Improving Freeway Mobility Using Cooperative Automation

Concept of Operations and High-Level Requirements

February 19, 2020
Approach

• The IFM concept enhances CACC capabilities by providing infrastructure information to vehicles using secure V2I communications.

• Details about CACC features that IFM will build on can be found in existing CACC documentation.
Identified IFM User Needs

1. All roadway participants (both with or without IFM) to safely co-exist on the same road network.

2. IOOs and all road users drivers need mobility to be maintained or improved.

3. Drivers in vehicles with IFM need to understand IFM modes/functions (CACC/ACC/CC mode, or full manual control).
4. To operate in IFM mode, the vehicle needs:

a) An IOO-provided current target speed with segment information to indicate the freeway segment for which the target speed applies.
   - i.e. posted speed limit or target speed greater or less than the posted speed limit to increase throughput.

b) To receive an IOO-provided current target time gap with segment information to indicate the freeway segment for which the target time gap applies.

c) To be aware of nearby downstream vehicles
   - Including information regarding nearby vehicles operating in either CACC or IFM mode to form or join a CACC string of vehicles on an ad-hoc basis.
ConOps Content

Four Perspectives:

- IFM Driver’s Perspective
- Non-IFM Driver’s Perspective
- IFM Vehicle System’s Perspective
- Infrastructure Owner-Operator Perspective

Examples:

- IFM driver may notice the speed increasing or decreasing without their input in order to maintain the target time gap.
  - Drivers in a vehicle without IFM will operate their vehicle as they do now.
- Vehicles in IFM mode will adjust speeds to maintain IOO-provided target speed and time gaps.
  - IOOs will determine and provide a target speed and time gap for specified segments.
### Operational Concept: IFM Driver Perspective

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<th>CURRENT STATE</th>
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### Transition from Manual to IFM:
- Driver activation of IFM on freeway segment with supporting IOO information
## Operational Concept: IFM Driver Perspective

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<tr>
<th>CURRENT STATE</th>
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<th>IFM</th>
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<td>Manual</td>
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<td>Manual</td>
<td>CC / ACC / CACC¹</td>
<td>Driver activation of IFM on freeway segment with supporting IOO information</td>
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<tr>
<td>Manual</td>
<td>CC / ACC / CACC¹</td>
<td>One of the following: a) Driver activation of CACC/ACC/CC; or b) Driver activation of IFM on freeway segment without supporting IOO information</td>
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<tr>
<td>Manual</td>
<td>IFM</td>
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<td>One of the following²: a) Brake activation b) Driver presses accelerator pedal (temporary override) c) Driver system deactivation d) Failure of forward object detection system</td>
<td>One of the following: a) Driver activation of IFM with supporting infrastructure b) IFM already activated and vehicle enters freeway segment with supporting IOO information</td>
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<td>One of the following²: a) Brake activation b) Driver presses accelerator pedal (temporary override) c) Driver system deactivation d) Failure of forward object detection system</td>
<td>One of the following: a) Vehicle no longer traveling on a freeway or freeway lane with supporting IOO information b) Failure of Infrastructure communications</td>
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### Transition from CC/ACC/CACC to IFM:
- Driver activation of IFM on freeway segment with supporting IOO information
- IFM already activated and vehicle enters freeway segment with supporting IOO information

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CACC + IFM High Level System-Logic Architecture
(proposed)

- Radar / Vision Sensors
  - Object Identification
- GPS Receiver
  - Host Vehicle GPS Information
- OBE DSRC Radios
  - Remote Vehicle Information
- RSE Radio(s)
  - Infrastructure Information

Vehicle Systems

- Engine Control Unit and Brake Control Unit
  - Brake and Engine Actuation
- CACC Control Unit
  - CACC / ACC / CC
  - Accel / Decel Request
  - System Status
  - Driver Gap Adjust
- IFM Speed & Gap
- Driver Interface
  - On/Off, Gap
- Location Data
- Object Detection Data

V2V Data
- Merging Vehicle Info
- IOO Segment Location
- IOO Target Speed & Gap

I2V Data

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Improved Freeway Mobility using Cooperative Automation - Conceptual System Overview

Key
- Vehicle ranging
- CV Messages (e.g.; BSM)
- Infrastructure Messages (e.g.; RSM)
- Segment Boundaries

IFM supports formation of Ad Hoc strings of vehicles – by using CACC + IOO provided targets

Traffic Data

Incident Data

Infrastructure System Logic (IOO)

Weather Data

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