–––––––––––––––––– MODULE SCS ––––––––––––––––––

This specification expresses the actions/states that happens arround cruise control system. Speed increase/decrease, car braking, etc are some behaviours that are somehow realated with a car with cruise control system.

$\#$

EXTENDS $Integers$

$\#$

VARIABLES $acousticWarn$, $brakePedal$, cc, $desiredLimit$, $desiredSpeed$, $engine$, $frontCarGap$, $gasPedal$, $lever$, sl, $slWarn$, $speed$, $visualWarn$

$\#$

Macro variables are established below.

$critical \triangleq 4$
$maxSpeed \triangleq 4$
$minSpeed \triangleq 2$
$none \triangleq 1$
$safe \triangleq 2$
$speedVariation \triangleq 1$
$stopped \triangleq 1$
$unsafe \triangleq 3$

$\#$

Anyone who wants to see if something is working/happening must enter below a predicate (which will be an invariant) where model will certainly fail, in order to see the steps until the desired state.

This invariant will force TLC to show a sequence of states before speed equals $desiredLimit$ when the speed limit function is available.
$End \triangleq \neg(speed = desiredLimit \wedge sl = \text{"on"})$

This invariant will force TLC to show a sequence of states before engine turns off. Note that engine's init state needs to be modified to "on" or TLC will always find this invariant to be false at the init state.
$End \triangleq engine \neq \text{"off"}$

This invariant will force TLC to show a sequence of states before engine turns off with speed limit function activated. Note that engine's init state needs to be modified to "on" or TLC will always find this invariant to be false at the init state.
$End \triangleq \neg(engine = \text{"off"} \wedge sl = \text{"off"})$

This invariant will force TLC to show a sequence of states before speed equals desired speed in order to check if, before that and after cruise control is activated, the lever turns, for example, position 3.

$End \triangleq \neg(cc = \text{"on"} \land speed \neq desiredSpeed \land lever = 3)$

This invariant will force TLC to show a sequence of states where $desiredLimit$ is either 2, 3 or 4.

$End \triangleq \neg(desiredLimit = 2) \land \neg(desiredLimit = 3) \land \neg(desiredLimit = 4)$

This invariant will force TLC to show a sequence of states where lever turns to 5, which turns the speed limit function off (it also turns it on but that's not what we want to check here.

$End \triangleq \neg(lever = 5 \land sl = \text{"off"})$

This invariant will force TLC to show a sequence of states where speed limit LED lights up (that happens when speed limit function is activated).

$End \triangleq \neg(slWarn = \text{"on"})$

$End \triangleq 1 = 1$

$$\#$$

$SCS1$

$SCS1 \triangleq (engine = \text{"off"}) \Rightarrow (desiredSpeed = none)$

$SCS2$

$SCS2 \triangleq (lever = 1) \Rightarrow \lor desiredSpeed = none$
$\lor speed < desiredSpeed$
$\lor speed > desiredSpeed$
$\lor speed = desiredSpeed$

$SCS3 -$ Assuming that below $20km/$h is equal to stopped.

$SCS3 \triangleq (speed = stopped \land desiredSpeed = none) \Rightarrow cc = \text{"off"}$

$SCSA - SCSA$ gathers $SCSs$ 4, 5, 7 and 8, assuming that the lever doesn't have resistance levels and that pushing the lever to 2 only increases the desired speed, under normal conditions (with speed limit function off).

$SCSA \triangleq (lever = 2 \land sl = \text{"off"}) \Rightarrow (desiredSpeed = desiredSpeed + speedVariation)$

$SCSB - SCSB$ gathers $SCSs$ 6, 9 and 10, assuming that the lever doesn't have resistance levels and that pushing the lever to 3 only decreases the desired speed, under normal conditions (with speed limit function off).

$SCSB \triangleq (lever = 3 \land sl = \text{"off"}) \Rightarrow (desiredSpeed = desiredSpeed - speedVariation)$

$SCS11$

$SCS11 \triangleq \land lever = 2 \lor lever = 3$
$\land cc = \text{"off"}$
$\land sl = \text{"off"}$

2

$$\Rightarrow (desiredSpeed = speed)$$

isto igual ao que est em cima certo ???
$SCS11 \triangleq ((lever = 2 \lor lever = 3) \land cc = \text{``off''} \land sl = \text{``off''}) \Rightarrow (desiredSpeed = speed)$

$SCS12$

$SCS12 \triangleq lever = 4 \Rightarrow cc = \text{``off''}$

$SCS13$

$SCS13 \triangleq lever = 1 \Rightarrow cc = \text{``on''}$

$SCS14$

$SCS15$

$SCS15 \triangleq (cc = \text{``on''} \land gasPedal = \text{``pressed''}) \Rightarrow speed > desiredSpeed$

$SCS16$

$SCS16 \triangleq brakePedal = \text{``pressed''} \Rightarrow cc = \text{``off''}$

$SCS17$

$SCS17 \triangleq lever = 4 \Rightarrow cc = \text{``off''}$

$SCS18$

$SCS19$

$SCS25 -$ Assuming that visual warning is activated if the actual distance is either unsafe or critical.

$SCS25 \triangleq (frontCarGap = unsafe \lor frontCarGap = critical) \Rightarrow visualWarn = \text{``on''}$

$SCS26 -$ Assuming that acoustic warning is activated if the actual distance is critical.

$SCS26 \triangleq frontCarGap = critical \Rightarrow acousticWarn = \text{``on''}$

$SCS29$

$SCS29 \triangleq (lever = 5 \land sl = \text{``on''}) \Rightarrow sl = \text{``on''}$

$SCS30$

$SCS30 \triangleq \land sl = \text{``on''} \Rightarrow slWarn = \text{``on''}$
$\qquad\qquad \land sl = \text{``off''} \Rightarrow slWarn = \text{``off''}$

$SCS31$

$SCS31 \triangleq \land ((lever = 2) \land (sl = \text{``on''})) \Rightarrow speed < desiredLimit$
$\qquad\qquad \land ((lever = 3) \land (sl = \text{``on''})) \Rightarrow speed \leq desiredLimit$

$SCS32$

$SCS32 \triangleq sl = \text{``on''} \Rightarrow speed \leq desiredLimit$

$SCS35 \stackrel{\Delta}{=} \wedge lever = 4 \Rightarrow sl = \text{``off''}$
$\qquad\qquad\quad \wedge (lever = 5 \wedge sl = \text{``off''}) \Rightarrow sl = \text{``off''}$

This predicate assures that the following specifications are true.

$SCSsOK \stackrel{\Delta}{=} \wedge SCS1$
$\qquad\qquad\quad \wedge SCS2$
$\qquad\qquad\quad \wedge SCS3$
$\qquad\qquad\quad \wedge SCSA$
$\qquad\qquad\quad \wedge SCSB$
$\qquad\qquad\quad \wedge SCS11$
$\qquad\qquad\quad \wedge SCS12$
$\qquad\qquad\quad \wedge SCS13$
$\qquad\qquad\quad \wedge scs14$
$\qquad\qquad\quad \wedge SCS15$
$\qquad\qquad\quad \wedge SCS16$
$\qquad\qquad\quad \wedge SCS17$
$\qquad\qquad\quad \wedge SCS19$
$\qquad\qquad\quad \wedge SCS25$
$\qquad\qquad\quad \wedge SCS26$
$\qquad\qquad\quad \wedge SCS29$
$\qquad\qquad\quad \wedge SCS30$
$\qquad\qquad\quad \wedge SCS31$
$\qquad\qquad\quad \wedge SCS32$
$\qquad\qquad\quad \wedge SCS33$
$\qquad\qquad\quad \wedge SCS34$
$\qquad\qquad\quad \wedge SCS35$

$$\#$$

This predicate is an invariant and remains true across all of the states. It establishes the type of each variable.

$TypeOK \stackrel{\Delta}{=} \wedge acousticWarn \in \{\text{``off''}, \text{``on''}\}$
$\qquad\qquad\quad \wedge brakePedal \quad\ \in \{\text{``pressed''}, \text{``unpressed''}\}$
$\qquad\qquad\quad \wedge cc \qquad\qquad\ \in \{\text{``off''}, \text{``on''}\}$
$\qquad\qquad\quad \wedge desiredLimit \ \in none \mathinner{\ldotp\ldotp} maxSpeed$ 1-none 2-slow 3-medium 4-fast
$\qquad\qquad\quad \wedge desiredSpeed \in none \mathinner{\ldotp\ldotp} maxSpeed$ 1-none 2-slow 3-medium 4-fast
$\qquad\qquad\quad \wedge engine \qquad \in \{\text{``off''}, \text{``on''}\}$
$\qquad\qquad\quad \wedge frontCarGap \ \in none \mathinner{\ldotp\ldotp} critical$ 1-none 2-safe 3-unsafe 4-critical
$\qquad\qquad\quad \wedge gasPedal \qquad \in \{\text{``pressed''}, \text{``unpressed''}\}$
$\qquad\qquad\quad \wedge lever \qquad\quad \in 0 \mathinner{\ldotp\ldotp} 5$
$\qquad\qquad\quad \wedge sl \qquad\qquad\ \in \{\text{``off''}, \text{``on''}\}$
$\qquad\qquad\quad \wedge slWarn \qquad\ \in \{\text{``off''}, \text{``on''}\}$
$\qquad\qquad\quad \wedge speed \qquad\quad \in stopped \mathinner{\ldotp\ldotp} maxSpeed$ 1-stopped 2-slow 3-medium 4-fast

4

$$\wedge\, visualWarn \quad \in \{\,\text{``off''},\ \text{``on''}\,\}$$

This predicate is another invariant and remains true across all of the states. It's different than the other above because it assures properties not related with variables types.

$PropertiesOK \;\triangleq\; 1 = 1$ Not necessary.

Defines initial state.

$$
\begin{aligned}
Init \;\triangleq\; &\wedge\, acousticWarn = \text{``off''}\\
&\wedge\, brakePedal \quad = \text{``unpressed''}\\
&\wedge\, cc \qquad\qquad\ = \text{``off''}\\
&\wedge\, desiredLimit \ = none\\
&\wedge\, desiredSpeed \ = none\\
&\wedge\, engine \qquad\ \ = \text{``off''}\\
&\wedge\, frontCarGap \ = none\\
&\wedge\, gasPedal \qquad = \text{``unpressed''}\\
&\wedge\, lever \qquad\qquad = 0\\
&\wedge\, sl \qquad\qquad\ \ = \text{``off''}\\
&\wedge\, slWarn \qquad\ = \text{``off''}\\
&\wedge\, speed \qquad\quad = stopped\\
&\wedge\, visualWarn \quad = \text{``off''}
\end{aligned}
$$

Puts speed equal to *desiredSpeed*.

$$
\begin{aligned}
ApproachesDesiredSpeed \;\triangleq\; \text{IF }\ &speed < desiredSpeed\\
\text{THEN }\ &speed' = speed + 1\\
\text{ELSE }\ &speed' = speed - 1
\end{aligned}
$$

The car brakes and reduces current speed (in one unit).

$$
\begin{aligned}
Brake \;\triangleq\; &\wedge\, engine \qquad\quad = \text{``on''}\\
&\wedge\, gasPedal \qquad = \text{``unpressed''}\\
&\wedge\, lever \qquad\qquad = 0\\
&\wedge\, speed \qquad\qquad > stopped\\
&\wedge\, acousticWarn' = acousticWarn\\
&\wedge\, brakePedal' \quad\ = \text{``pressed''}\\
&\wedge\, cc' \qquad\qquad\ \ = \text{``off''}\\
&\wedge\, desiredLimit' \ = desiredLimit\\
&\wedge\, desiredSpeed' \ = desiredSpeed
\end{aligned}
$$

5

$$
\begin{aligned}
&\wedge\ engine' && = engine \\
&\wedge\ frontCarGap' && = frontCarGap \\
&\wedge\ gasPedal' && = gasPedal \\
&\wedge\ lever' && = lever \\
&\wedge\ sl' && = sl \\
&\wedge\ slWarn' && = slWarn \\
&\wedge\ speed' && = speed - speedVariation \\
&\wedge\ visualWarn' && = visualWarn
\end{aligned}
$$

Decreases front car gap from safe to unsafe or from unsafe to critical, activating the corresponding warnings.

$DecreaseFrontCarGap \triangleq$
$$
\begin{aligned}
&\wedge\ cc && = \text{``on''} \\
&\wedge\ engine && = \text{``on''} \\
&\wedge\ frontCarGap && < critical \\
&\wedge\ lever && = 0 \\
&\wedge\ \text{IF } frontCarGap = 3 \\
&\qquad \text{THEN } \wedge\ acousticWarn' = \text{``on''} \\
&\qquad\qquad\qquad \wedge\ visualWarn' = \text{``on''} \\
&\qquad \text{ELSE } \text{IF } frontCarGap = 2 \\
&\qquad\qquad\qquad \text{THEN } \wedge\ acousticWarn' = \text{``off''} \\
&\qquad\qquad\qquad\qquad\qquad \wedge\ visualWarn' = \text{``on''} \\
&\qquad\qquad\qquad \text{ELSE } \wedge\ acousticWarn' = \text{``off''} \\
&\qquad\qquad\qquad\qquad\qquad \wedge\ visualWarn' = \text{``off''} \\
&\wedge\ brakePedal' && = brakePedal \\
&\wedge\ cc' && = cc \\
&\wedge\ desiredLimit' && = desiredLimit \\
&\wedge\ desiredSpeed' && = desiredSpeed \\
&\wedge\ engine' && = engine \\
&\wedge\ frontCarGap' && = frontCarGap + 1 \\
&\wedge\ gasPedal' && = gasPedal \\
&\wedge\ lever' && = lever \\
&\wedge\ sl' && = sl \\
&\wedge\ slWarn' && = slWarn \\
&\wedge\ speed' && = speed
\end{aligned}
$$

Decreases current speed (in one unit).

$DecreaseSpeed \triangleq$
$$
\begin{aligned}
&\wedge\ brakePedal && = \text{``unpressed''} \\
&\wedge\ cc && = \text{``off''} \\
&\wedge\ engine && = \text{``on''} \\
&\wedge\ gasPedal && = \text{``unpressed''} \\
&\wedge\ lever && = 0 \\
&\wedge\ speed && > stopped \\
&\wedge\ acousticWarn' && = acousticWarn \\
&\wedge\ brakePedal' && = brakePedal \\
&\wedge\ cc' && = cc
\end{aligned}
$$

$$\begin{aligned}
&\wedge\ desiredLimit' &&= desiredLimit\\
&\wedge\ desiredSpeed' &&= desiredSpeed\\
&\wedge\ engine' &&= engine\\
&\wedge\ frontCarGap' &&= frontCarGap\\
&\wedge\ gasPedal' &&= gasPedal\\
&\wedge\ lever' &&= lever\\
&\wedge\ sl' &&= sl\\
&\wedge\ slWarn' &&= slWarn\\
&\wedge\ speed' &&= speed - speedVariation\\
&\wedge\ visualWarn' &&= visualWarn
\end{aligned}$$

Predicate that is continuously called since when the lever is turned to 1 untill speed equals desired speed.

$$\begin{aligned}
EqualsDesiredSpeed\ \triangleq\ &\wedge\ brakePedal &&= \text{``unpressed''}\\
&\wedge\ cc &&= \text{``on''}\\
&\wedge\ desiredSpeed &&\neq none\\
&\wedge\ engine &&= \text{``on''}\\
&\wedge\ gasPedal &&= \text{``unpressed''}\\
&\wedge\ lever &&= 0\\
&\wedge\ speed &&\neq desiredSpeed\\
&\wedge\ acousticWarn' &&= acousticWarn\\
&\wedge\ brakePedal' &&= brakePedal\\
&\wedge\ cc' &&= cc\\
&\wedge\ desiredLimit' &&= desiredLimit\\
&\wedge\ desiredSpeed' &&= desiredSpeed\\
&\wedge\ engine' &&= engine\\
&\wedge\ frontCarGap' &&= frontCarGap\\
&\wedge\ gasPedal' &&= gasPedal\\
&\wedge\ lever' &&= lever\\
&\wedge\ sl' &&= sl\\
&\wedge\ slWarn' &&= slWarn\\
&\wedge\ visualWarn' &&= visualWarn\\
&\wedge\ ApproachesDesiredSpeed
\end{aligned}$$

Increases front car gap from critical to unsafe or from unsafe to safe, deactivating the corresponding warnings.

$$\begin{aligned}
IncreaseFrontCarGap\ \triangleq\ &\wedge\ cc &&= \text{``on''}\\
&\wedge\ engine &&= \text{``on''}\\
&\wedge\ frontCarGap &&> safe\\
&\wedge\ gasPedal &&= \text{``unpressed''}\\
&\wedge\ lever &&= 0\\
&\wedge\ \text{IF } frontCarGap = 3\\
&\quad\quad \text{THEN}\ \wedge\ acousticWarn' = \text{``off''}\\
&\quad\quad\quad\quad\quad\ \wedge\ visualWarn' = \text{``off''}\\
&\quad\quad \text{ELSE}\ \wedge\ acousticWarn' = \text{``off''}\\
&\quad\quad\quad\quad\quad\ \wedge\ visualWarn' = \text{``on''}
\end{aligned}$$

$$
\begin{aligned}
&\land\ brakePedal' && = brakePedal \\
&\land\ cc' && = cc \\
&\land\ desiredLimit' && = desiredLimit \\
&\land\ desiredSpeed' && = desiredSpeed \\
&\land\ engine' && = engine \\
&\land\ frontCarGap' && = frontCarGap - 1 \\
&\land\ gasPedal' && = gasPedal \\
&\land\ lever' && = lever \\
&\land\ sl' && = sl \\
&\land\ slWarn' && = slWarn \\
&\land\ speed' && = speed
\end{aligned}
$$

$$
\begin{aligned}
IncreaseSpeed \triangleq\ &\land\ brakePedal && = \text{``unpressed''} \\
&\land\ \lor\ \land\ cc && = \text{``off''} \\
&\qquad\ \land\ sl && = \text{``off''} \\
&\qquad\ \land\ speed && < maxSpeed \\
&\quad\ \lor\ \land\ cc && = \text{``off''} \\
&\qquad\ \land\ sl && = \text{``on''} \\
&\qquad\ \land\ speed && < desiredLimit \\
&\quad\ \lor\ \land\ cc && = \text{``on''} \\
&\qquad\ \land\ sl && = \text{``off''} \\
&\qquad\ \land\ speed && \geq desiredSpeed \\
&\qquad\ \land\ speed && < maxSpeed \\
&\land\ engine && = \text{``on''} \\
&\land\ lever && = 0 \\
&\land\ acousticWarn' && = acousticWarn \\
&\land\ brakePedal' && = brakePedal \\
&\land\ cc' && = cc \\
&\land\ desiredLimit' && = desiredLimit \\
&\land\ desiredSpeed' && = desiredSpeed \\
&\land\ engine' && = engine \\
&\land\ frontCarGap' && = frontCarGap \\
&\land\ gasPedal' && = \text{``pressed''} \\
&\land\ lever' && = lever \\
&\land\ sl' && = sl \\
&\land\ slWarn' && = slWarn \\
&\land\ speed' && = speed + speedVariation \\
&\land\ visualWarn' && = visualWarn
\end{aligned}
$$

$$
\begin{aligned}
NothingChanges \triangleq\ &\land\ brakePedal && = \text{``unpressed''} \\
&\land\ gasPedal && = \text{``unpressed''} \\
&\land\ lever && = 0
\end{aligned}
$$

$$\begin{aligned}
&\wedge\ acousticWarn' = acousticWarn\\
&\wedge\ brakePedal' \quad = brakePedal\\
&\wedge\ cc' \qquad\qquad = cc\\
&\wedge\ desiredLimit' \ \ = desiredLimit\\
&\wedge\ desiredSpeed' = desiredSpeed\\
&\wedge\ engine' \qquad\ = engine\\
&\wedge\ frontCarGap' = frontCarGap\\
&\wedge\ gasPedal' \qquad = gasPedal\\
&\wedge\ lever' \qquad\qquad = lever\\
&\wedge\ sl' \qquad\qquad\ \ = sl\\
&\wedge\ slWarn' \qquad\ = slWarn\\
&\wedge\ speed' \qquad\qquad = speed\\
&\wedge\ visualWarn' \quad = visualWarn
\end{aligned}$$

Releases brake pedal right after being pressed unless it keeps breaking.

$$ReleaseBrakePedal \ \triangleq\ \begin{aligned}
&\wedge\ brakePedal \qquad = \text{``pressed''}\\
&\wedge\ engine \qquad\qquad = \text{``on''}\\
&\wedge\ gasPedal \qquad\ \ = \text{``unpressed''}\\
&\wedge\ lever \qquad\qquad\ = 0\\
&\wedge\ acousticWarn' = acousticWarn\\
&\wedge\ brakePedal' \quad\ = \text{``unpressed''}\\
&\wedge\ cc' \qquad\qquad\ = cc\\
&\wedge\ desiredLimit' \ \ = desiredLimit\\
&\wedge\ desiredSpeed' = desiredSpeed\\
&\wedge\ engine' \qquad\ = engine\\
&\wedge\ frontCarGap' = frontCarGap\\
&\wedge\ gasPedal' \qquad = gasPedal\\
&\wedge\ lever' \qquad\qquad = lever\\
&\wedge\ sl' \qquad\qquad\ \ = sl\\
&\wedge\ slWarn' \qquad\ = slWarn\\
&\wedge\ speed' \qquad\qquad = speed\\
&\wedge\ visualWarn' \quad = visualWarn
\end{aligned}$$

Releases gas pedal right after speed increasement unless it keeps increasing speed.

$$ReleaseGasPedal \ \triangleq\ \begin{aligned}
&\wedge\ brakePedal \qquad = \text{``unpressed''}\\
&\wedge\ engine \qquad\qquad = \text{``on''}\\
&\wedge\ gasPedal \qquad\ \ = \text{``pressed''}\\
&\wedge\ lever \qquad\qquad\ = 0\\
&\wedge\ acousticWarn' = acousticWarn\\
&\wedge\ brakePedal' \quad\ = brakePedal\\
&\wedge\ cc' \qquad\qquad\ = cc\\
&\wedge\ desiredLimit' \ \ = desiredLimit\\
&\wedge\ desiredSpeed' = desiredSpeed\\
&\wedge\ engine' \qquad\ = engine
\end{aligned}$$

$$\wedge \; frontCarGap' \quad = frontCarGap$$
$$\wedge \; gasPedal' \qquad = \text{"unpressed"}$$
$$\wedge \; lever' \qquad\qquad = lever$$
$$\wedge \; sl' \qquad\qquad\quad = sl$$
$$\wedge \; slWarn' \qquad\;\; = slWarn$$
$$\wedge \; speed' \qquad\quad = speed$$
$$\wedge \; visualWarn' \quad\; = visualWarn$$

Lever goes to it's neutral state after being manipulated.

$TurnLever0 \;\triangleq\;$
$$\wedge \; engine \qquad\quad = \text{"on"}$$
$$\wedge \; gasPedal \qquad = \text{"unpressed"}$$
$$\wedge \; lever \qquad\qquad \neq 0$$
$$\wedge \; acousticWarn' = acousticWarn$$
$$\wedge \; brakePedal' \quad = brakePedal$$
$$\wedge \; cc' \qquad\qquad\; = cc$$
$$\wedge \; desiredLimit' \;\; = desiredLimit$$
$$\wedge \; desiredSpeed' = desiredSpeed$$
$$\wedge \; engine' \qquad\; = engine$$
$$\wedge \; frontCarGap' \; = frontCarGap$$
$$\wedge \; gasPedal' \qquad = gasPedal$$
$$\wedge \; lever' \qquad\qquad = 0$$
$$\wedge \; sl' \qquad\qquad\quad = sl$$
$$\wedge \; slWarn' \qquad\;\; = slWarn$$
$$\wedge \; speed' \qquad\quad = speed$$
$$\wedge \; visualWarn' \quad = visualWarn$$

Activates cruise control.

$TurnLever1 \;\triangleq\;$
$$\wedge \; cc \qquad\qquad\quad = \text{"off"}$$
$$\wedge \; brakePedal \quad\;\; = \text{"unpressed"}$$
$$\wedge \; engine \qquad\quad = \text{"on"}$$
$$\wedge \; gasPedal \qquad = \text{"unpressed"}$$
$$\wedge \; lever \qquad\qquad = 0$$
$$\wedge \; sl \qquad\qquad\quad = \text{"off"}$$
$$\wedge \; \vee \; desiredSpeed > none$$
$$\qquad \vee \; speed \qquad\; > stopped$$
$$\wedge \; acousticWarn' \; = \text{"off"}$$
$$\wedge \; brakePedal' \quad = brakePedal$$
$$\wedge \; cc' \qquad\qquad\; = \text{"on"}$$
$$\wedge \; desiredLimit' \;\; = desiredLimit$$
$$\wedge \; engine' \qquad\; = engine$$
$$\wedge \; frontCarGap' \; = safe$$
$$\wedge \; gasPedal' \qquad = gasPedal$$
$$\wedge \; lever' \qquad\qquad = 1$$
$$\wedge \; sl' \qquad\qquad\quad = sl$$
$$\wedge \; slWarn' \qquad\;\; = slWarn$$

$$\wedge \; speed' \qquad\qquad = speed$$
$$\wedge \; visualWarn' \qquad = \text{``off''}$$
$$\wedge \; \text{IF} \;\; desiredSpeed = none$$
$$\qquad \text{THEN} \;\; desiredSpeed' = speed$$
$$\qquad \text{ELSE} \;\; \wedge \; desiredSpeed' = desiredSpeed$$
$$\qquad\qquad\qquad \wedge \; ApproachesDesiredSpeed$$

$TurnLever2 \;\triangleq\; \wedge \; brakePedal \qquad = \text{``unpressed''}$

$\qquad\qquad\qquad \wedge \; engine \qquad\qquad = \text{``on''}$

$\qquad\qquad\qquad \wedge \; gasPedal \qquad\quad = \text{``unpressed''}$

$\qquad\qquad\qquad \wedge \; lever \qquad\qquad\;\; = 0$

$\qquad\qquad\qquad \wedge \; acousticWarn' = acousticWarn$

$\qquad\qquad\qquad \wedge \; brakePedal' \qquad = brakePedal$

$\qquad\qquad\qquad \wedge \; cc' \qquad\qquad\qquad = cc$

$\qquad\qquad\qquad \wedge \; engine' \qquad\qquad = engine$

$\qquad\qquad\qquad \wedge \; frontCarGap' \;\; = frontCarGap$

$\qquad\qquad\qquad \wedge \; gasPedal' \qquad\quad = gasPedal$

$\qquad\qquad\qquad \wedge \; lever' \qquad\qquad\;\; = 2$

$\qquad\qquad\qquad \wedge \; sl' \qquad\qquad\qquad = sl$

$\qquad\qquad\qquad \wedge \; slWarn' \qquad\qquad = slWarn$

$\qquad\qquad\qquad \wedge \; speed' \qquad\qquad = speed$

$\qquad\qquad\qquad \wedge \; visualWarn' \qquad = visualWarn$

$\qquad\qquad\qquad \wedge \; \vee \;\; \wedge \; cc \qquad\qquad\quad = \text{``on''}$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredSpeed \; < maxSpeed$

$\qquad\qquad\qquad\qquad\qquad \wedge \; sl \qquad\qquad\quad = \text{``off''}$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredLimit' = desiredLimit$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredSpeed' = desiredSpeed + speedVariation$

$\qquad\qquad\qquad\quad \vee \;\; \wedge \; cc \qquad\qquad\quad = \text{``off''}$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredLimit \; < maxSpeed$

$\qquad\qquad\qquad\qquad\qquad \wedge \; sl \qquad\qquad\quad = \text{``on''}$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredLimit' = desiredLimit + speedVariation$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredSpeed' = desiredSpeed$

$\qquad\qquad\qquad\quad \vee \;\; \wedge \; cc \qquad\qquad\quad = \text{``off''}$

$\qquad\qquad\qquad\qquad\qquad \wedge \; speed \qquad\qquad > stopped$

$\qquad\qquad\qquad\qquad\qquad \wedge \; sl \qquad\qquad\quad = \text{``off''}$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredLimit' = desiredLimit$

$\qquad\qquad\qquad\qquad\qquad \wedge \; desiredSpeed' = speed$

$TurnLever3 \;\triangleq\; \wedge \; brakePedal \qquad = \text{``unpressed''}$

$\qquad\qquad\qquad \wedge \; engine \qquad\qquad = \text{``on''}$

$\qquad\qquad\qquad \wedge \; gasPedal \qquad\quad = \text{``unpressed''}$

$$
\begin{aligned}
&\wedge\ lever &&= 0 \\
&\wedge\ acousticWarn' &&= acousticWarn \\
&\wedge\ brakePedal' &&= brakePedal \\
&\wedge\ cc' &&= cc \\
&\wedge\ engine' &&= engine \\
&\wedge\ frontCarGap' &&= frontCarGap \\
&\wedge\ gasPedal' &&= gasPedal \\
&\wedge\ lever' &&= 3 \\
&\wedge\ sl' &&= sl \\
&\wedge\ slWarn' &&= slWarn \\
&\wedge\ speed' &&= speed \\
&\wedge\ visualWarn' &&= visualWarn
\end{aligned}
$$

$$
\begin{aligned}
\wedge\ \vee\ &\wedge\ cc &&= \text{“on”} \\
&\wedge\ desiredSpeed\ &&> minSpeed \\
&\wedge\ sl &&= \text{“off”} \\
&\wedge\ desiredLimit' &&= desiredLimit \\
&\wedge\ desiredSpeed' &&= desiredSpeed - speedVariation \\
\vee\ &\wedge\ cc &&= \text{“off”} \\
&\wedge\ desiredLimit\ &&> minSpeed \\
&\wedge\ sl &&= \text{“on”} \\
&\wedge\ desiredLimit - speedVariation \geq speed \\
&\wedge\ desiredLimit' = desiredLimit - speedVariation \\
&\wedge\ desiredSpeed' = desiredSpeed \\
\vee\ &\wedge\ cc &&= \text{“off”} \\
&\wedge\ speed\ &&> stopped \\
&\wedge\ sl &&= \text{“off”} \\
&\wedge\ desiredLimit' = desiredLimit \\
&\wedge\ desiredSpeed' = speed
\end{aligned}
$$

MAIS SIMPLES EM *CIMA, NAO ?? CONFIRMAR*

$$
\begin{aligned}
TurnLever3\ \triangleq\ \vee\ &\wedge\ brakePedal = \text{“unpressed”} \\
&\wedge\ desiredSpeed > minSpeed \\
&\wedge\ engine &&= \text{“on”} \\
&\wedge\ gasPedal &&= \text{“unpressed”} \\
&\wedge\ lever &&= 0 \\
&\wedge\ sl &&= \text{“off”} \\
&\wedge\ brakePedal' = brakePedal \\
&\wedge\ cc' &&= cc \\
&\wedge\ desiredLimit' = desiredLimit \\
&\wedge\ desiredSpeed' = desiredSpeed - speedVariation \\
&\wedge\ engine' &&= engine \\
&\wedge\ gasPedal' &&= gasPedal \\
&\wedge\ lever' &&= 3 \\
&\wedge\ sl' &&= sl \\
&\wedge\ speed' &&= speed \\
\vee\ &\wedge\ brakePedal = \text{“unpressed”} \\
&\wedge\ desiredLimit > minSpeed
\end{aligned}
$$

$$
\begin{aligned}
&\wedge\ engine && =\ \text{``on''}\\
&\wedge\ speed && <\ desiredLimit\\
&\wedge\ lever && =\ 0\\
&\wedge\ sl && =\ \text{``on''}\\
&\wedge\ brakePedal' = brakePedal\\
&\wedge\ cc' && =\ cc\\
&\wedge\ desiredLimit' = desiredLimit - speedVariation\\
&\wedge\ desiredSpeed' = desiredSpeed\\
&\wedge\ engine' && =\ engine\\
&\wedge\ gasPedal' && =\ gasPedal\\
&\wedge\ lever' && =\ 3\\
&\wedge\ sl' && =\ sl\\
&\wedge\ speed' && =\ speed
\end{aligned}
$$

Deactivates cruise control or speed limit function.

$$
\begin{aligned}
TurnLever4 \ \triangleq\ &\wedge\ brakePedal && =\ \text{``unpressed''}\\
&\wedge\ \vee\ cc && =\ \text{``on''}\\
&\quad\ \vee\ sl && =\ \text{``on''}\\
&\wedge\ engine && =\ \text{``on''}\\
&\wedge\ gasPedal && =\ \text{``unpressed''}\\
&\wedge\ lever && =\ 0\\
&\wedge\ brakePedal' && =\ brakePedal\\
&\wedge\ acousticWarn' && =\ \text{``off''}\\
&\wedge\ cc' && =\ \text{``off''}\\
&\wedge\ desiredLimit' && =\ desiredLimit\\
&\wedge\ desiredSpeed' && =\ desiredSpeed\\
&\wedge\ engine' && =\ engine\\
&\wedge\ frontCarGap' && =\ none\\
&\wedge\ gasPedal' && =\ gasPedal\\
&\wedge\ lever' && =\ 4\\
&\wedge\ sl' && =\ \text{``off''}\\
&\wedge\ slWarn' && =\ \text{``off''}\\
&\wedge\ speed' && =\ speed\\
&\wedge\ visualWarn' && =\ \text{``off''}
\end{aligned}
$$

Activates or deactivates speed limit depending on the actual state.

$$
\begin{aligned}
TurnLever5 \ \triangleq\ &\wedge\ brakePedal && =\ \text{``unpressed''}\\
&\wedge\ cc && =\ \text{``off''}\\
&\wedge\ engine && =\ \text{``on''}\\
&\wedge\ gasPedal && =\ \text{``unpressed''}\\
&\wedge\ lever && =\ 0\\
&\wedge\ speed && \leq\ desiredLimit\\
&\wedge\ acousticWarn' && =\ acousticWarn\\
&\wedge\ brakePedal' && =\ brakePedal\\
&\wedge\ cc' && =\ cc\\
&\wedge\ desiredLimit' && =\ desiredLimit\\
&\wedge\ desiredSpeed' && =\ desiredSpeed
\end{aligned}
$$

$$
\begin{aligned}
&\land\ engine' && = engine\\
&\land\ frontCarGap' && = frontCarGap\\
&\land\ gasPedal' && = gasPedal\\
&\land\ lever' && = 5\\
&\land\ \lor\ \land\ sl && = \text{``on''}\\
&\qquad\quad \land\ sl' && = \text{``off''}\\
&\qquad\quad \land\ slWarn' && = \text{``off''}\\
&\quad\ \lor\ \land\ sl && = \text{``off''}\\
&\qquad\quad \land\ sl' && = \text{``on''}\\
&\qquad\quad \land\ slWarn' && = \text{``on''}\\
&\land\ speed' && = speed\\
&\land\ visualWarn' && = visualWarn
\end{aligned}
$$

Turn engine off.

$$
TurnEngineOff\ \triangleq
\begin{aligned}[t]
&\land\ brakePedal && = \text{``unpressed''}\\
&\land\ engine && = \text{``on''}\\
&\land\ gasPedal && = \text{``unpressed''}\\
&\land\ speed && = stopped\\
&\land\ acousticWarn' && = \text{``off''}\\
&\land\ brakePedal' && = brakePedal\\
&\land\ cc' && = \text{``off''}\\
&\land\ desiredLimit' && = none\\
&\land\ desiredSpeed' && = none\\
&\land\ engine' && = \text{``off''}\\
&\land\ frontCarGap' && = none\\
&\land\ gasPedal' && = gasPedal\\
&\land\ lever' && = 0\\
&\land\ sl' && = \text{``off''}\\
&\land\ slWarn' && = \text{``off''}\\
&\land\ speed' && = stopped\\
&\land\ visualWarn' && = visualWarn
\end{aligned}
$$

Turn engine on.

$$
TurnEngineOn\ \triangleq
\begin{aligned}[t]
&\land\ brakePedal && = \text{``unpressed''}\\
&\land\ cc && = \text{``off''}\\
&\land\ engine && = \text{``off''}\\
&\land\ gasPedal && = \text{``unpressed''}\\
&\land\ lever && = 0\\
&\land\ sl && = \text{``off''}\\
&\land\ acousticWarn' && = acousticWarn\\
&\land\ brakePedal' && = brakePedal\\
&\land\ cc' && = cc\\
&\land\ desiredLimit' && = none\\
&\land\ desiredSpeed' && = desiredSpeed\\
&\land\ engine' && = \text{``on''}
\end{aligned}
$$

$$\begin{aligned}
&\wedge\ frontCarGap' &&= frontCarGap\\
&\wedge\ gasPedal' &&= gasPedal\\
&\wedge\ lever' &&= 0\\
&\wedge\ sl' &&= sl\\
&\wedge\ slWarn' &&= slWarn\\
&\wedge\ speed' &&= 1\\
&\wedge\ visualWarn' &&= visualWarn
\end{aligned}$$

############################

Defines the next state.

$Next \triangleq\ \vee\ Brake$
$\quad\quad\quad\ \vee\ DecreaseFrontCarGap$
$\quad\quad\quad\ \vee\ DecreaseSpeed$
$\quad\quad\quad\ \vee\ EqualsDesiredSpeed$
$\quad\quad\quad\ \vee\ IncreaseFrontCarGap$
$\quad\quad\quad\ \vee\ IncreaseSpeed$
$\quad\quad\quad\ \vee\ NothingChanges$
$\quad\quad\quad\ \vee\ ReleaseBrakePedal$
$\quad\quad\quad\ \vee\ ReleaseGasPedal$
$\quad\quad\quad\ \vee\ TurnLever0$
$\quad\quad\quad\ \vee\ TurnLever1$
$\quad\quad\quad\ \vee\ TurnLever2$
$\quad\quad\quad\ \vee\ TurnLever3$
$\quad\quad\quad\ \vee\ TurnLever4$
$\quad\quad\quad\ \vee\ TurnLever5$
$\quad\quad\quad\ \vee\ TurnEngineOff$
$\quad\quad\quad\ \vee\ TurnEngineOn$

############################

D *VIDAS SCS*11, turn lever 3

$SCS - 1 \rightarrow$ check! *MAS PERGUNTAR AO PROF*
$SCS - 2 \rightarrow$ check! *MAS PERGUNTAR AO PROF*
$SCS - 3 \rightarrow$ check!
$SCS - 4 \rightarrow$ check *SCSA*!
$SCS - 5 \rightarrow$ check *SCSA*!
$SCS - 6 \rightarrow$ check *SCSB*!
$SCS - 7 \rightarrow$ check *SCSA*!
$SCS - 8 \rightarrow$ check *SCSA*!
$SCS - 9 \rightarrow$ check *SCSB*!
$SCS - 10 \rightarrow$ check *SCSB*!
SCS-A $\rightarrow$ check! *MAS PERGUNTAR AO PROF PQ NAO SE SABE FAZER* ASSERT
SCS-B $\rightarrow$ check! *MAS PERGUNTAR AO PROF PQ NAO SE SABE FAZER* ASSERT

$SCS - 11 \rightarrow$ check! *MAS PERGUNTAR AO PROF PQ NAO SE SABE FAZER* ASSERT 'BEM'

$SCS - 12 \rightarrow$ check!

$SCS - 13 \rightarrow$ check!

$SCS - 14 \rightarrow$ check! *MAS PERGUNTAR AO PROF PQ NAO SE SABE FAZER* ASSERT

$SCS - 15 \rightarrow$ not hap

$SCS - 16 \rightarrow$ check!

$SCS - 17 \rightarrow$ check!

$SCS - 18 \rightarrow$ check! *MAS PERGUNTAR AO PROF PQ NAO SE SABE FAZER* ASSERT

$SCS - 19 \rightarrow$ check! *MAS PERGUNTAR AO PROF PQ NAO SE SABE FAZER* ASSERT

$SCS - 20 \rightarrow$ won't be specified.

$SCS - 21 \rightarrow$ won't be specified.

$SCS - 22 \rightarrow$ won't be specified.

$SCS - 23 \rightarrow$ won't be specified.

$SCS - 24 \rightarrow$ won't be specified.

$SCS - 25 \rightarrow$ check!

$SCS - 26 \rightarrow$ check!

$SCS - 27 \rightarrow$ won't be specified.

$SCS - 28 \rightarrow$ won't be specified.

$SCS - 29 \rightarrow$ check! *MAS PERGUNTAR AO PROF*

$SCS - 30 \rightarrow$ check!

$SCS - 31 \rightarrow$ check! *MAS PERGUNTAR AO PROF*

$SCS - 32 \rightarrow$ check!

$SCS - 33 \rightarrow$ won't be specified.

$SCS - 34 \rightarrow$ won't be specified.

$SCS - 35 \rightarrow$ check! *MAS PERGUNTAR AO PROF*

$SCS - 36 \rightarrow$ won't be specified.

$SCS - 37 \rightarrow$ won't be specified.

$SCS - 38 \rightarrow$ won't be specified.

$SCS - 39 \rightarrow$ won't be specified.

$SCS - 40 \rightarrow$ won't be specified.

$SCS - 41 \rightarrow$ won't be specified.

$SCS - 42 \rightarrow$ won't be specified.

$SCS - 43 \rightarrow$ won't be specified.

\ * Modification History
\ * Last modified Sun *Jan* 05 11:11:09 WET 2020 by ricardo