MACHINE
Car_M1
REFINES
ControlledSystem
SEES
Car_C1
VARIABLES t, x_s, v, x
INVARIANTS
inv1: $v \in RRealPlus \to RReal$
inv2: $x \in RRealPlus \to RReal$
inv3: $x\_p = bind(v, x)$
inv4: $\forall t0 \cdot t0 \in RRealPlus \Rightarrow Rzero \mapsto v(t0) \in leq$
inv5: $\forall t0 \cdot t0 \in RRealPlus \wedge x\_s = stopped \Rightarrow x(t0) \mapsto SP \in leq$
EVENTS
INITIALISATION
WITH
x_p': $x\_p' = bind(v', x')$
THEN
act1: $t := Rzero$
act2:
$v, x :|$
$x' \in RRealPlus \to RReal \wedge v' \in RRealPlus \to RReal \wedge$
$solutionOf(RRealPlus, bind(v', x'), ode(f\_stable, (v0 \mapsto Rzero), Rzero))$
act3: $x\_s := stabilizing$
END

Progress
REFINES *Progress*
THEN
act1: $t :| t' \in RRealPlus \wedge (t \mapsto t' \in lt)$
END

Behave
REFINES *Behave*
ANY e
WHERE
grd1: $e \in DE(S)$
grd2: $Solvable(Closed2Infinity(t), e)$
WITH
x_p': $x\_p' = bind(v', x')$
THEN
act1:
$v, x :|$
$x' \in RRealPlus \to RReal \wedge v' \in RRealPlus \to RReal \wedge$
$AppendSolutionBAP($
$e,$
$RRealPlus,$
$Closed2Open(Rzero, t), Closed2Infinity(t),$
$bind(v, x), bind(v', x')$
$)$
END

Transition
REFINES *Transition*
ANY s
WHERE
grd1: $s \in \mathbb{P}1(STATES)$
THEN
act1: $x\_s :\in s$
END

ctrl_sense_near_stop
REFINES *Sense*
WHERE
grd1: $plus(x(t) \mapsto divide(times(v(t) \mapsto v(t)) \mapsto times(Rtwo \mapsto b))) \mapsto SP \in geq$
grd2: $v(t) \mapsto Rzero \in gt$
WITH
s: $s = \{nearing\_stop\}$
p:
$p = STATES \times RReal \times \{v\_ \mapsto x\_ \mid plus(x\_ \mapsto divide(times(v\_ \mapsto v\_) \mapsto times(Rtwo \mapsto b))) \mapsto SP \in geq \wedge v\_ \mapsto Rzero \in gt\}$
THEN
act1: $x\_s := nearing\_stop$

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END

ctrl_sense_stopping
REFINES Sense
WHERE
  grd1: v(t) = Rzero
WITH
  s: s = {stabilizing, stopped}
  p: p = STATES × RReal × {v_ ↦ x_ | v_ = Rzero ∧ x_ ∈ RReal}
THEN
  act1:
    x_s :|
      (x_s = nearing_stop ⇒ x_s' = stopped) ∧
      (x_s ≠ nearing_stop ⇒ x_s' = stabilizing)
END

ctrl_sense_user_input_accelerate
REFINES Sense
WHERE
  grd1: plus(x(t) ↦ divide(times(v(t) ↦ v(t)) ↦ times(Rtwo ↦ b))) ↦ SP ∈ lt
WITH
  s: s = {accelerating}
  p: p = STATES × RReal × {v_ ↦ x_ | plus(x_ ↦ divide(times(v_ ↦ v_) ↦ times(Rtwo ↦ b))) ↦ SP ∈ lt}
THEN
  act1: x_s := accelerating
END

ctrl_sense_user_input_stabilize
REFINES Sense
WHERE
  grd1: plus(x(t) ↦ divide(times(v(t) ↦ v(t)) ↦ times(Rtwo ↦ b))) ↦ SP ∈ lt
WITH
  s: s = {stabilizing}
  p: p = STATES × RReal × {v_ ↦ x_ | plus(x_ ↦ divide(times(v_ ↦ v_) ↦ times(Rtwo ↦ b))) ↦ SP ∈ lt}
THEN
  act1: x_s := stabilizing
END

ctrl_sense_user_input_brake
REFINES Sense
WHERE
  grd1: v(t) ↦ Rzero ∈ gt
WITH
  s: s = {braking}
  p: p = STATES × RReal × {v_ ↦ x_ | v_ ↦ Rzero ∈ gt ∧ x_ ∈ RReal}
THEN
  act1: x_s := braking
END

ctrl_actuate_brake
REFINES Actuate
WHERE
  grd1: x_s ∈ {braking, nearing_stop}
WITH
  e: e = ode(f_deceleration(t ↦ v(t)), (v(t) ↦ x(t)), t)
  s: s = {braking, nearing_stop}
  x_p': x_p' = bind(v', x')
THEN
  act1:
    v, x :|
      x' ∈ RRealPlus → RReal ∧ v' ∈ RRealPlus → RReal ∧
      AppendSolutionBAP(
        ode(f_deceleration(t ↦ v(t)), (v(t) ↦ x(t)), t),
        RRealPlus,
        Closed2Open(Rzero, t), Closed2Infinity(t),
        bind(v, x), bind(v', x')
      )
END

ctrl_actuate_accelerate
REFINES Actuate
WHERE
  grd1: x_s = accelerating
WITH
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    e: e = ode(f_acceleration, (v(t) ↦ x(t)), t)
    s: s = {accelerating}
    x_p': x_p' = bind(v', x')
  THEN
    act1:
      v, x :|
        x' ∈ RRealPlus → RReal ∧ v' ∈ RRealPlus → RReal∧
        AppendSolutionBAP(
          ode(f_acceleration, (v(t) ↦ x(t)), t),
          RRealPlus,
          Closed2Open(Rzero, t), Closed2Infinity(t),
          bind(v, x), bind(v', x')
        )
  END

  ctrl_actuate_stabilize
  REFINES Actuate
  WHERE
    grd1: x_s ∈ {stabilizing, stopped}
  WITH
    e: e = ode(f_stable, (v(t) ↦ x(t)), t)
    s: s = {stabilizing, stopped}
    x_p': x_p' = bind(v', x')
  THEN
    act1:
      v, x :|
        x' ∈ RRealPlus → RReal ∧ v' ∈ RRealPlus → RReal∧
        AppendSolutionBAP(
          ode(f_stable, (v(t) ↦ x(t)), t),
          RRealPlus,
          Closed2Open(Rzero, t), Closed2Infinity(t),
          bind(v, x), bind(v', x')
        )
  END

END
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