resp. in the SoC used for calculation
Environmental Condition	Environmental conditions will impact the SoC and the energy consumption. Changing environmental conditions e.g. ambient temperature are considered in the range calculation resp. in the used calculation terms.
Range displayed during charging	While charging the BEV the SoC will increase and therefor the estimated range. The actual range is shown in a display.
Range is content of the trip computer	Nearly all vehicles have a trip computer showing consumption, distance, time on route etc. The estimated range is part of this computer.
Range is displayed on map	Nearly all vehicles have a navigation system. The estimated range is visualized on the navigation map w/o having a destination defined.
Initial range is based on	The initialization of the range value can be done on historic e.g. previous driving cycle or fixed data e.g. WLTP result.
Life calculation	During driving with the vehicle, the life calculation of the estimated range can consider the driving style and traffic e.g. by consumption value.
Navigation	In case a navigation is active and a destination is defined, the range calculation considers also the landscape profile of the known route by using values of the navigation system

# FEATURE COMPARISON COMPETITORS VS. POLESTAR 2

Range Display & Calculation Feature	Vehicle Brand & Type															
	Jaguar I Pace	Fiat e500	Hyundai IONIC electric	Honda e	Tesla Model 3	Hyundai IONIC5	Aiways U5	VW ID3	Renault ZOE	Hyundai Kona Electric	BMW i3	Ford Mach E	Kia e-Niro	Skoda ENYAQ	Porsche Taycan	Polestar 2
Battery Degradation	n.k.	n.k.	n.k.	n.k.	yes	yes	n.k.	n.k.	n.k.	n.k.	n.k.	n.k.	yes	n.k.	n.k.	no
Environmental Condition	yes	n.k.	yes	yes	no	yes	n.k.	yes	n.k.	yes	yes	yes	yes	n.k.	yes	no
Range displayed during charging	yes	yes	yes	yes	yes		n.k.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Range is content of the trip computer	yes	no	yes	yes Trip A & B	yes global & for short, 10, 25, 50 km	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
Range is displayed on map	yes	no	yes	n.k.	no	yes	n.k.	n.k.	n.k.	yes	n.k.	n.k.	yes	yes	yes	no
Initial range is based on	n.k.	n.k.	prev. drv. cycle	prev. drv. cycle	fixed EPA cycle	prev. drv. cycle	n.k.	prev. drv. cycle	fixed value or last 200km	prev. drv. cycle	n.k.	prev. drv. cycle	prev. drv. cycle	n.k.	prev. drv. cycle	fixed value 400km@100%
Life calculation	yes	yes	yes	yes	for global: no short dist.: yes	yes	n.k.	yes	yes	yes	yes	yes	yes	n.k.	yes	on cockpit: no  last 10km(?) on range assistant
Navigation	n.k.	no	n.k.	n.k.	no	yes	n.k.	n.k.	n.k.	n.k.	yes	n.k.	yes	n.k.	yes	no

Source: public available vehicle manuals (print or WEB)

Abbreviation:

n.k.	not known, no public information available
prev. drv. cycle	previous driving cycle

# REQUESTS

## ESTIMATED RANGE IN DRIVER COCKPIT DISPLAY

- There are already 2 trip computers (Trip Manual TM and Trip Automatic TA) integrated in the system. Both trip computers contain an independent consumption value in kWh/100km or kWh/100mi.
- The range calculation shall in principle be based on these two consumption values. In analogy, this results in a manually resettable range value RM and a self-resetting range value RA.  
This provides the driver with the range information based on his driving style (RM) and the information based on the current route (RA) resulting from driving style and current traffic situation.
- Range RM is calculated from the available battery charge and the consumption calculated in TM.  
Range RA is calculated from the available battery charge and the consumption as calculated in TA.
- If the TM trip computer is reset manually, there is no plausible consumption value existing. The range RM is therefore initialized with a fixed value corrected by actual ambient temperature, e.g. 400km@100%SoC@20°C.  
If the TA trip computer is reset automatically, no plausible consumption value exists. The range indication RA is initialized with the consumption value of the manual trip computer TM and the actual SoC, corrected by the actual ambient temperature.
- The initial value shall be corrected by the life time degradation of the main battery.
- The driver shall have the choice to see the range RM or the range RA on the driver display.  
In addition, both values can be shown in the separate window of the on-board computer.
- In the case a navigation target is defined, RM and RA shall be corrected by the profile of the navigation routing.
- At least RM shall be stored and linked to the individual driver profile.

# PROPOSAL COCKPIT DISPLAY

Today's solution



change to



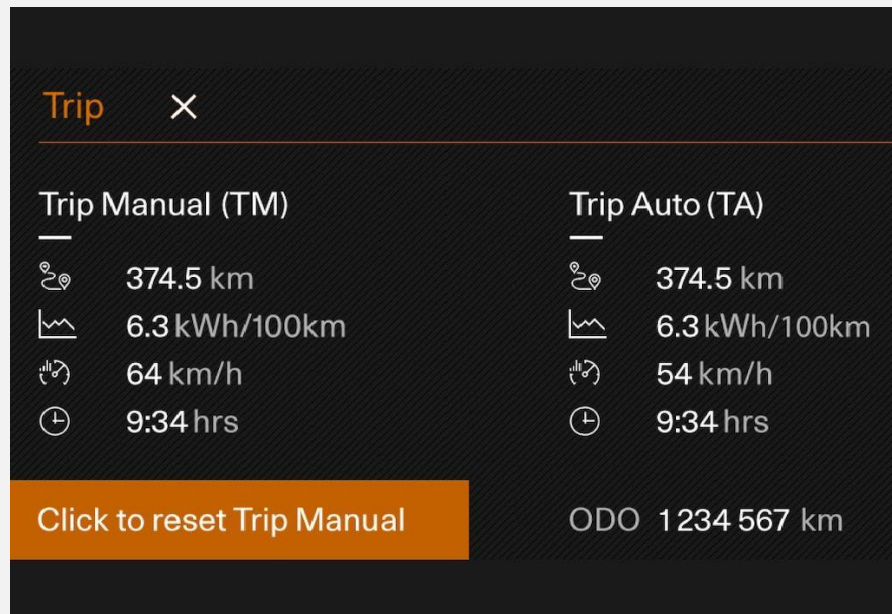
alternative display  
chosen by driver



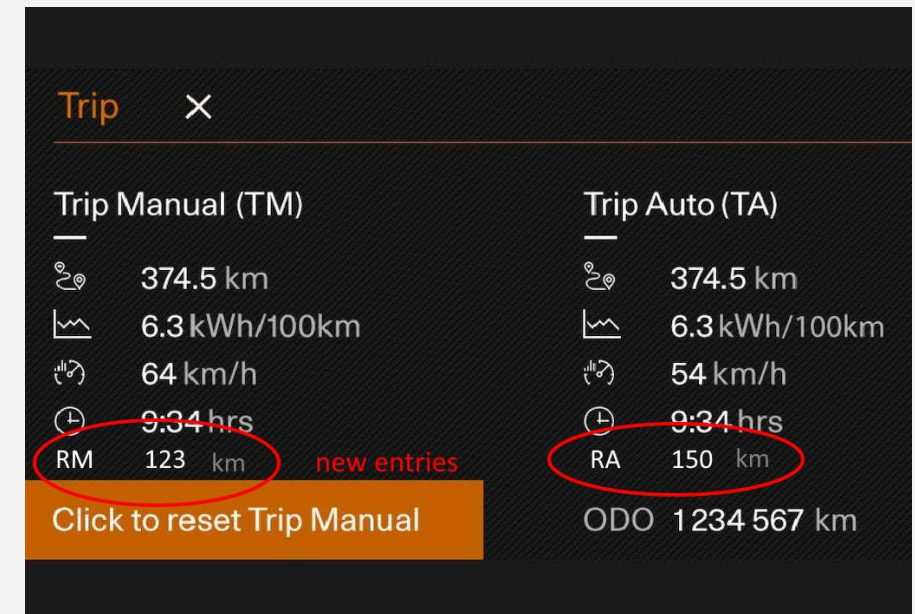
Remark: same visualization on second cockpit display

# PROPOSAL TRIP COMPUTER DISPLAY

Today's solution



change to



# REQUESTS

## ESTIMATED RANGE IN RANGE ASSISTANT APP

- There are already 3 instantaneous values shown in the range assistant app. These values are the instantaneous maximum range (IR\_MAX), the instantaneous minimum range (IR\_MIN) and the instantaneous average range (IR\_AV).
- These values shall be calculated based on the actual SoC and the instantaneous energy consumption.
- The instantaneous energy consumption shall be evaluated for a defined distance (RD) based on the already past route.
- The distance (RD) shall be adjustable by the driver. The driver shall have the choice of minimum 3 pre-defined distances, e.g. 10, 25 and 50km.
- The instantaneous average range IR\_AV represents the average energy consumption the vehicle has past the distance RD.

The instantaneous average range IR\_MIN represents the average of highest 25% energy consumption the vehicle has past the distance RD.

The instantaneous average range IR\_MAX represents the average of lowest 25% energy consumption the vehicle has past the distance RD.

(For better understanding see schematic on the last page.)

- All instantaneous ranges shall be initialized by “car active / key on” with the values of the previous driving cycle.

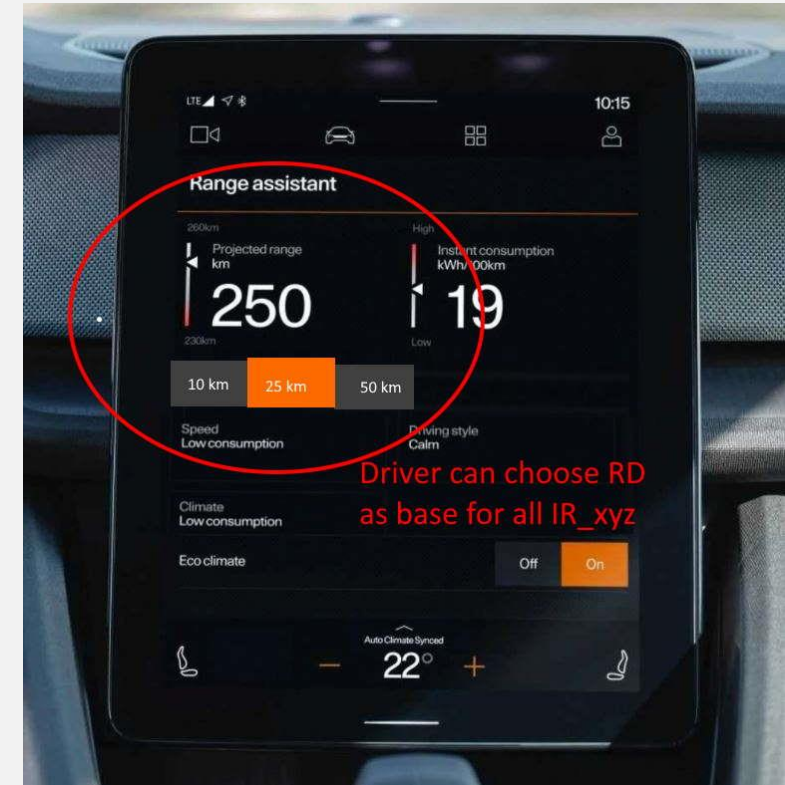


# PROPOSAL RANGE ASSISTANT DISPLAY

Today's solution



change to

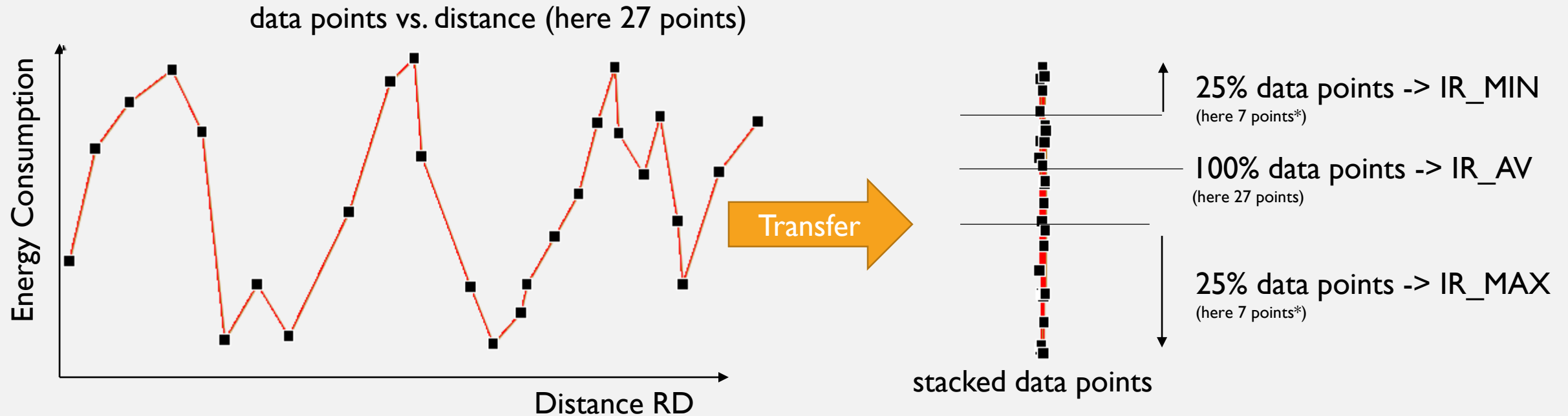


all IR\_xyz will change their values by choice of RD

# BENEFITS

- The estimated range reflects the individual use of the vehicle, taking into account the driving style and the most frequently driven routes.
- It provides a good indication of whether the desired route can be covered with the current SoC without using navigation. This makes it more comfortable to cover short distances on known routes with reduced SoC.
- The RM allows the driver to look at range-influencing factors individually, e.g. winter/summer tires; trailer; roof box, etc.
- Since RA resets after 4 hours of rest anyway, RM can also be used for long-term observations.
- The instantaneous ranges give the driver a good indication of his driving style and route profile. With the help of this information, the driver can estimate whether the destination can be reached with a "sporty" or "quiet" driving style, or what the effect of a change in weather will be.
- In particular, the instantaneous range IR\_AV compared to the shortest RD allows a quick assessment of additional consumers, e.g. is ECO mode necessary to reach the destination yes/no.
- The consideration of navigation destinations in the range values RM & RA shows a realistic remaining range at the destination and thus the still possible action radius. This is important if charging is not possible at the destination (e.g. Hotel).
- Consideration of battery degradation ensures reliable values over the entire lifetime.

# SCHEMATIC FOR INSTANTANEOUS RANGE



\* 7 data points results out of:  $\text{round}(27 \times 25\%) = \text{round } 6.75 = 7$