Safety and batteries

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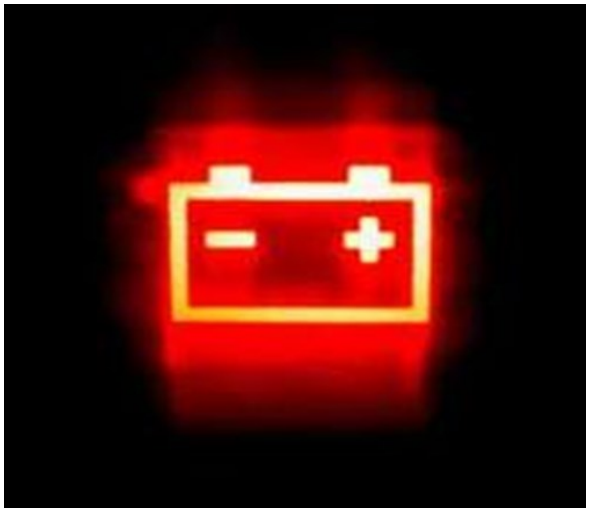


What does safety mean?

- Oxford Dictionary:

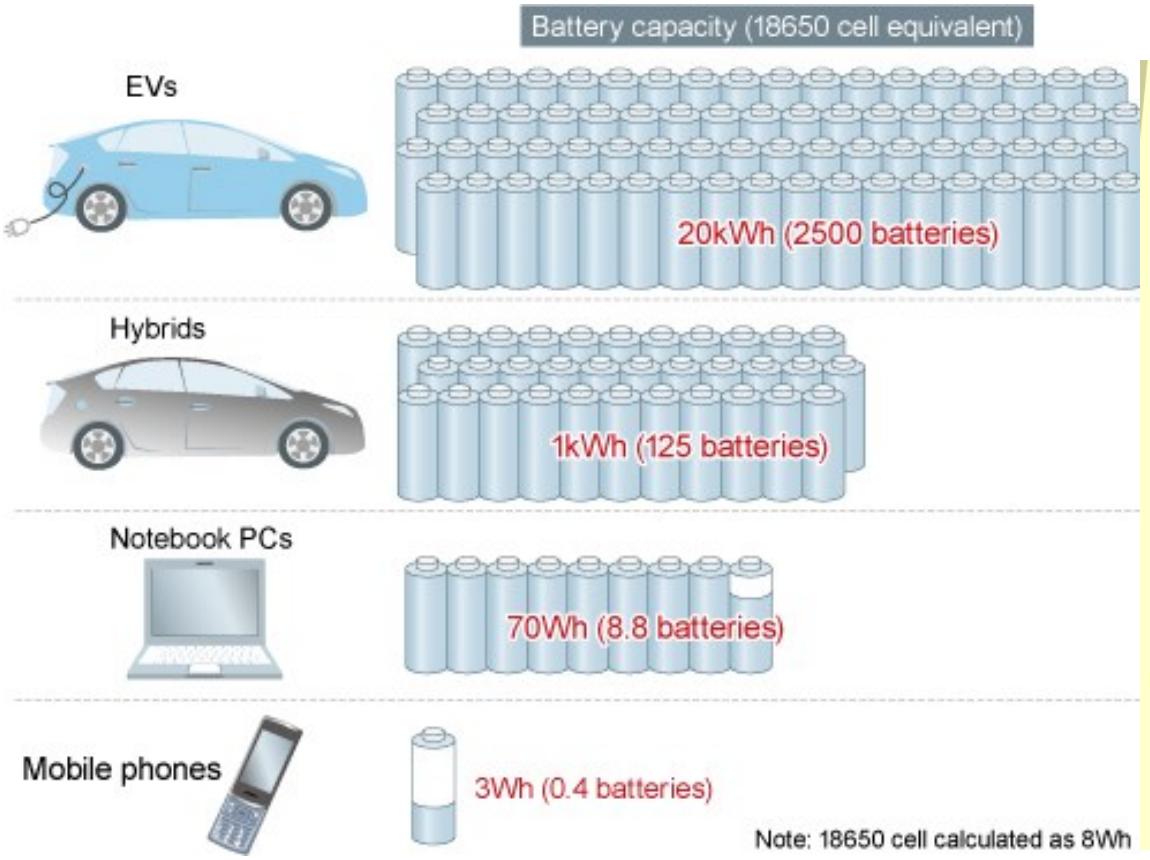
  ”The condition of being protected from or unlikely to cause danger, harm or injury”

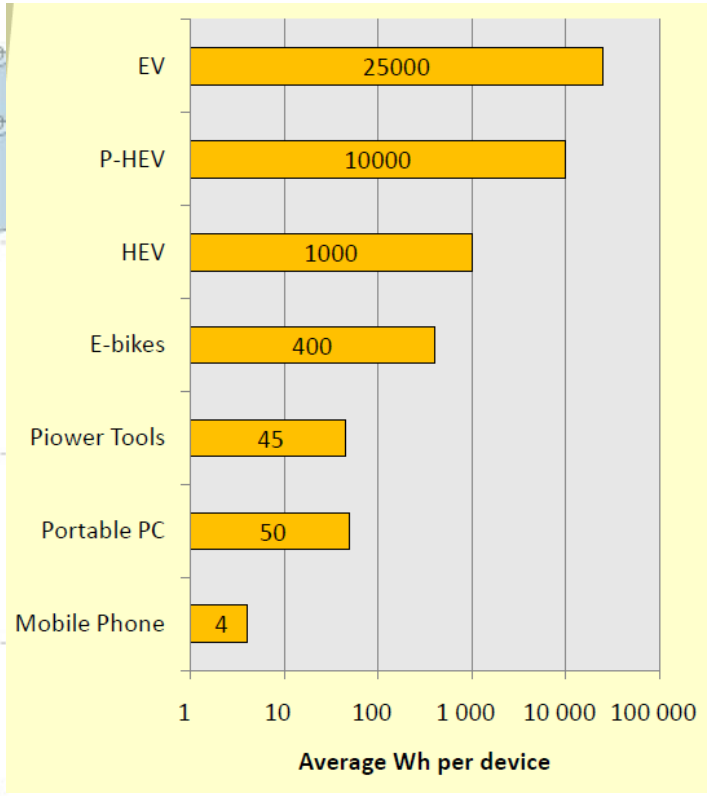
- Safety is relative.
- Eliminating all risk, if even possible, would be extremely difficult and very expensive. A situation is safe when risks of injury or property damage are low and manageable

Different kinds of safety

- **Normative safety**
  - ”objective”
  - achieved when a product or design meets applicable standards and/or practices, regardless of the product's actual safety history
- **Perceived safety**
  - subjective
  - refers to the users' level of comfort and perception of risk

Relative energy contents





Source: Nikkei Electronics Asia, Feb 2010

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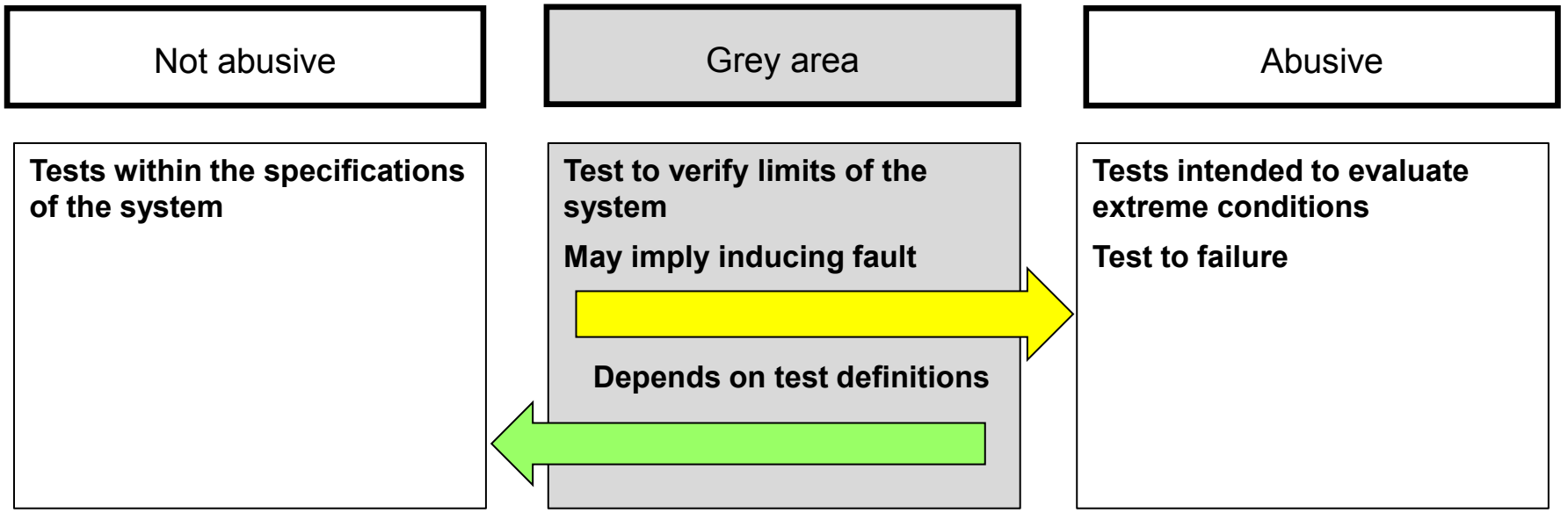
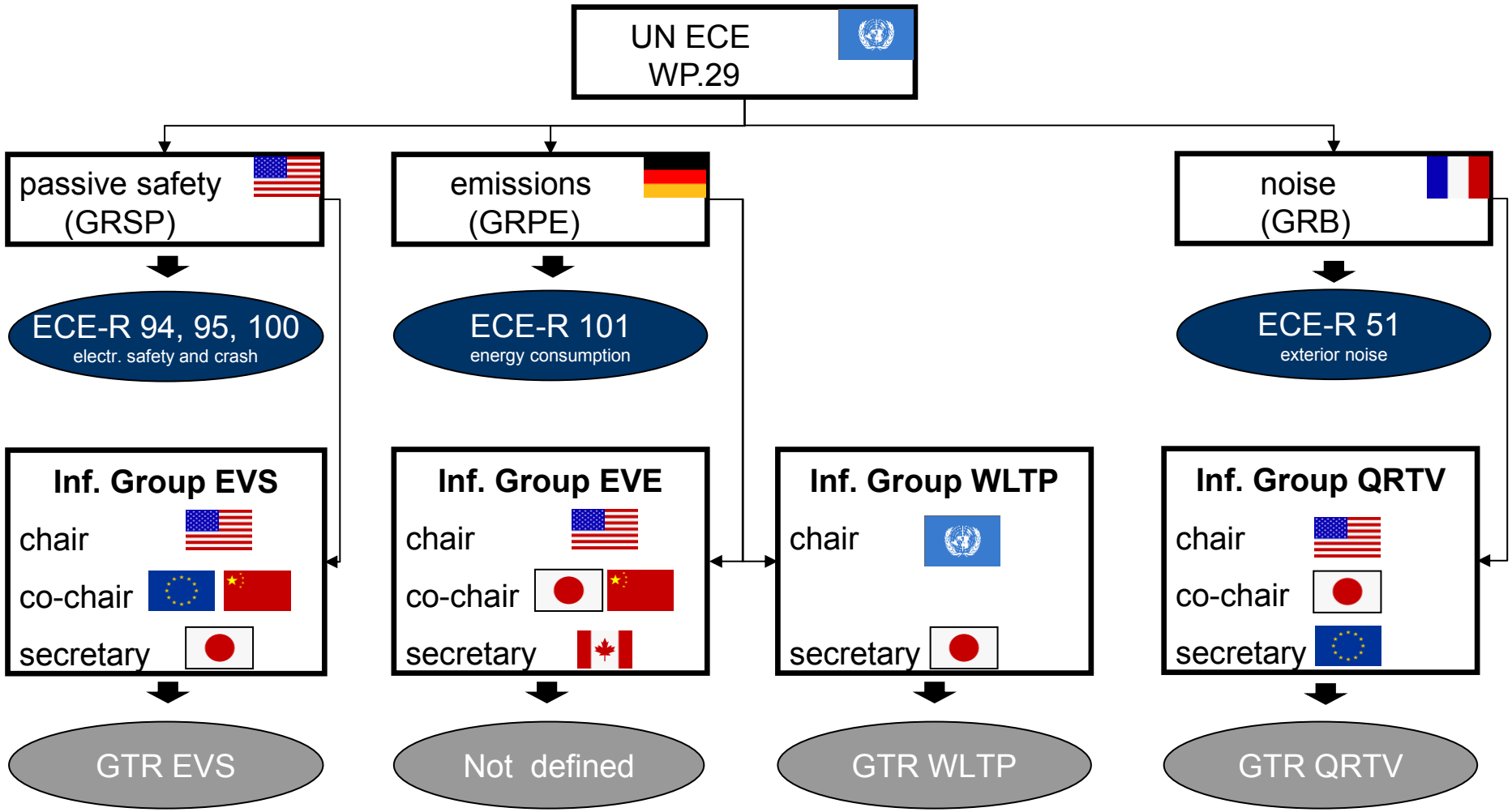
What is acceptable safety?

- Equivalent safety to competing technologies
- Normal operating conditions vs abuse conditions
  - Acceptance criteria
  - What needs to be regulated and what can be left to ”the market”?



The boundary between abusive and non-abusive tests is not clear cut.

UN ECE working structure for Global Technical Regulations (EV focus)



GTR – global technical regulation

QRTV – quiet road transport vehicle

WLTP – world wide light duty test procedure

GRB – Groupe rapporteur de la bruit

GRSP – Groupe rapporteur de la sécurité passive

GRPE – Groupe rapporteur de la pollution et de l'éngergie

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UN ECE Vehicle regulation – R100

- UN 1954 vehicle agreement – 41 countries, mainly Europe
- Electrical safety requirements during normal conditions
  - Vibration
  - Thermal shock and cycling
  - Mechanical impact
  - Mechanical integrity
  - External fire exposure (short term)
  - External short circuit protection
  - Overcharge protection
  - Underdischarge protection
  - Overtemperature protection

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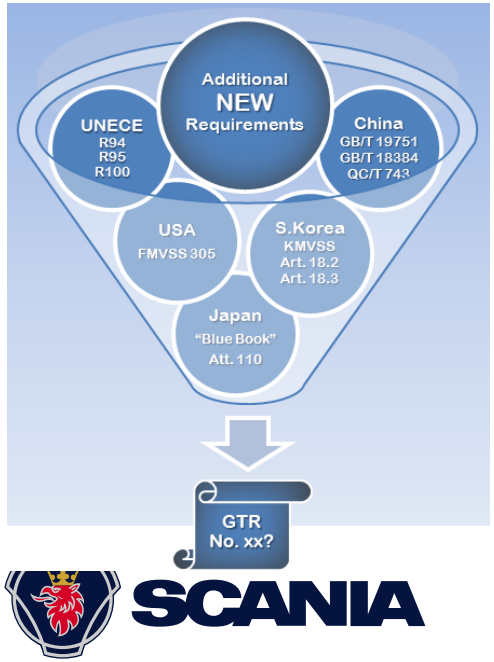
UN ECE vehicle regulation – EVS-GTR – the next step

- UN 1998 Vehicle regulations agreement
- 2016 Planned completion of phase 1 as informal document
- Topics requiring additional research are postponed to phase 2
- Expanded scope – operation and post crash
  - New tests and pass/fail criteria compared to R100_02
    - Water resistance
    - Thermal propagation
    - Electrolyte leakage and venting
  - Harmonization between R100_02 and EVS-GTR will occur



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What is the pivotal issue?

- Thermal runaway in a Li ion cell resulting in thermal propagation
- China & Japan proposes thermal initiation by
  - Partial Nail penetration
  - Localized heat element
- Initiation must lead to thermal runaway in initiated cell
- No propagation to adjacent cells is allowed
  - No fire
  - No explosion

Venting is a controversial topic!

- Venting is normally considered a safety feature on a battery cell
- Venting releases mixture of electrolyte decomposition products
- Gas mixture may contain flammable and/or toxic constituents
- Emitted gases in case of cell/battery failure must be managed to prevent potential harmful effects on vehicle occupants.

Conclusions

- Perception of safety is plays a major role in technology acceptance
- There is a lack of confidence in real safety characteristics of high energy density battery technologies, i.e. Li ion batteries
- System safety concept is too abstact outside of engineering/technical contexts
- Challenging to define ”objective” test methods to verify ”subjective” safety risks
- Failure to address perceived safety concerns may lead to technology restrictive/prohibitive requirements and tests
  - Thermal propagation
  - Toxicity of battery emissions in case of failure