Discussion materials for new mandate on in-vehicle battery durability

EVE interim teleconference

December 12, 2019

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

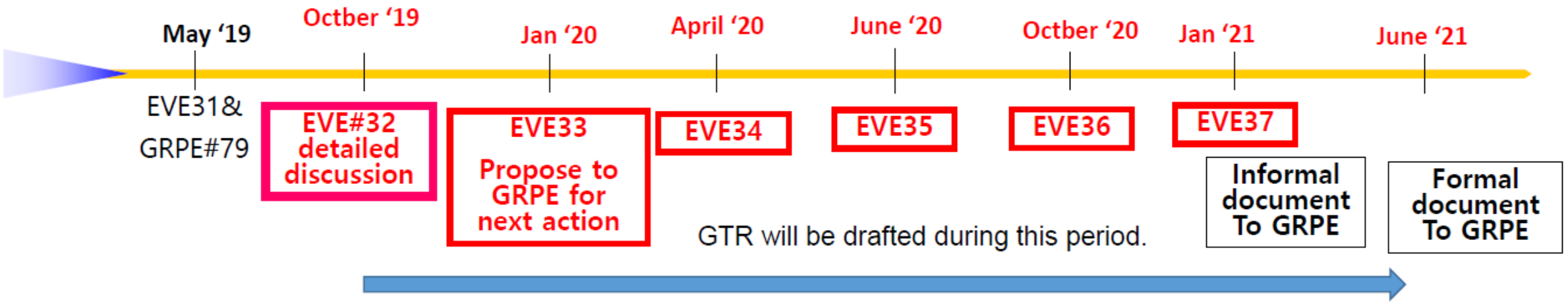
Observations of Japan – EVE32

- 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
  - Verified by ISC (need to define pass/fail criteria, vehicle selection, etc)

European Commission suggestion – EVE32

- Might define DFs (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
- Performance definition component:
  - Use gathered information to further refine DFs
- Performance verification component (ISC):
  - WLTC procedure for range determination, or alternative
  - Vehicle selection criteria
  - Statistical method for analysis

Observations of US (new since EVE32)

- 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 products (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% DF 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: Exposure Indices (EI) on OBD

- A way to account for actual usage of vehicle at ISC
- ECU monitors actual exposure of vehicle over time
  - Converts it to an EI value (e.g. 0 to 1) that is stored in OBD
  - EI 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 EI 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 (established concept)	• Establishes performance requirement	• Define preliminary "substandard" baseline DF • Refine using incoming SOH data • Refine using TEMA and incoming EI data
SOH on OBD (Japan proposal)	• Represents actual performance • Provides data (to refine DFs)	• Define basis for determining SOH • Validate via testing
EIs on OBD (US proposal)	• Represents actual usage • Distinguishes between normal and extreme usage • Provides data to define normal usage	• Identify exposures to be indexed (temp, etc) • Define how to compute EI index value for each • Define "normal" EI values using incoming data
TEMA model (established tool)	• Relates usage to SOH (to suggest or refine DFs)	• Use TEMA to correlate usage with SOH

Possible framework – three phases

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

Phase 1 – OBD and preliminary DF

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

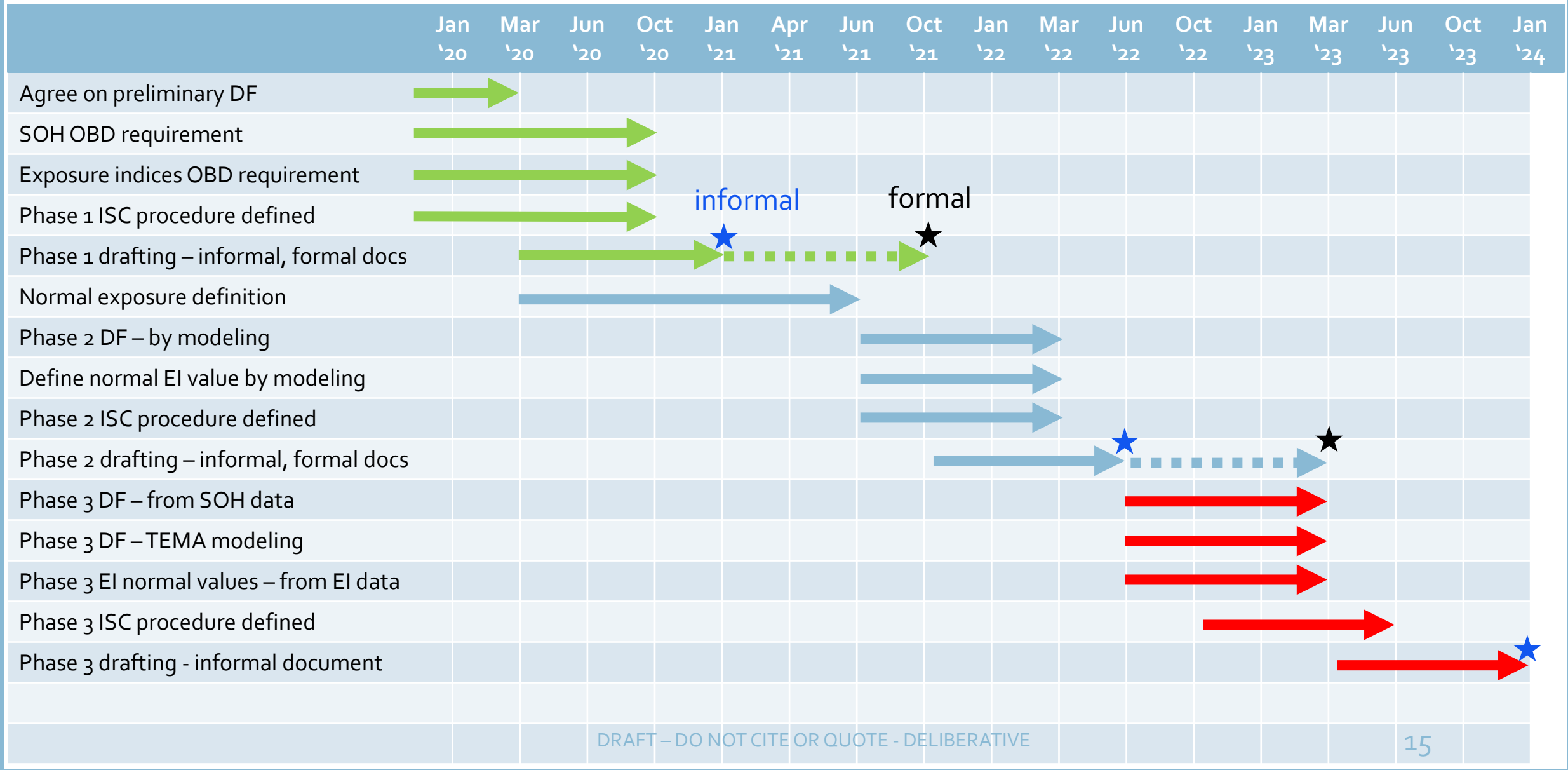
Phase 2 – refine DF, consider EIs at ISC

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

Phase 3 – data-based DF

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

Timeline (conceptual, for discussion only)



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