# SAE J2735 DSRC Messages
## A few remarks on testing DSRC messages

## Presented to
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David Kelley, Editor J2735, davidkelley@itsware.net

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  - The SSP / CERT process and validation
  - A few Remarks about MAP/SPaT messages

# Preliminaries and Disclaimers

- Some of the materials here state the normative content found in published SAE standards.
- But much of this information is simply culled from experience and recommendations.
- This information provided by David Kelley, long time editor of various SAE standards including the J2735 Message set dictionary.
- Until such recommendation are voted on by the fully committee and published in SAE's normal process, they remains subject to further evolution and change.

# The Relevant Stds of SAE

These are the key standards you will need to use:

- J2735_201603  Dedicated Short Range Communications (DSRC) Message Set Dictionary
    - The master data dictionary, a **repository for all defined messages** / data concepts

- J2945/1_201603  On-Board System Requirements for V2V Safety Communications
    - Min **requirements for BSM message use** for light duty vehicles (only).
      Lays the basics for most other /x documents, which then build on it

- J2945/2_draft   Dedicated Short Range Communications (DSRC)   [In ballot] Performance Requirements for V2V Safety Awareness
    - Of importance to this group; this standard has all the **normative detail regarding how to use the SAE SSP security system** for managing message rights

- J2540/2_200911  ITIS Phrase Lists (International Traveler Information Systems)
    - Of importance to this group; all the 1200+ ITIS codes are defined here.  All the normative **MUTCD roadside signage mappings** are found in an annex here

Several other /x documents are now in development.
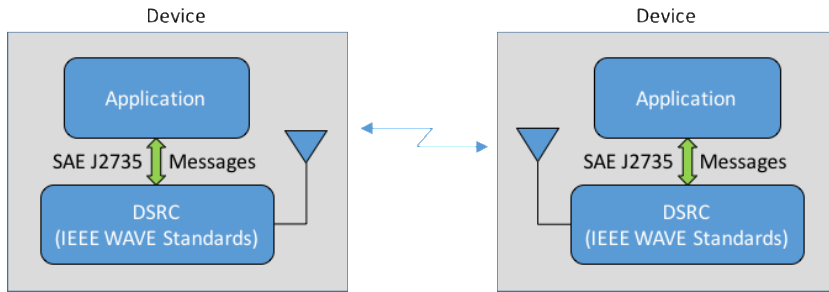
# How it fits with IEEE 1609

Another View of
the Protocol Stack
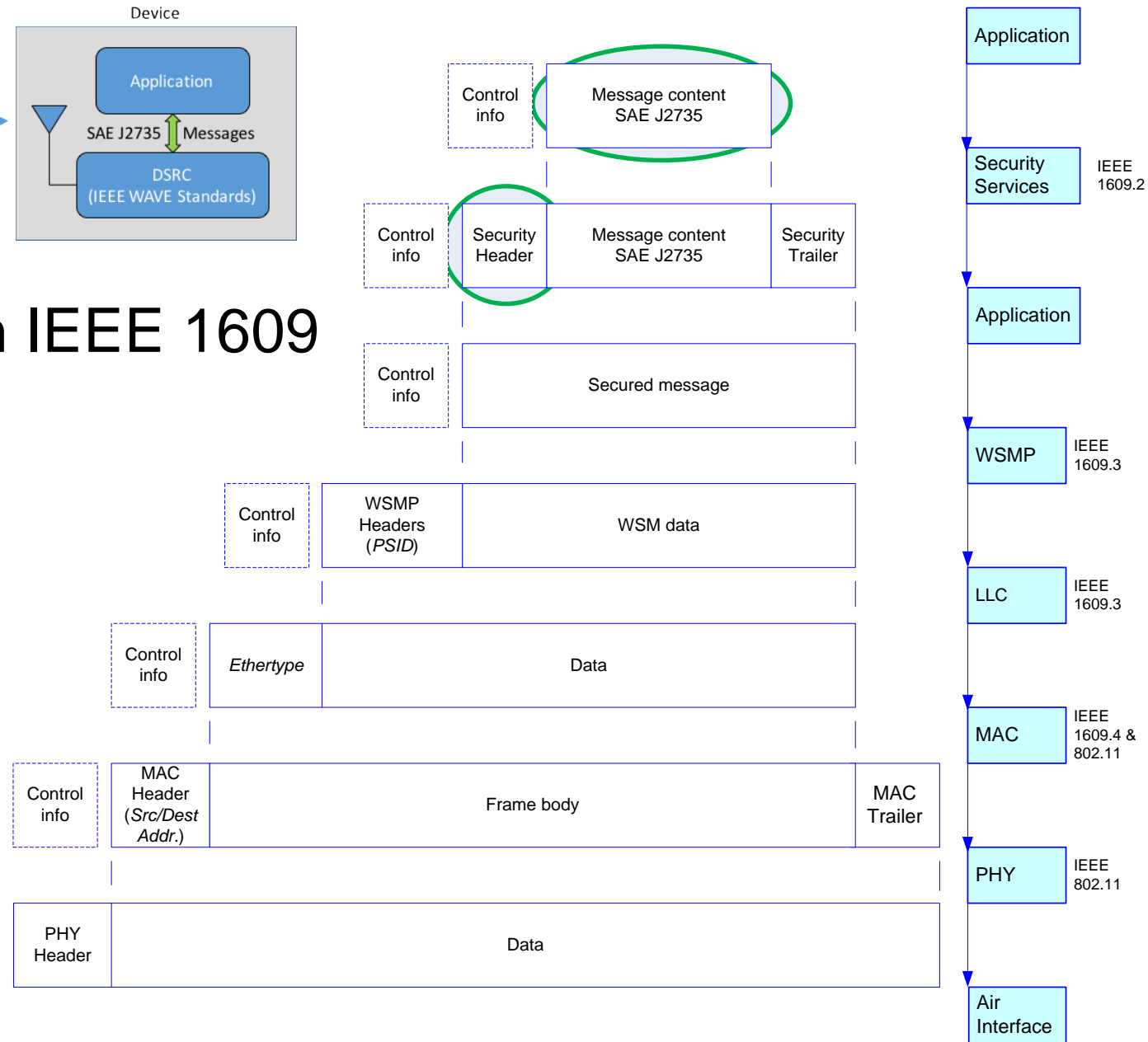
From J2945/0, *Figure 23 – Packaging a message for transmission via WAVE*

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# There are 15 Messages in J2735

- These You care about now
    - BSM          The all purpose message
    - MAP          Roadway geometry (not just intersections)
    - SPAT         Signal timing data
    - RTCM         Differential correction for improved positional accuracy

- These You *will* care about soon
    - TIM / RSA    All the "ATIS" message content  (called BIM, or RSM as the new name)
    - SRM / SSM    Used for intersection signal requests
    - ICA          Advanced intersection general warning message, use by pilot deployments
    - PSA          At-risk personal safety message version of the BSM

- These ones you probably will not
    - CSR          Never used, unwieldy
    - Eva          (Outdated by /2 WORK)
    - NMEA         No longer used, if ever was
    - PDM / PDV    Old probe related work, used in early deployments, buts needs updating

- Here is a useful cheat sheet:
    http://dsrc-tools.com/map-spat/index.php/knowledge-base/a-dsrc-message-cheat-sheet/

# Gross time sequence

- BSMs enable everything else
  - J2945/1 and J2945/2 are just the start
  - Commercial Vehicle, Fleets & Trucks all want a new /X
- As this week's meeting shows,
  - The security system for BSMs, is a key "new" issue
  - MAP / SPaT / RTCM are next  (all RSU-centric)
  - SSPs used to control message content is also "new/next"
  - BSM Part II and various TIM/BIM/RSM likely follow
  - App level Geospatial testing remains fairly primitive
- SAE has 6 other J2945/x items in work now, and another 2 that required re-issue (J2735 and J2540).
  - Most of this will not obsolete the current work.

# Misc. Useful Advice

1. The overall message frame, PDUs, and 1609
2. Error States in the DSRC Message
3. Offsets and Delta Encoding methods
4. Proper Time Handling
5. Common Issues with LLH
(things to avoid)
6. The XYZ and the LLH coordinate Systems
(the two systems coexist well)
7. Coherent movement data
(velocity, acceleration, estimation limits)
8. The use of ITIS code groups

# The general framework used

- All "messages" are in fact within one top message
- All new message will fit in to this paradigm
- Any message can also have "regional" content added to it
- As of J2945/2 being published, you will need an SSP for each

```
MessageFrame ::= SEQUENCE {
   messageId   MESSAGE-ID-AND-TYPE.&id({MessageTypes}),
   value       MESSAGE-ID-AND-TYPE.&Type({MessageTypes}{@.messageId}),
   ...
   }

MESSAGE-ID-AND-TYPE ::= CLASS {
   &id     DSRCmsgID UNIQUE,
   &Type
   } WITH SYNTAX {&Type IDENTIFIED BY &id}

MessageTypes MESSAGE-ID-AND-TYPE ::= {
   { BasicSafetyMessage    IDENTIFIED BY basicSafetyMessage    } |
   { MapData               IDENTIFIED BY mapData               } |
   { SPAT                  IDENTIFIED BY signalPhaseAndTimingMessage } |
Etc. Etc. Etc. Etc.
```

# Ranges and Errors States in J2735

- Most Data Concepts have an error state – **Use It !**
  - Error states are within the valid value range
  - Typically the largest number, or a known bit pattern, but lowest is also used

- Some Data Concepts have "local" or "regional" ranges
  - In octet this is typically from 128 to 254
  - In SEQUENCES this is done with the "regional" entry
  - In the (outdated) XML schema form, a "local" keyword was used
  - You are free to ignore this content, but you must be able to parse over it.

- The preferred way to state "unknown" is not to send it in the first place
  - Not always possible  (blobs etc.) i.e. if not OPTIONAL

*Also*

- Many ASN tools DO NOT set values to these 'safe' states in new messages
  - As a result many people develop their own  xxx_init() methods
- Some ASN tool do set pointers to NULL either
  - Most ASN tools use a pointer to convey OPTIONAL contents

# Offsets and Delta Coding methods

- BSM use <u>full</u> LLH values (in WGS-84) and a <u>partial</u> TIME
  - Add the date, hour, and minute for full time (record keeping)

- LLH are stored in 32/31 bit formats  (~1cm)
- The $1/10^{th}$ micro degree is the basic LSB value
- That's 9 digits past the degree: DD.dddddddd

- Most Everything else uses offsets
  - From an accurate LLH anchor point
  - In orthogonal units of 1cm step  scaled by zoom
  - A dual offset method for the LLH system also exists

# Proper Time Handling

- All time is expressed <u>only</u> in UTC time, not GPS time!
- Convert your GNSS time to UTC then to the Dsecond
  - Today that means that GPS+17 seconds
  - Learn to read when the next leap second is coming
  - You get a 6 month warning!
- Time shall be accurate to <1 mS
  - Or you are VERY VERY lost  (+300km!)
- The Time is the time of GNSS measurement  (tom)
  - So CAN bus data and other data is aligned to this
- DO NOT send BSMs at the top of every 100mS epoch
  - The Std requires you the randomize this interval

# Common LLH Issues in BSMs

- Always use <u>WGS-84</u> for LL,
  - Not NAD27/29 or any other local system/datum
  - Rotate the GNSS L1 phase center to the center of the vehicle (you need heading) and report that
- Height is height <u>above the reference ellipsoid</u>
  - Not the value you get from NMEA-183  (sea level)
  - Or the value you get from the local Geoid.
  - Height is vital for BSM safety lane determination
  - Subtract the GNSS L1 phase center height to the ground surface presuming the attitude is "level" and report that
- You must report the error <u>ellipsoid with every update</u>

Tips:
- Learn how you device behaves when WAAS/DGPS is lost
- Learn how you choice of hybrid antenna may affect you
- Learn how to share a GNSS antenna for validation testing

# The XYZ and the LLH coordinate Systems

- In the BSM, the path history uses LL offset style values, expressed "backwards" in time
- Delta Offsets come in both LLH and XYZ formats
  (ellipsoidal and orthogonal coordinate systems)
- For MAP and TIM/BIM/RSM the
  XYZ system is used for most road geometry (with or without Zoom)
- The point of connection between them is a *precise* LLH
  called the anchor point or reference point.
- Both systems support ~1cm LSBs, precise enough for tomorrow
- Local conversion rates are determined with the Vincenty method

*Helpful further information links:*
https://www.use-snip.com/kb/knowledge-base/precise-distances-ellipsoidal-surface/
https://www.use-snip.com/kb/knowledge-base/converting-ecef-to-llh-and-back/
https://www.use-snip.com/kb/knowledge-base/converting-nad83-to-wgs84/

# Coherent Movement Issues

- Independent velocity estimates are available from your GNSS device
  - At movement rates above ~0.5 m/s these are generally very good
- Independent (but rather noisy) acceleration estimates are available from your GNSS device
  - If you get this data from the CAN bus use it, but time jitter is an issue
  - Accurate IMU devices cost more that ~1cm accuracy from GNSS devices
- Yaw is expressed with respect to the platform body
  - There is no pitch or roll output, there is no advice on 3D movement
- Vehicle Heading is expressed in WGS-84 North
  - A frame of reference translation is needed.
- Report your current covariance matrix data with the error episode!
- Do not try and "fake" OBU device velocity with past positional estimated data, it adds nothing
- Output the unknown condition value if you must
- At this time the SAE DSRC committee has not addressed many minimum performance issues of this type
  - What we have agreed on is found in the current J2945/1 document

# The use of ITIS Code Groups

Perhaps to be reviewed in another time,   *but…*

- – All roadside signs are handled with these codes
- – All "traffic reporting" works this way
- – All "weather reports" works this way
- – Outside the US, other (somewhat similar) formats exist

- In the J2540/2 document

  - – About 1200+ codes, in 40+ groups, plus MUTCD maps

- If you find yourself using "free text" for anything other than *place names* and *road names*, you may be failing to use the IT IS codes.

# Remarks on Ground Truth

- Further content dropped for lack of time…

- Key points:
  - Find a few local benchmarks to compare with
    - Learn how to convert between data when needed
    - A known course is very helpful for this sort of work
  - Share a common ant with the DUT and a known good device
    - Learn how accurate your "good" truth really is
    - Consider investing in a playback device
  - Gather raw observational data when you can
  - Use a common cellular link and RTCM/RTK to hold ~2cm on the "good device" and compare with that
  - Post process for greater accuracy
    - And to learn why it failed in selected places

# What are folk's biggest issues?

- Audience Q&A  (on and Wed as time allows)

  The goal of the SAE DSRC committee is to see deployment; what is it you most need from us?

  What additional training or support materials are wanted?
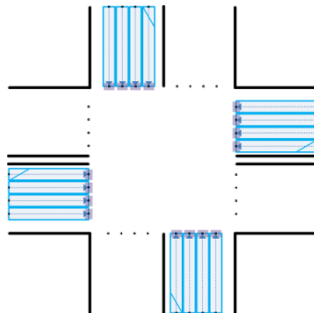
  Do we need to do this sort of talk again?

For any questions on this presentation:
Please contact: David Kelley
Editor of the J2735 DSRC message set,
davidkelley@itsware.net

# Further DSRC TC involvement

- The DSRC TC generally meets by phone every 4$^{th}$ Wednesday of the month.  **All are welcome**.
  - Meeting details and further information please go to: https://www.sae.org/servlets/works/committeeHome.do?comtID=TEVDSRC
  - The DSRC Technical Committee chairman is:
    - Sue Bai, Honda R&D Americas  SBai@oh.hra.com

- Support questions about using the DSRC message set are answered on a time available basis. Please send them to:
    - David Kelley, Editor of J2735,  davidkelley@itsware.net

# News Related to MAP messages…

- [Self promotion of SCSC related MAP work]
  - The first release of a new "how to create a MAP" support site occurred late last week
  - There is a very early draft document outlining the steps to create a typical map message, now in review.
  - This *plug-fest is* the first distribution of it (get hub)
  - A supporting web site is being created
  - In time, the site should grow into something useful

www.DSRCtools.com/map-spat