CALIFORNIA AIR RESOURCES BOARD

HEAVY-DUTY LOW NOx PROGRAM

PUBLIC WORKSHOP

JANUARY 23, 2019

PROPOSED DURABILITY DEMONSTRATION PROGRAM FOR ON-ROAD HEAVY-DUTY DIESEL-CYCLE ENGINES

MOBILE SOURCE CONTROL DIVISION

DURABILITY DEMONSTRATION PROGRAM (DDP) - BACKGROUND

- The objective of the certification DDP is to:
  - Demonstrate that each certified engine family meets the applicable emissions standards at the end of its useful life (UL)
  - Demonstrate emission related component durability throughout UL (subject to scheduled maintenance intervals)
- DDP is a certification requirement
- For heavy-duty diesel engines, DDP is currently performed by aging the engine and aftertreatment system (EAS) to a portion of the useful life (≈35-50% UL) on an engine dynamometer
- Since EAS is currently aged to a portion of UL, the deteriorated full UL emissions are estimated by linear extrapolation of emissions data from the DDP

NO PROPOSED CHANGES FOR HEAVY-DUTY OTTO-CYCLE DDP

- The following proposals apply only to engine families that are certified through heavy-duty diesel test procedures
- Engine families certified through heavy-duty Otto-cycle test procedures will continue to use the existing procedures to demonstrate full UL durability demonstration. Adjustments to the useful life period will need to be considered.

PROPOSED DDP PROCESS

- **Goal**
  - Obtaining Deterioration Factor (DF) values that better reflect real world deterioration for EAS at time of certification
- **Method**
  - Standardizing the DDP Process for 2022 and subsequent model year NEW heavy-duty diesel engine families (does not apply to 2022 model year carryover engine families)
- **Elements**
  - Regenerations prior to emissions tests
  - Break-in Period

  } Applicable to durability & certification engines

  - Standardized Dynamometer Aging Cycles & Accelerated Aftertreatment Aging option
  - Opportunities for validation of durability via in-use and NOx sensor data in 2026+ MY (Alternate Durability Program Concept)

REGENERATIONS BEFORE OFFICIAL EMISSIONS TESTS

- New preconditioning procedures to minimize the impacts of auto and manual regenerations on emissions test results
  - Need to assure that emission levels have stabilized prior to an official emissions test
- Manual regenerations
  - If used, report in the certification application or durability test results
  - No emissions test allowed until 40 hours of service accumulation after each manual regen event
- Auto regenerations (includes: soot cleaning, ammonia de-crystallization, sulfur removal, hydrocarbon removal, etc.)
  - No emissions test allowed until 10 hours of service accumulation after each auto regen event

BREAK-IN PERIOD

- Initial break-in period is required to assure that emissions are stabilized before an official emissions test is conducted
- Survey of on-road heavy-duty diesel-cycle durability data indicate that the current default 125 hours of break-in period is insufficient for achieving stabilized emissions
- Propose to increase the default break-in period to 300 hours
  - Similar to Tier IV off-road compression-ignition engines
- Manufacturers may propose alternate break-in period as described in §86.004-26(c)(4). Must provide actual emission test results at various intervals to verify that FTP, SET and Low Load Cycle (LLC) stabilized emissions have been reached for each engine family

NEED FOR DDP REVISIONS

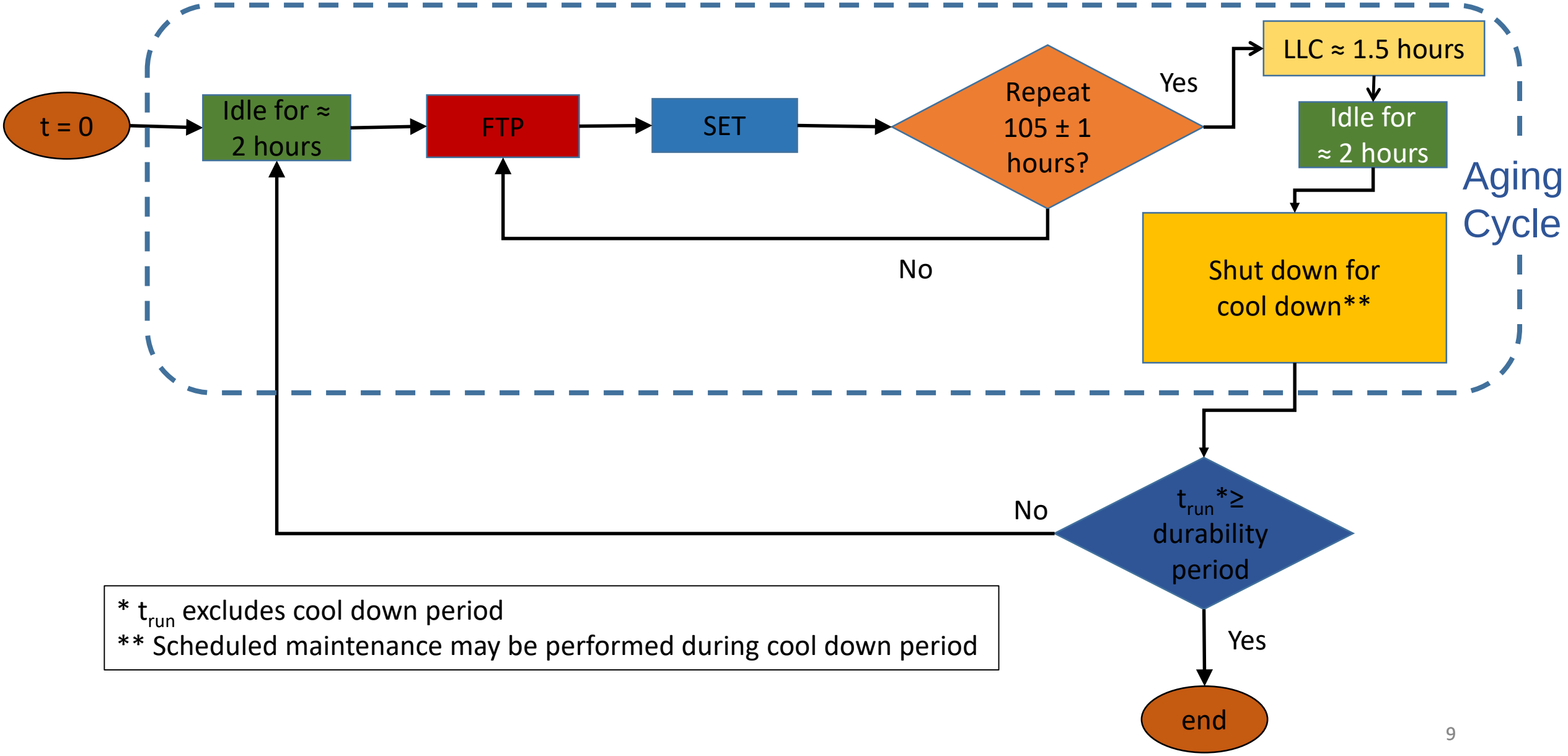
- Staff believes that current 35-50% of UL method does not fully represent real life component failures and emission deterioration of EAS
- Need to enhance the process for EAS aging
- OBD regulations (adopted Nov. 2018) defined a standardized process for OBD-aging
  - Objective is to obtain similar OBD system response between laboratory aging and real-life in-use aging
- Certification DDP objectives & compliance evaluation process are different:
  - Demonstrate emission related component durability,
  - Estimate expected deterioration of EAS over UL, i.e. develop DFs

DDP PROPOSAL

- Goal is to have a program that represents full UL (FUL) EAS aging
- Manufacturers must use standardized DDP process and aging cycles for all certified products
  - For EAS aging on a dynamometer, we propose two possible pathways:
    - Pathway 1 - Use the standardized certification cycles (FTP, SET) for aging
    - Pathway 2 - Use Phase 2 GEM model to create engine aging cycle
    - Select the pathway which yields the highest cycle-average engine power level (CAPL) based on maximum engine power
- An option for using Diesel Aftertreatment Accelerated Aging Cycle (DAAAC*) protocol is proposed for a portion of the durability testing period for HHDD
- Other accelerated aftertreatment aging processes under development may also be considered in lieu of DAAAC (subject to CARB pre-approval)

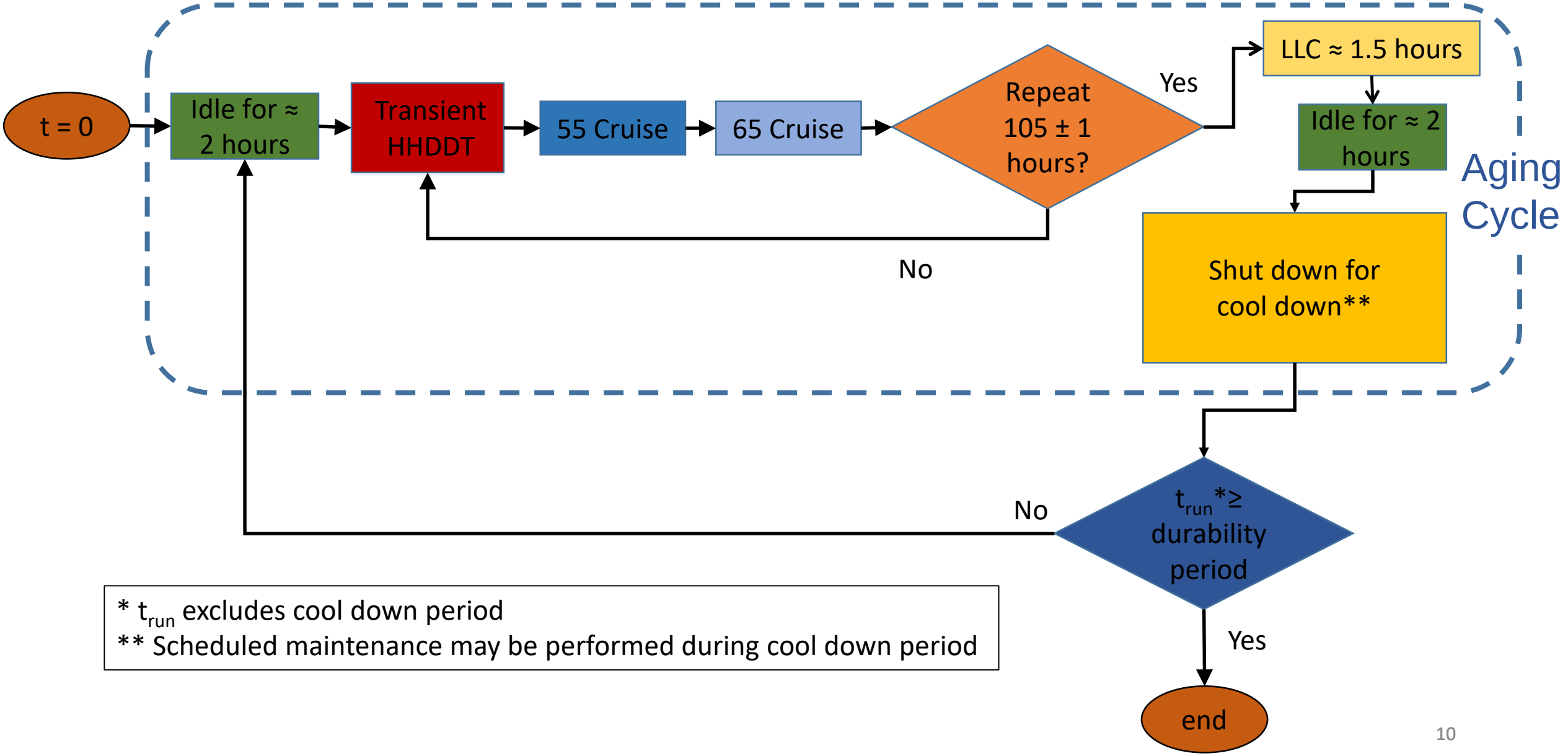
* https://cleers.org/wp-content/uploads/formidable/3/Bartley_CLEERS2012.pdf

Pathway 1 – Engine Certification Cycles



* t_{run} excludes cool down period
** Scheduled maintenance may be performed during cool down period

Pathway 2 – Phase 2 GEM Drive Cycles



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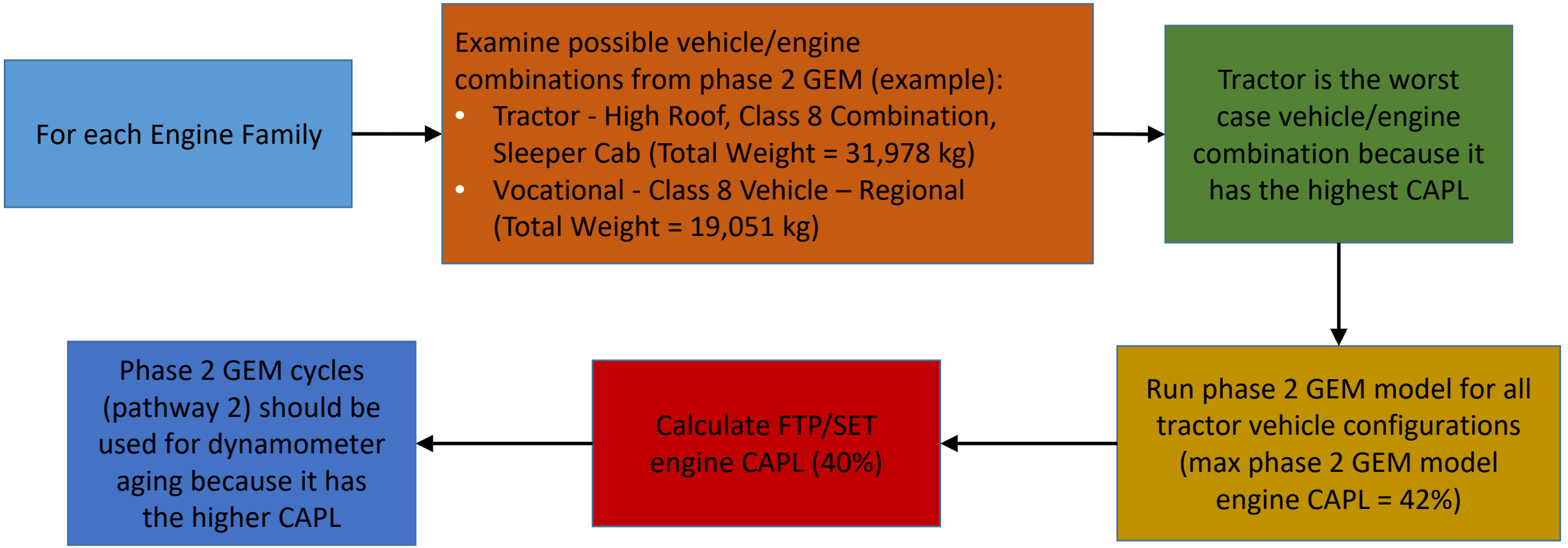
Example – Dynamometer Pathway Selection Process (for illustration purpose only)

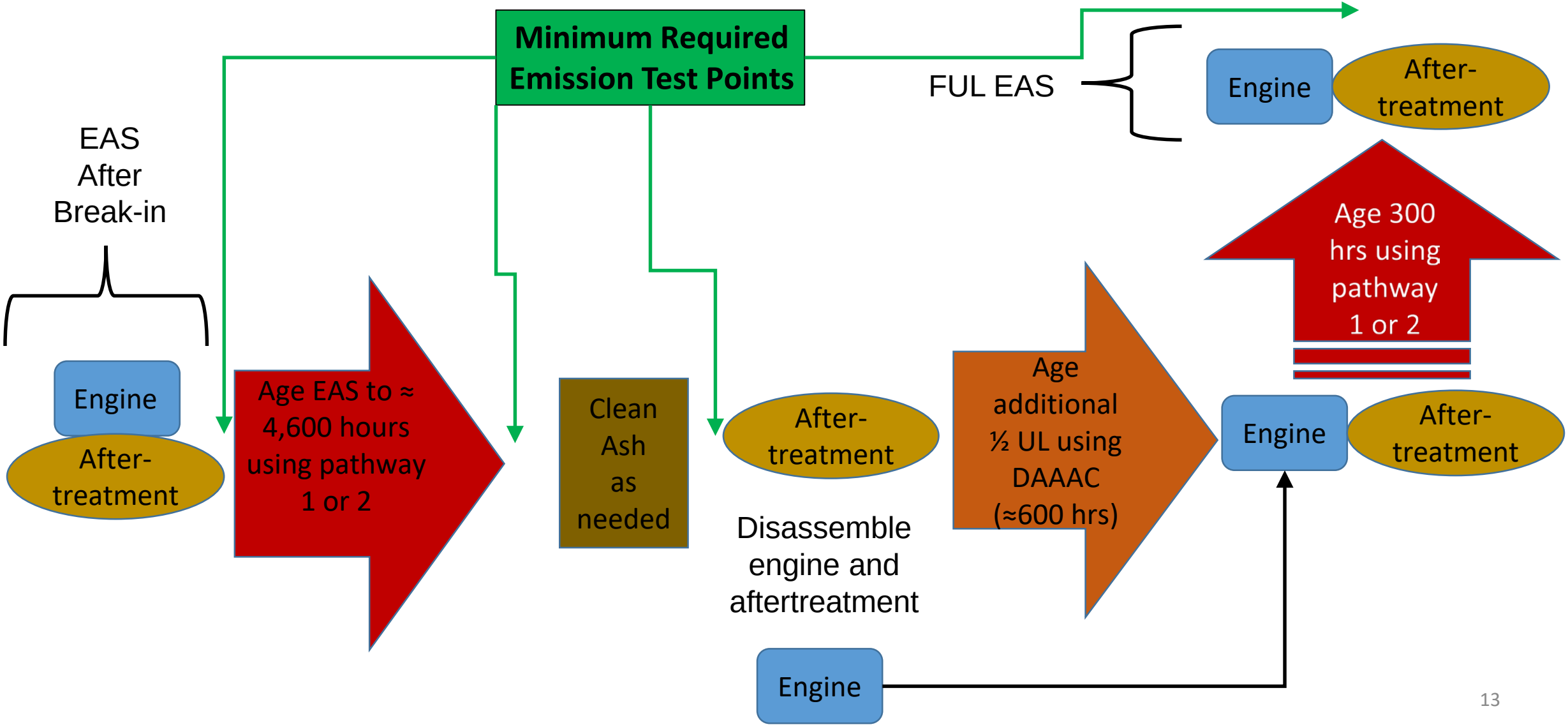


PROPOSED DDP SERVICE ACCUMULATION SCHEDULES

Primary Intended Service Class	Current UL (miles)	DDP Procedures
LHDD	**110,000**	Age EAS on dynamometer to FUL using pathway 1 or 2 cycles **(≈ 2,500* hours)**
MHDD	**185,000**	Age EAS on dynamometer to FUL using pathway 1 or 2 cycles **(≈ 4,200* hours)**
HHDD	**435,000**	Two possible options: • Age EAS on dynamometer to FUL using pathway 1 or 2 cycles **(≈ 9,800* hours)**, or • Age EAS on dynamometer for 4,600 hours using pathway 1 or 2 cycles, and then age aftertreatment only using DAAAC for an additional 500-600 hours (equivalent to ½ UL). Age for 300 additional dyno hours **(≈ 5,500* hours).** This option requires NOx sensor data submittal.

* Service accumulation schedule DOES NOT INCLUDE time required for cool down. Assumes 11 MPH average speed and 1.5 hour duration for LLC (subject to change).

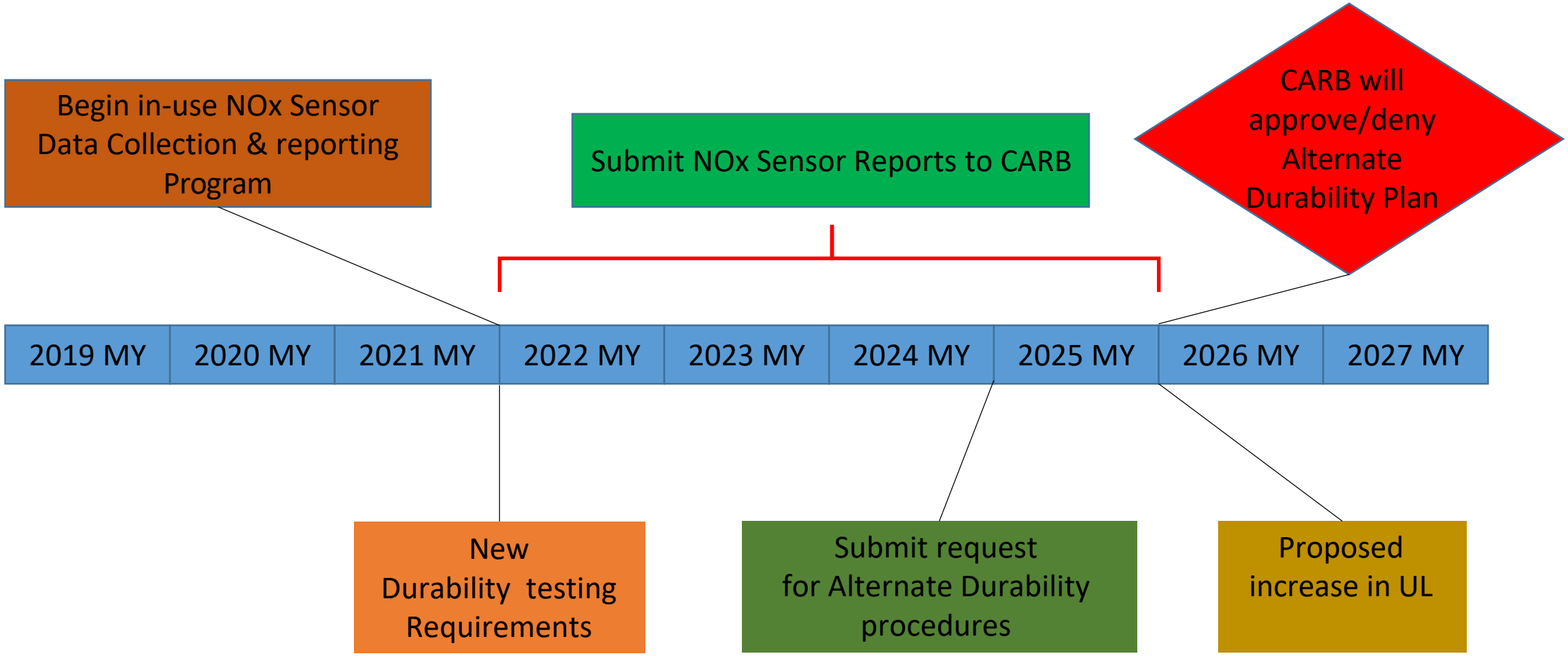
Combined Dyno aging + DAAAC Protocol for HHDD (UL = 435,000 miles)



ALTERNATE DURABILITY PROGRAM CONCEPT (2026+ MY)

- CARB is considering an increase to UL for all HD primary intended service classes beyond current values starting with 2026 MY
- By 2026 MY, CARB anticipates that a combination of in-use test data, lab aging data, and NOx sensor reporting may lead to the development of an alternate durability program that relies on submittal of NOx sensor reports combined with a shortened lab aging program
- Manufacturers with high emission related component failure rates may not be eligible to use the accelerated aftertreatment aging option or alternate durability program

Timeline – Alternate Durability Program Concept



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