

Discussion materials for new mandate on in-vehicle battery durability

EVE 33 – Geneva

January 13, 2020

Changes from conference call of 12 Dec

❖ Terminology

- “DF” (Deterioration Factor) changed to “PR” (Performance Requirement)
- “EI” (Exposure Indices) changed to “UI” (Usage Indices)

❖ Timeline updated to reflect mandate proposal

GTR on battery durability: Status

- ❖ General goals of a durability GTR (EVE 31):
 - Establish **minimum durability requirements**
 - **Prevent substandard products** from entering the market
 - Allow **continued development of the GTR** as the industry evolves
 - Implement a **data collection mechanism** for improving the GTR in the future
- ❖ EVE32, Brussels: near-term approach could be some combination of:
 - Predetermined deterioration factors (DFs)
 - Confirmation via in-service conformity (ISC)
- ❖ GRPE desires preliminary GTR by January 2021

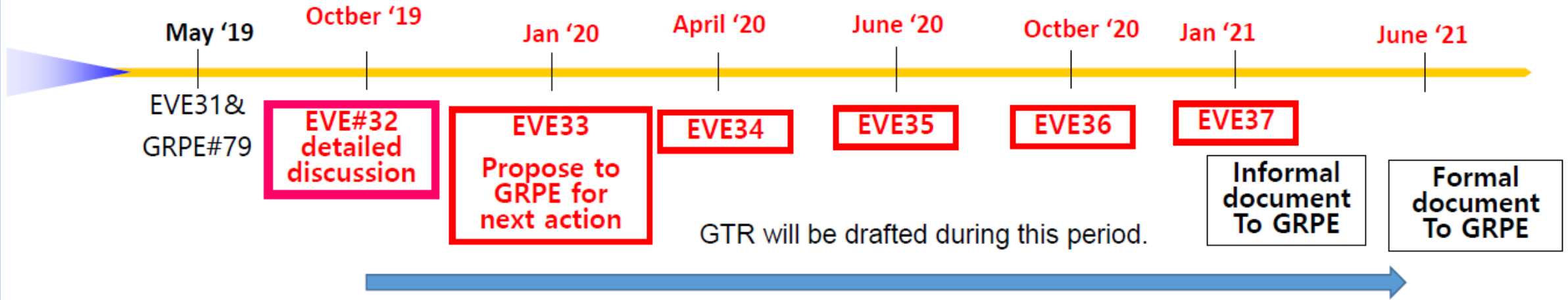
Observations of Japan – EVE₃₂

- ❖ Difficult to determine an appropriate DF
 - There is no durability test method that is representative and market-correlated
 - TEMA model limited by chemistries; results not yet correlated to the market
 - Other sources of degradation data are limited due to lack of information on usage (charging rate, temperature exposure, etc.)
 - Uncertain how DF would affect the driving range shown on certification label
- ❖ Need to describe how to perform ISC
 - How to select ISC vehicles (what variations in environment and usage; how many)
 - How to define pass/fail criteria – there are no regulatory values
 - Long-range PEVs impose long test time; are there other ways to evaluate at ISC?
- ❖ Accomplishing all this by January 2021 is extremely difficult

Japan proposal – EVE32

- ❖ Limit initial scope of GTR to provide information on battery condition
 - Battery State of Health (SOH) envisioned as a measure of either:
 - Remaining electric driving range, compared to original range (CoC)
 - Remaining energy capacity, compared to original capacity (catalogue)
 - SOH readable by customer and from OBD
- ❖ Scope of GTR:
 - Define SOH measurement method
 - Establish requirement for SOH on OBD
- ❖ Validation testing also would be performed
- ❖ Might be possible to have preliminary GTR by January 2021

Timeline proposed by Japan (EVE32)



	2019_4Q	2020_1Q	2020_2Q	2020_3Q	2020_4Q	2021_1Q	2021_2Q
Application to SAE OBD ID	Apply☆	----->	----->	★Registered			
Validation tests by JARI.Prius_PHV,LEAF	----->	----->		by JRC,EPA?	----->		
verification of Error and variation standardization		----->	----->				
Guidelines ver.FY2019 completed				★			
Incorporation into the GTR		----->	----->	----->	----->	----->	----->

Observations of European Commission – EVE₃₂

- ❖ GTR for battery durability is a must
- ❖ Japan SOH proposal contains good elements
 - Proposal needs to clearly define how the SOH is measured
 - Means of independent verification needed (not just OBD value)
 - Define verification test using WLTC
 - Define sample sizes, tolerances, etc.
- ❖ Alternative approaches:
 - Manufacturer defines and declares a capacity or range DF
(or)
 - CPs define a maximum range deterioration performance requirement (PR)
 - Verified by ISC (need to define pass/fail criteria, vehicle selection, etc)

European Commission suggestion – EVE₃₂

- ❖ Might define DFs or PRs (by OEM or CP) based on current knowledge
- ❖ Information gathering component:
 - Require SOH indicator and SOH reading capability
 - Use TEMA or other models to further inform DF or PR
- ❖ Performance definition component:
 - Use gathered information to further refine DFs or PRs
- ❖ Performance verification component (ISC):
 - WLTC procedure for range determination, or alternative
 - Vehicle selection criteria
 - Statistical method for analysis

Observations of US

- ❖ Japan proposal is a good starting point
 - SOH on OBD helps identify “substandard” products
 - SOH data could be collected at ISC to improve GTR over time
- ❖ “Preliminary” DF could be established now, using current knowledge
 - Find consensus on clearly substandard performance (e.g. 60% @ 3 yrs, or similar)
 - Acts as baseline for all usage cases, to be made more stringent later
 - CoC should continue to show driving range at beginning-of-life
 - E.g. a 60% PR applied to 200 km range when new should not be 120 km on label
- ❖ ISC should take actual usage into account, somehow
 - Very expensive to design battery for the very rarest, extreme use cases
 - If actual usage of ISC vehicle is known, “extreme” use cases could be evaluated differently from “normal” use cases

New concept: Usage Indices (UI) on OBD

- ❖ A way to account for actual usage of vehicle at ISC
- ❖ ECU monitors actual exposure of vehicle over time
 - Converts it to a UI value (e.g. 0 to 1) that is stored in OBD
 - UI to be collected for each of several parameters that affect battery health:
 - Temperature of battery
 - Charge rates
 - Discharge rates
 - Ampere-hour throughput
 - Elapsed time since manufacture
 - Others?
- ❖ Vehicles with extreme UI values at ISC are eliminated, or adjusted
- ❖ Manufacturers are almost certainly already recording many of these parameters, to help with warranty claim assessment

“Durability toolbox”

Tool	What it does	Tasks
DFs/PRs (established concept)	<ul style="list-style-type: none"> Establishes performance requirement 	<ul style="list-style-type: none"> Define preliminary “substandard” baseline PR Refine using incoming SOH data Refine using TEMA and incoming EI data
SOH on OBD (Japan proposal)	<ul style="list-style-type: none"> Represents actual performance Provides data (to refine PRs) 	<ul style="list-style-type: none"> Define basis for determining SOH Validate via testing
UIs on OBD (US proposal)	<ul style="list-style-type: none"> Represents actual usage Distinguishes between normal and extreme usage Provides data to define normal usage 	<ul style="list-style-type: none"> Identify exposures to be indexed (temp, etc) Define how to compute UI index value for each Define “normal” UI values using incoming data
TEMA model (established tool)	<ul style="list-style-type: none"> Relates usage to SOH (to suggest or refine PRs) 	<ul style="list-style-type: none"> Use TEMA to correlate usage with SOH

Possible framework – three phases

- ❖ Phase 1 *(implements data collection mechanism and PR/ISC framework)*
 - Limited scope GTR with consensus PR, OBD requirements, simple ISC
 - Might allow draft GTR by January 2021 target
- ❖ Phase 2 *(tightens PR and considers usage at ISC)*
 - SOH and UI data continues to be collected; “Normal” usage defined
 - PR refined based on TEMA modeling of “normal” usage
 - ISC focuses on vehicles with “normal” UI values from OBD
- ❖ Phase 3 *(allows incoming data to inform PR)*
 - Data-based PR, derived from SOH and UI data from Phases 1 and 2
 - Vehicles with “extreme” UI values either eliminated or adjusted

Phase 1 – OBD and preliminary PR

- ❖ Require SOH on OBD (the Japan proposal)
- ❖ **New:** Require UIs on OBD
- ❖ **New:** Establish preliminary PR
 - Consensus of current knowledge on deterioration and customer expectations
 - It is only a “baseline” to exclude “substandard” performers
- ❖ ISC consists of:
 - Collect SOH and UIs from OBD – for data collection purposes
 - Perform range test by WLTC
 - Measured range must satisfy the preliminary PR
- ❖ Informal GTR draft might be possible by January 2021

Phase 2 – refine PR, consider UIs at ISC

- ❖ Refine PR using modeling
 - Define “normal” usage for each UI factor
 - Use TEMA to refine PR by modeling “normal” usage
 - Determine corresponding “normal” values for each UI by modeling
- ❖ ISC consists of:
 - Collect SOH and UIs from OBD
 - Evaluate only vehicles that have “normal” UIs (eliminate outliers)
 - SOH must satisfy Phase 2 PR
 - Subject to independent verification by WLTC
- ❖ Update GTR (2022-23?)

Phase 3 – data-based PR (or DF)

- ❖ By now, SOH and UI data is coming in from Phase 1 and 2 ISC
- ❖ Refine PR using incoming data and modeling (*or adopt DF*)
 - SOH data collected in Phase 1 and 2
 - Additional TEMA modeling of “normal” usage
- ❖ Use incoming UI data to refine “normal” values for each UI
- ❖ ISC consists of:
 - Collect SOH and UIs from OBD
 - Evaluate only vehicles that had “normal” UIs, or apply adjustment to “extreme”
 - SOH must satisfy Phase 3 PR (or DF)
 - Subject to independent verification by WLTC
- ❖ Update GTR (2024-25?)

Proposed mandate tasks

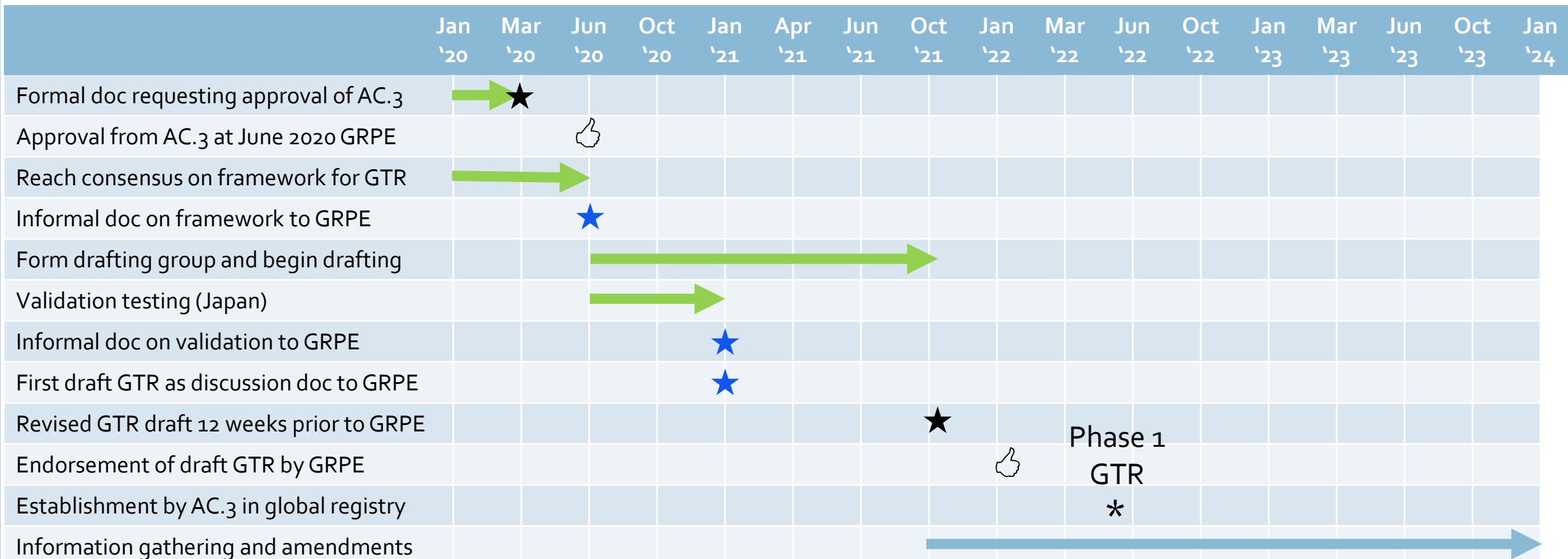
- ❖ (a) Deliver a limited scope GTR to AC.3 by May 2022 with:
 - (i) electrified vehicle battery performance criteria,
 - (ii) OBD requirements on battery health information and usage data; and
 - (iii) a provisional in-service conformity test.
- ❖ (b) Refine performance criteria for in-vehicle battery durability through assessment of further modelling with data collected and developing normal usage criteria
- ❖ (c) Improve GTR and in-service conformity criteria with collected data and updated modelling

Proposed timeline for mandate

👍 approval

★ informal

★ formal



Subject to 1 additional year for Phase 1 GTR or full mandate

Important note

- ❖ All concepts discussed here (Japan, EC, US) address only the impact of energy capacity fade on EV or PHEV electric range
- ❖ They may not fully address:
 - Effect of power fade on air pollutants or energy consumption for HEVs, or blended PHEVs
 - Uncertain if capacity fade is an adequate indication of change in energy consumption for BEV

	Air pollutants	CO2/energy consumption	Electric range
HEV	No	No	n/a
PHEV	partly, via UF	partly, via UF	Yes
BEV	n/a	uncertain	Yes