Software Design: RTSAD for Cruise Control

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Design Process

1. Decompose system into components
   - Define the software architecture
   - Identify components
     - Control components vs. Data processing components
     - ...

2. Determine relationships between components
   - Control transfer, event transfer, data transfer
   - OO relationships (association, inheritance, composition, ...)
   - ...

3. Specify each component
   - Functionality
   - Interface
Design Principles

- Abstraction
  - Procedural abstraction, data abstraction
- Modularity
  - Information hiding, low coupling, high cohesion
- Separation of concerns
  - Focus one’s attention upon one of the aspects
  - by Edsger W. Dijkstra in his 1974 paper "On the role of scientific thought"
- Keep it simple (minimalism)
  - Occam's razor
  - Leonardo da Vinci's "Simplicity is the ultimate sophistication"
- Don’t Repeat Yourself (DRY)
  - Every piece of knowledge must have a single, unambiguous, authoritative representation within a system
  - by Andy Hunt and Dave Thomas in their book The Pragmatic Programmer
Design Guidelines
(by Douglas C. Schmidt)

- Make sure that the problems is well-defined
- What comes before how
- Separate orthogonal concerns
- Design external functionality before internal functionality
- Work at multiple levels of abstraction
- Design for extensibility
- Details should depend upon abstractions
- Make it work correctly, then make it work fast
Requirements for Cruise Control
Requirements

- With cruise control, a speed of about 40 km/h (25 mph) or more can be maintained without keeping your foot on the accelerator.
- Cruise control does not work at speeds below about 40 km/h (25 mph).
- When the brakes are applied, cruise control is turned off.
Requirements

☐ ON/Off
  ▪ Press to turn the system on or off
  ▪ A white cruise control indicator comes on when cruise control is on and turns off when cruise control is off

☐ RES (Resume/Accelerate)
  ▪ Press briefly to make the vehicle resume to a previously set speed, or press and hold to accelerate

☐ SET − (Set/Coast)
  ▪ Press to set the speed and activate cruise control or make the vehicle decelerate

☐ Cancel
  ▪ Press to disengage cruise control without erasing the set speed from memory
Use Case #1

Setting Cruise Control

- Press the (On/Off) button
- Get up to the desired speed
- Press the SET– button located on the steering wheel and release it
- Take your foot off the accelerator
Use Case #2

☐ Resuming a Set Speed

- If the cruise control is set at a desired speed and then the brakes are applied, the cruise control is disengaged without erasing the set speed from memory
- Once the vehicle speed reaches about 40 km/h (25 mph) or more, press the +RES button on the steering wheel
- The vehicle returns to the previous set speed and stays there
Use Case #3

☐ Increasing Speed While Using Cruise Control
  - If the cruise control system is already activated, press and hold the +RES button on the steering wheel until the desired speed is reached, then release it
  - To increase vehicle speed in small amounts, press the +RES button
  - Each time this is done, the vehicle goes about 1.6 km/h (1 mph) faster
Use Case #4

Reducing Speed While Using Cruise Control

- If the cruise control system is already activated, press and hold the SET–button on the steering wheel until the desired lower speed is reached, then release it.
- To slow down in small amounts, press the SET–button on the steering wheel briefly.
- Each time this is done, the vehicle goes about 1.6 km/h (1 mph) slower.
Use Case #5

❑ Passing Another Vehicle While Using Cruise Control
  ▪ Use the accelerator pedal to increase the vehicle speed
  ▪ When you take your foot off the pedal, the vehicle will slow down to the previous set cruise speed

❑ Using Cruise Control on Hills
  ▪ When going up steep hills, pressing the accelerator pedal may be necessary to maintain vehicle speed
  ▪ When going downhill, Cruise Grade Braking helps maintain the driver selected speed
    • Cruise Grade Braking is enabled when the vehicle is started and Cruise Control is active
    • It assists in maintaining driver selected speed when driving on downhill grades by using the engine and transmission to slow the vehicle
Use Case #6

- Ending Cruise Control
  - There are three ways to end cruise control:
  - To disengage cruise control, step lightly on the brake pedal
  - Press 🛑 (Cancel) on the steering wheel
  - To turn off the cruise control, press 🔄 (On/Off) on the steering wheel

- Erasing Speed Memory
  - The cruise control set speed is erased from memory by pressing the 🔄 (On/Off) button or if the ignition is turned off
Schematic Representation of Cruise Control
RTSAD Notation

- Real-Time Structured Analysis and Design

Diagram:
- External Device
- Data Transformation
- Control Transformation
- Data Flow (discrete & continuous)
- Control Flow
- Data Store
Context Diagram

Cruise Controller

Accelerator Pedal
Throttle
Transmission
Display
Brake
Cruise Buttons
Speed Sensor
Engine

accelerator input
throttle position
transmission control
engine control
display output
brake input
cruise command
current speed
Decomposition Method A (from Use Cases)

- **Set Cruise Control**
- **Resume Cruise Control**
- **Increase Speed**
- **Reduce Speed**
- **Cruise Grade Braking**

- Cruise command
- Display output
- Brake input
- Current speed
- Engine control
- Transmission control
- Accelerator input
- Throttle position

Cruise Controller
Decomposition Method A

Set Cruise Control

Resume Cruise Control

Increase Speed

Reduce Speed

Cruise Grade Braking

cruise command

throttle position

accelerator input

transmission control

display output

brake input

current speed

engine control

throttle position

accelerator input

transmission control

display output

brake input

current speed

engine control

throttle position

accelerator input

transmission control

display output

brake input

current speed

engine control
Refinement #1

Setting Cruise Control
If the cruise button is on when not in use, it could get bumped and go into cruise when not desired. Keep the cruise control switch off when cruise is not being used.

The cruise control light on the instrument panel cluster comes on green after the cruise control has been set to the desired speed.

1. Press the button.
2. Get up to the desired speed.
3. Press the SET+ button located on the steering wheel and release it.
4. Take your foot off the accelerator.
Refinement #2

Resuming a Set Speed
If the cruise control is set at a desired speed and then the brakes are applied, the cruise control is disengaged without erasing the set speed from memory.

Once the vehicle speed reaches about 40 km/h (25 mph) or more, press the +RES button on the steering wheel. The vehicle returns to the previous set speed and stays there.
Increasing Speed While Using Cruise Control

If the cruise control system is already activated,
- Press and hold the +RES button on the steering wheel until the desired speed is reached, then release it.
- To increase vehicle speed in small amounts, press the +RES button. Each time this is done, the vehicle goes about 1.6 km/h (1 mph) faster.
Refinement #4

Reducing Speed While Using Cruise Control
If the cruise control system is already activated,
• Press and hold the SET—button on the steering wheel until the desired lower speed is reached, then release it.
• To slow down in small amounts, press the SET—button on the steering wheel briefly. Each time this is done, the vehicle goes about 1.6 km/h (1 mph) slower.
Refinement #5

Using Cruise Control on Hills
How well the cruise control works on hills depends on the vehicle speed, the load, and the steepness of the hills. When going up steep hills, pressing the accelerator pedal may be necessary to maintain vehicle speed. When going downhill, Cruise Grade Braking helps maintain the driver selected speed. It assists in maintaining driver selected speed when driving on downhill grades by using the engine and transmission to slow the vehicle.
Decomposition Method B
(from Architectural Pattern)

Control Loop Architecture Pattern

Cruise Controller

Input Processing

Output Processing

Cruise Control
Decomposition Method B

- Cruise command
- Monitor Command
- Monitor Brake
- Accelerator input
- Monitor Accelerator
- Monitor Speed
- Current speed
- Desired Speed
- Control Speed
- Output Display
- Display output
- Cruise Grade Braking
- Transmission control
- Engine control
- Throttle position

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Decomposition Method B

- Cruise command
- Brake input
- Current speed
- Accelerator input

- Monitor Command
- Set Speed
- Output Display
- Desired Speed
- Monitor Brake
- Maintain Speed
- Throttle position
- Engine control
- Transmission control
- Monitor Speed
- Change Speed
- Monitor Accelerator
- End Cruising
- Display output