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ON THE NEED TO DIFFERENTIATE BETWEEN FIXED AND VARIABLE (ELECTRONIC) SIGNS

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1. INTRODUCTION

The first point in the proposal made by the VMS Unit (ECE-TRANS-WP.1-2012-1e) was a definition for VMS within the 1968 Convention. There is a lack of definitions of what signs are (fixed, variable, road markings) in the 1968 Convention. We provided one for VMS because we thought it was necessary for a number of reasons. The basic need to differentiate the use of certain content, on fixed signs vs VMS, is that one sign displayed in a post does not mean exactly the same as the very same sign displayed in a VMS or in-car display (table 1).

	Fixed	VMS/in-car
Wind	There is a risk of wind ahead	Wind is dangerous ahead
Congestion	There may be a congestion ahead	There is a congestion ahead
Dangerous bend	There is a dangerous bend ahead	There is a dangerous bend ahead, very dangerous!

TABLE 1. MEANING OF SIGNS AND INFRASTRUCTURES DISPLAYING THEM

From the point of view of the 1968 Convention, does such difference make sense? We face two main issues:

1. The first issue concerns the legalist view regarding roads signs, the 1968 Convention and law: one sign means one thing. The 1968 Convention is a book containing road sign pictures. But then those contents are displayed in a real infrastructure mounted in roads. Clearly, the meaning of the very same content is not autonomous or independent of the infrastructure used (fixed, VMS, in-car, internet). The type of infrastructure where the content is displayed may act introducing variations on inferences concerning the meaning of signs. Otherwise road signs would be a disaster (I would put snow chains in my car in August, with 30 degrees). Human beings are intelligent after all.
2. The second, related, issue is that we normally assume the 1968 Convention as the *book of posted signs*, even implicitly. But new technologies are confronting us against a different function for the 1968 Convention: plainly, a book of contents that can be displayed in a number of signage infrastructures.

To date, the effect of the infrastructure upon meaning was not an issue within the 1968 Convention because the basic infrastructures (1909-1968) were post, panel and paint. Now diverging infrastructures may have an effect, and we can act in two ways:

1. Make this issue explicit in the Convention and consider on a sign by sign case the nuances that signing infrastructures introduce in the meaning of basic contents.
2. Keep the basic contents in the Convention as they are and assume that the effects upon meaning of displaying certain *content* on certain *infrastructure* will be adequately managed by each national or local road administration.

The ad hoc expert group on VMS (*VMS Unit*) decided that the second option was better. But there are some considerations that need being explicit.

2. REASONS FOR NOT DIFFERENTIATING BETWEEN FIXED AND VARIABLE SIGNS WITHIN THE 1968 CONVENTION

As a matter of fact (considering our eyes and the resolution provided by painted vs electronic signs) a paint coat is always better, allowing for richer, nuanced and more sophisticated, yet visible, designs. It is true that

light and movement (electronic signs) may help with conspicuity, and focusing attention. But as a matter of the information given by a road sign (message content) painted signs are highly functional and effective[1]. Consider the design[2] of the British Advance Direction Sign in Fig. 1. The sign is complex, design is not bad and the cost-effectiveness is very good. Coming to Eduard Tufte (1983, 1990) the data-ink maximization principle is also quite good. However, take a standard resolution for VMS today, and put this message there, taking into account the sizes required (speed, reading time). What VMS panel would you need for it? At what cost?

From the point of view of the content complexity that either painted or electronic signs can display, painted signs clearly outperform electronic signs (this difference is less acute with regards to the coming in-vehicle displays). The best possible world in terms of contents design would be one where no difference between them is noticeable. In sum, electronic signs are but a poor subset fitting well in the larger, extended display capabilities of the 1968 Convention designs, chiefly represented by paint coat.

FIGURE 1. BRITISH ADVANCE DIRECTION SIGN

2.1. REASONS FOR DIFFERENTIATING BETWEEN FIXED AND VARIABLE SIGNS WITHIN THE 1968 CONVENTION

The 1968 Convention is a catalogue of **contents**, including both elementary (borders and rims, shapes, panels, colors, symbols and inscriptions, and signs) and complex contents (e.g., panels that include several signs, making signs out of signs, or signs that are just drafted or barely exemplified -the G, 1 type, and the like). These contents need to rely on specific **visual standards** (i.e., red triangle is for danger warning) and also on specific **composition rules** (i.e., danger warning signs are always inscribed in a type of shape, with a specific border and color).

The 1968 Convention makes the use and combination of some of these contents explicit and official (e.g., danger warning signs), but some other contents (e.g., layouts available, rules for combining simple elements into complex signs, composition rules that are not compatible) are only implicit there. For example, consider Advance Direction Signs category G, 1, and the placement of city names in the sign. The composition rule for G, 1^a and G, 1^b (diagrammatic) is not compatible with the composition rule for G, 1^c (stack signs, following

[1] A similar reasoning is applicable to the actual powers of PowerPoint compared with old 35mm high resolution slides, see Eduard Tufte's essay "The Cognitive style of PowerPoint" (2003).

[2] This and other complex designs in Europe can be seen at: https://en.wikipedia.org/?title=Comparison_of_European_road_signs

verbal reading schemes: left-right, top-down). You should never design G, 1[a] placing some city names according to a diagrammatic principle (then, the upper part of the sign panel means *far*) and some other city names according to a verbal principle (then, the first name above is *near*). Drivers would mix up which is which. All these composition principles are logical but only implicit in the 1968 Convention.

Infrastructures as VMS or in-car displays not only nuance existing contents (table 1). New display technologies introduce three basic needs:

1. The need for new contents (signs and symbols) not existing as fixed infrastructures (e.g., bad visibility, fog; ghost driver; delays on travel times; rerouting; detour, and the like).
2. The need to know specifically how to turn complex signs on the 1968 Convention (e.g., G, 1[a], G, 1[c]) into signs that make sense for variable, electronic signage (see Fig. 4 and 6 below).
3. The need to follow clear recommendations concerning the way different and differing reading schemes should be displayed simultaneously in a number of signing devices (e.g., posted, VMS, in-car).

2.1.1. THE NEED FOR NEW CONTENTS

The need for new signs is basically an empirical matter (ISO-9186, 2007). Identifying the road/traffic situations needing them; considering potentially adequate design variations; testing them; using them; and then proposing them to the 1968 Convention.

The first point also bring us again to table 1. Does it really make sense showing a congestion sign in fixed format? Or passing by a snow-ice danger warning sign in a mountain, in summer with 35 degrees Celsius? However, if we implicitly consider drivers are intelligent and able to infer, this issue can be overlooked, or left tacit. Contents in the 1968 Convention are there, and road operators putting a danger warning sign indicating congestion in a fixed format believe that drivers will understand it just as a possibility.

Using contents of signs in this way is not actually advisable, because it introduces the need for drivers to judge the likelihood of the event announced. But this issue is not actually a matter for the book of contents that the 1968 Convention is. Rather this issue concerns the savoir-faire and operative possibilities of national road practitioners.

2.1.2. THE NEED TO KNOW HOW TO TURN CURRENT COMPLEX ROAD SIGNS INTO THE REQUIRED DESIGNS FOR ELECTRONIC DISPLAYS

Consider the 1995 amendment of the 1968 Convention (p. 51):

> *"NOTE: Advance direction signs G, 1 may bear the symbols used on other signs informing road users of the characteristics of the route or of traffic conditions (for example: signs A, 2; A, 5; C, 3e; C, 6; E, 5a; F, 2)."*

Figure 2 shows the signs exemplified in the note above.

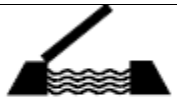
				
A, 2a	A, 5	C, 6	E, 5a	F, 2

FIGURE 2. SIGNS THAT COULD WORK ADDITIONALLY WITH G, 1 CLASS

Let us bring to Fig. 3 how this principle is applied with fixed locations other than cities (railway stations, petrol stations, and so on) taking the G, 1^c model as departure point. Note that the Spanish sign is not actually fully international (use of prepositions *de* and *a*, respectively *from* and *to*).

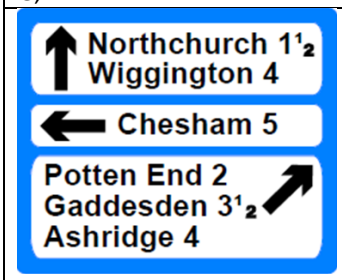
G, 1^c	G, 1^c plus other fixed elements	G, 1^c plus other fixed elements
		
Example in the 1968 Convention (p. 101)	Example of British sign	Example of Spanish sign

FIGURE 3. SIGNS AFTER G, 1^C: MAKING THE MOST OF NOTE IN P. 51 (1968 CONVENTION)

Consider now a different problem: informing about a *variable event*. According to Denis (1996, 1997), and others, you would normally tell a foreign pedestrian where something is (i.e., post office) by giving him/her main landmarks as reference in the way (e.g., red bridge, enormous oak tree). For example: you pass the red bridge ahead, keep on. You'll find the post office right ahead, just besides an enormous oak tree.

Electronic signs attempt to do something similar: tell about something temporary, variable, giving fixed landmarks as the main reference (cities, nodes, bridges, etc.). You may give quantitative distance and length as well (m, km…), but this is not so popular among TCC operators because variable events (congestion, fog, road works) move, and giving a precise location to drivers is a double risk (for their own reputation and for drivers' safety). There is another reason why distance and length are not popular: drivers normally mix international distance (H, 1) and length (H, 2) 1968 Convention formulations (see the Spanish sign: prepositions are used to avoid confusion).

So we will keep our analysis with regards to a basic question: locating variable events with regards to fixed places (e.g., congestion *before* Location A; road works *between* Locations A and B; and the like). We will consider the two basic structures followed in the 1968 Convention for Advance Location Signs: stack signs and diagrammatic signs (Lay, 2004).

2.1.2.1. G, 1^C AS MODEL FOR LOCATING VARIABLE EVENTS: STACK SIGNS OR THE VERBAL PATTERN

How can one locate variable events having G, 1^c as a basic model? Advance Direction Signs G, 1^c are directional paths (the arrow) where you will find locations as you approach to them. But, how do you build a mental model (Johnson-Laird, 2006) in order to place locations beforehand? G, 1^c makes the most of standard (western) reading patterns. The assumption is that you will approach the information on the sign from left to right and from top to bottom (i.e., verbally, as reading text), and then you will build the mental model following the reading patterns: first thing read comes first (Northchurch), second location read comes afterwards (Wiggington). Numbers (miles) reinforce that reading pattern and disambiguate any alternative explanation (otherwise, see the third column, right, in Fig. 4). This basic model is also used when different

reading patterns are mixed (for example, in Fig. 1, up, when we presume that Birmingham comes first than Bourne, although both come after the exit to Nutfield or Penderton). Perhaps that is why Birmingham and Bourne need a box to close them apart (as well as to indicate that it is a motorway, in blue).

At any case, the only way to include variable events within this formulation is the interpolation of the variable events *taking into account the verbal reading patterns*. Fig. 3 shows a hypothetical example taking the upper box of G, 1^{c} as a guide for making. The main issue here is the way to write the event (congestion, road works, wind, etc.). Locations are basically toponyms, but events must be symbols. Provided that our electronic sign is full matrix, we may write the messages as shown in the second column of Fig. 4. An additional question regarding the use of numbers in todays' VMS is: *would that numbers be taken as miles or as minutes?* Travel times are more and more displayed on VMS.

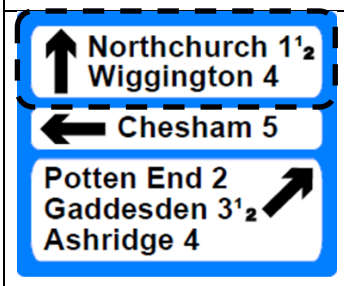
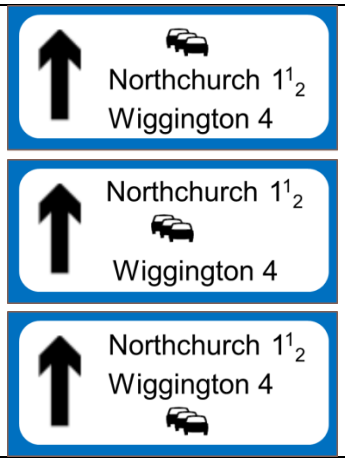
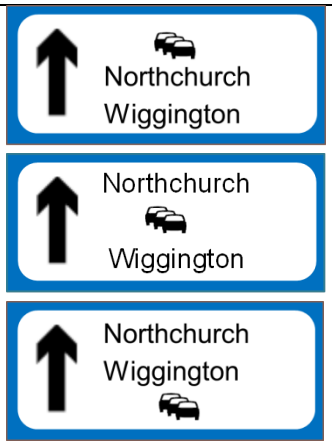
G, 1^{c}	G, 1^{c} plus variable elements	G, 1^{c} (no numbers) plus variable elements
		
Example in the 1968 Convention (p. 101)	Hypothetical example for before, between and after	Hypothetical example for before, between and after

FIGURE 4. BUILDING A HYPOTHETICAL ELECTRONIC MESSAGE BASED ON G, 1^{C}

2.1.2.2. G, 1A OR G, 1B AS MODELS FOR LOCATING VARIABLE EVENTS: DIAGRAMMATIC SIGNS OR THE MAP-LIKE PATTERN

The third column in Fig. 4 (from left to right) gives us a hint of a complementary way of processing the information. Consider the message on the center. Any of us could think that Wiggington comes first, then the congestion, then Northchurch. The arrow then is not only expressing abstract direction (*towards there*) but is also a symbol of the road path (near is below, far is above). In this other way of doing, the panel sign itself is not a *page* but a *map*, or it is both. What would be the way most drivers would read it? Drivers live in three dimensions, but road signs are bi-dimensional. The main axis in driving is forward (rear). So, how is depth of focus (forward) brought to surfaces of two dimensions? Far is up, near is down. G, 1^{a} and G, 1^{b}, and many other signs in the 1968 Convention, adopt this convention (Fig. 5).

How to turn current complex G, 1^{b} signs into the required designs for electronic displays? Advance Direction Signs G, 1^{b} are also directional paths (the arrow) where you will find locations as you approach to them. But first one must *break the verbal order* and build a mental model actually using the visual path offered by the sign. Some visual cues indicate that one is looking to a different representational tool. This is a topological system, giving you a basic, schematic abstraction of the road geometry. For that representation to make sense you need adopting a bird-like perspective, and so a mental model (structural analogy) is built up

following the diagrammatic reading patterns: below is near, above is far; right and left are actually your right and left sides. Note that numbers (miles, kilometers) are not necessary to disambiguate any alternative explanation.

G, 1[b]	G, 1[c] plus other fixed elements	G, 1[c] plus other fixed elements
		
Example in the 1968 Convention (p. 101)	Example of Italian sign	Example of Dutch sign

FIGURE 5. SIGNS AFTER G, 1[B]

The way to include variable events within this formulation is the interpolation of the variable events taking into account the map-like reading patterns. Fig. 6 shows a hypothetical example, showing first (right) G, 1[b]. Note that the examples of the third column in Fig. 4 could also be taken as map-like reading (then the first message above would indicate a congestion right after Northchurch, the middle one between both cities – arriving to Wiggington first; and the one below congestion before arriving to Wiggington). The message in the third column in Fig. 4 can be seen as a diagrammatic variation, but other variations are possible.

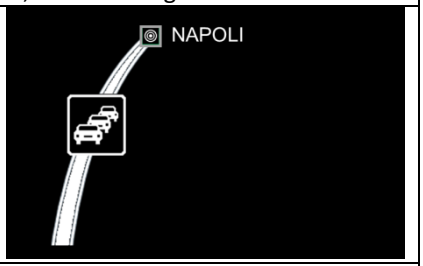
G, 1[B]	G, 1[B] plus variable elements	G, 1[B] other diagrammes
		
Example in the 1968 Convention (p. 101)	Hypothetical example for before, between and after	Hypothetical example for *towards Napoli*

FIGURE 6. BUILDING A HYPOTHETICAL ELECTRONIC MESSAGE BASED ON G, 1[B]

The first columns in Figures 2-5 show Advance Direction Signs, i.e., signs that inform of fixed locations ahead. But the second columns in these figures show what could be termed *Advance Location Signs*, as they refer to congestion… road works, ghost driver, fog, and the like. These are *signs that inform of variable events with reference to fixed locations ahead*. This is a core function for any electronic sign.

Are these extensions of G, 1[a-c] difficult to integrate within the 1968 Convention? We think that surely not. In fact, if we read again the note on p. 51:

> *"NOTE: Advance direction signs G, 1 may bear the symbols used on other signs informing road users of the characteristics of the route or of* ***traffic conditions*** *(for example: signs A, 2; A, 5; C, 3e; C, 6; E, 5a; F, 2)."*

And then we add to that list of signs other signs as congestion, road works, bad visibility, snow-ice, wind signs and so on, and then place them in any electronic sign, the maneuver seems well integrated.

2.1.3. CONSIDERING THE SIMULTANEOUS INTERACTION OF DIFFERING READING PRINCIPLES (VERBAL VS MAP-LIKE)

Human beings, also when driving, are good at producing inferences after many types of stimulus (body language, facial expressions, music, dance and movement, pictures, text, etc.). But even so, some stimulus present features that make inferences harder to perform. Difficulties mainly come from ambiguity, i.e., visual stimulus having more than one interpretation or different messages giving contradictory information. Consider figure 7[3]: posted signs, electronic signs and road markings.

FIGURE 7. CONTRADICTORY AND UNNECESSARY USE OF OPPOSING ARROWS FOR INDICATING DIRECTIONS AHEAD

If we are to combine fixed and variable signs, posted or electronic (on the road, in-car), this issue is also important. We may see differing reading rationales for signs on posted signs, in particular in Advance Direction Signs and *Advance Location Signs*. Clearly, these differing reading patterns (for stack vs. diagrammatic signs) can coexist on the roads on the form of static signs as far as they do not mix together awkwardly. Advance Direction Signs aim orientation to certain fixed landmarks and so, directing towards them in one form or the other, is not a problem.

However, electronic signs are not meant to sign fixed referents, but variable ones. We have seen in the previous section the possibilities offered by the stack vs the diagrammatic rationales. We may take the basic stack sign and modify it in order to insert variable events on it, and the same goes for the diagrammatic ones. In this way, we extend each basic fixed matrix to incorporate variable events. We observe that we can, still, locate variable events on each basic matrix, although some ambiguities may arise (e.g. 3rd column on the right, Fig. 4).

What would happen if drivers were confronted to a simultaneous set of road signs (e.g., one posted, another one in a VMS, another one in-car) aiming to represent a similar scenario (e.g., congestion between two cities) but adopting two differing design patterns? Consider figure 8, a patchwork of road signs. The posted sign is a standard stack sign (perhaps not the right one for motorways). But the design is presumably adequate to indicate drivers that they are in the right the direction towards Northchurch and Wiggington. The VMS sign relies on a standard model (pictogram on the left, three lines of text with an average of 15

[3] We are indebted to Chantal Merkx, from Rijkswaterstaat, for providing this example. It seems that arrows down are being banned in signing panels in The Netherlands.

characters per line). This is a standard VMS in many countries in Europe (Ellenberg & Fabré, 1995). It seems to indicate, by means of a verbal reading scheme, that there is congestion between Northchurch and Wiggington. Recent data indicate that more than 70% of UE drivers understand this sign (EIP 2015, Deliverable 2). Last, the in-car display adopts a diagrammatic sign indicating congestion between Northchurch (coming first, so near-below) and Wiggington (coming later, far-above). The arrow in the posted sign comes up; the arrow in the VMS comes down; the road depicted in the in-car display points forward. All messages are international ones, relying on symbols and toponyms. But, could we make it easier for drivers?

FIGURE 8. POSSIBLE POSTED, VMS AND IN CAR DISPLAYS (SCENARIO 1)

Consider now Fig. 9. It presents a different (possible) combination of road signs. The posted sign is a diagrammatic sign (G, 1^{b}). The design is adequate to indicate drivers that they are in the right the direction towards Northchurch and Wiggington and Chesam. The VMS sign also relies on the standard model (Ellenberg & Fabré, 1995). It seems to indicate, by means of a diagrammatic scheme, that there is congestion between Northchurch (below) and Wiggington (above). Recent data indicate *also* that around 70% of UE drivers understand this sign (EIP 2015, Deliverable 1). Last, the in-car display adopts a stack, verbal pattern indicating congestion lies between Northchurch (coming first, so above) and Wiggington (coming later, below). The arrow in the posted sign comes up and it is a topological representation of the road; the arrow in the VMS comes up; the arrow displayed in the in car display points up, but it does not represent a road where the toponyms are located. Again, all messages are international ones, relying on symbols and toponyms. But, could we make it easier for drivers?

The main problem when several posted sign co-exist in the same point on the road is visual cluttering: drivers having too much information to attend to that may result in a cognitive load. Different signs with different contents and requiring a number of possible actions should be better mounted along the road.

The main problem here is the potential confusion resulting after the differing reading processes required by each sign. Some designs are meant to read as maps, others as text. Mixing them inadequately may cause unnecessary confusion, ambiguity and cognitive load. There should be some thinking and certain agreements on the way to build up and display road signs that present diverging reading modes.

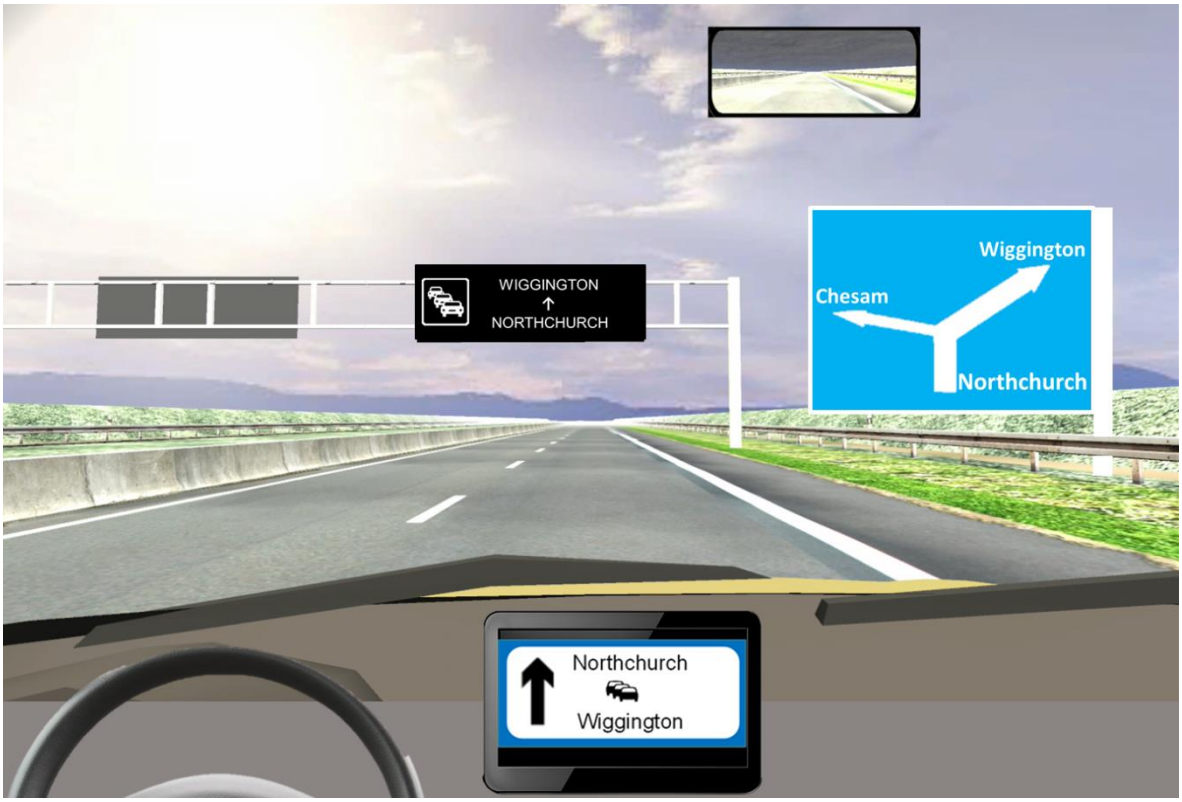


FIGURE 9. POSSIBLE POSTED, VMS AND IN CAR DISPLAYS (SCENARIO 2)

3. CONCLUSION

At this point, it seems that making explicit differences between fixed and variable signs within the 1968 Convention is not necessary, after all. If we just follow the Convention as it is, keep contents clear and assume drivers are capable of inference, and also capable of understanding the nuances introduced on meaning by type of infrastructures (the post, VMS, in-vehicle, internet), everything seems fine.

However, new signs are needed for the emerging needs coming after certain infrastructures (VMS, in-car). So innovating, creating new designs for certain uses (e.g., ghost driver sign, bad visibility, etc.) is necessary and should find a way in the Convention. This concerns electronic signage in particular.

As we have seen, there are two other issues concerning the use of 1968 Convention contents on posted and electronic signs:

- The building process: from current models in the 1968 Conventions to models needed for electronic road signs (VMS, in-car). Are all the possible resulting models (after stack or diagrammatic models) equally good in terms of comprehension?
- Foreseeing the appropriate way for combining those contents in posted and electronic signs that are or may be displayed together.

This issue should get attention by WP.1 and the EGRSS.

Complex situations and electronic signage are important, because they are key issues concerning road and traffic management. There are at least *three types of complex situations* when using electronic signs:

A. *Qualitative location (analyzed in this document): events going on towards, between, after certain locations*
B. Rerouting and detour (there are different types of it)
C. Strategic management: telling drivers in one road what goes on in a adjacent or near road

From our point of view, some additional analytical efforts should be given not only to point A, but also to points B and C with regards to electronic signage, trying to figure out the *could be* departure point of the 1968 Convention with regards to these situations and then prepare and integrate design options within such terms.

4. POOR ELECTRONIC SIGNS: HYBRID VMS. WHAT TO DO?

Good electronic signs are full matrix (at least if they have to be complex). Consider an abstract principle: the panel-pigment relationship. Only unrestricted correspondence of panel-pigment is considered under the 1968 Convention design provisions: we can paint anywhere we need to. The resolution of full matrix electronic signs is poorer than the paint coat, but still any painted sign may obtain a replica in full matrix.

Hybrid VMS combine one small part that is full matrix (normally a 32x32 or a 64x64 pixel matrix) and then three lines for text (with 12-18 little panels per line, having 5x7 or 8x11 pixel matrix each), and so are poor electronic signs. With difficulties, they can display some international electronic messages, but they cannot follow the a priori unrestricted panel-pigment relationship as the 1968 Convention signs do. They cannot follow the full logic of road signs design available in the 1968 Convention.

As a result, *hybrid-VMS can only display certain messages that adopt an international structure.* Fig. 10 shows the basic movements that would bring a) a stack sign model G, 1^c to b) a *would-be* Advance Location Sign adapted for a full-matrix VMS and c) to a hybrid-VMS.

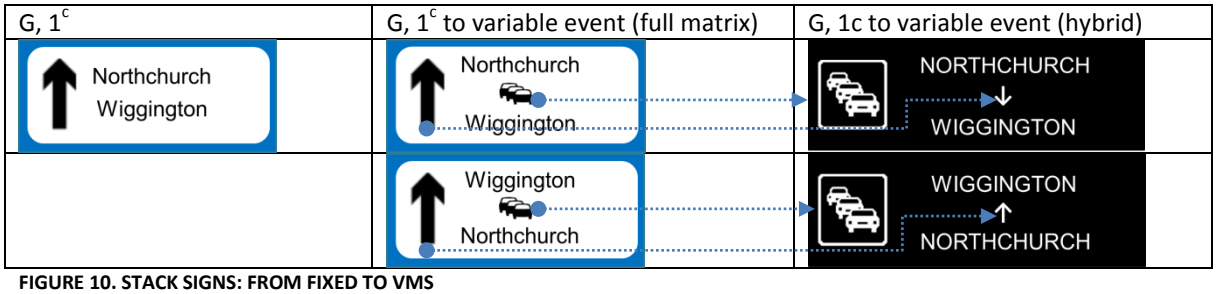


FIGURE 10. STACK SIGNS: FROM FIXED TO VMS

It is interesting to note the resulting signs if one stick to the verbal reading or if one assumes that the arrow up can be better understood (map-like). We have some data concerning the two hybrid-signs in the third

column: both get good comprehension levels. But the case for between is easier because it forms a closed block of elements and inference. Consider figure 11, either following the verbal reading pattern or the map-like one. We keep focused on qualitative location formulations: before, between, after. Note that the criteria regarding symbols is: where can symbols be actually placed? A congestion pictogram cannot be placed in a 5x7 matrix, but a simple arrow can. So the placement in the panel is now changed, compared with messages in Fig. 4 (2nd and 3rd columns).

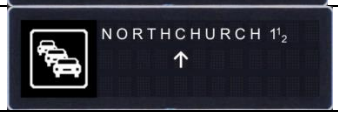
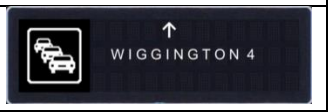
	Event before/towards city	Event between city	Event after city
Verbal reading pattern			
Map-like reading pattern			

FIGURE 11. HYBRID VMS AND BASIC READING PATTERNS IN THE 1968 CONVENTION

Elements that a priori should communicate the same meaning *take nearly opposite visual displays*. Here is where the deductive or inferential aspect of road signs is most evident. I would deduce that the first message up in the left column means *towards* if I read the arrow as *on the way to*. If I take a bird-like stance, I would assume that the congestion is located in the road after Northchurch, but my way to Northchuch is free. If inferences as such are too complex, drivers will probably dissociate the message into two simple ones, for example: instead of "congestion on the way to Northchurch" they would say "the message says that there is congestion and also that this is the way to Northchurch".

Our data point to good results for the central column, regardless of the reading pattern selected. Also the left column message under map-like reading enjoys good results. However the corresponding message to indicate event after city (right column, bottom) yields very poor results.

What, if any, should be the role of these infrastructures and these designs (even if some are universally understood) in the 1968 Convention?

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