

## Chapter 34

# An MCDM Approach to the Selection of Novel Technologies for Innovative In–Vehicle Information Systems

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### ABSTRACT

*Driving a car is a complex skill that includes interacting with multiple systems inside the vehicle. Today's challenge in the automotive industry is to produce innovative In-Vehicle Information Systems (IVIS) that are pleasant to use and satisfy the costumers' needs while, simultaneously, maintaining the delicate balance of primary task vs. secondary tasks while driving. The authors report a MCDM approach for rank ordering a large heterogeneous set of human-machine interaction technologies; the final set consisted of hundred and one candidates. They measured candidate technologies on eight qualitative criteria that were defined by domain experts, using a group decision-making approach. The main objective was ordering alternatives by their decision score, not the selection of one or a small set of them. The authors' approach assisted decision makers in exploring the characteristics of the most promising technologies and they focused on analyzing the technologies in the top quartile, as measured by their MCDM model. Further, a clustering analysis of the top quartile revealed the presence of important criteria trade-offs.*

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## INTRODUCTION

### Problem Context

Ever since the first instrument that provided information to the car driver was introduced – the speedometer, invented in the early 1900's but standard in cars only two decades later – the driver's main task of driving the car, the primary task, is shared with multiple secondary tasks which have grown larger in number and complexity. These secondary tasks, whose main objective is to enhance the driving experience while addressing the driver's needs, are mostly related to the interaction with In-Vehicle Information Systems (IVIS) (Damiani, Deregibus, & Andreone, 2009; Harvey & Stanton, 2013).

To the first category of IVIS, *instrumentation*, designed to assist driving by conveying the car's internal state, manufacturers quickly added IVIS for *infotainment* (e.g. radio), *comfort* (e.g. A/C controls) and later, *navigation* (e.g. GPS) – see Damiani et al. (2009) and Harvey & Stanton (2013) for a review. Together, the four types of IVIS should address the driving assistance, the maximization of the safety and pleasure of driving, and should be part of a product differentiation when it comes to marketing any car model.

Societal changes, consumer trends, and multiple technological innovations in the automotive industry – e.g. autonomous driving (Merat & Jamson, 2009; Saffarian, De Winter, & Happee, 2012), large-scale use of smartphones, connected cars (Lu, Cheng, Zhang, Shen, & Mark, 2014; Zhao, 2002) or multimodal interaction (Jæger, Skov, & Thomassen, 2008; Muller, Weinberg, & Vetro, 2011; Spence & Ho, 2012) – pressure towards the introduction of novel devices and technologies inside the car that will be shared by different IVIS and advanced driver-assistance systems (ADAS) (Amditis, A. et al., 2010). Thus, in the always-connected lifestyle of a digital era it is reasonable to expect consumers wishing to extend highly “connected” behaviors into the experience of driving a car, for example, using social media tools by seamless integration of a smartphone when inside an internet-connected car (Harvey & Stanton, 2013; Walker, Stanton, & Young, 2001; Zhao, 2002). Both autonomous driving and multimodal interaction have in common the fact of enabling more complex interactions with IVIS. While manufactures are starting to introduce autonomous self-driving cars in production processes, IVIS' multimodal interactions are already a predominant trend, such as 3D gesture interaction combined with speech recognition (Spence & Ho, 2012). Driving mostly requires visual attention; hence, the combined use of other modalities (audio or tactile), which do not interfere with the modality the driver is already using, might be advantageous. An interesting solution for IVIS is therefore provided by approaches based on multimodal interactions since the disadvantages of a single modality can often be overcome by the cautious combination of other modalities (Muller et al., 2011; Pickering, Burnham, & Richardson, 2007; Spence & Ho, 2012).

Introducing new technologies inside a car, however, comes at considerable risk and a key design challenge of IVIS development remains, as before, the problem of solving the delicate balance of how to introduce novel IVIS technologies to the driver without compromising the primary task of safely driving to a destination. Driving is a complex task that constantly requires “eyes on the road”; it demands attention, different motor responses, and combined perceptual-motor skills (Calhoun et al., 2002; Groeger, 2000). Paradigmatic and sometimes counter-intuitive examples of how difficult it can be to stay on task abound in the literature of interference effects on driving performance: a simple conversation can disturb the driver's attentive scanning and representation of a traffic scene (McCarley et al., 2001); ignoring an incoming phone call (Holland & Rathod, 2013) or even just a phone notification (Stothart, Mitchum, & Yehner, 2015) can cause significantly more infractions on a road. Finally, even “eyes on the road”

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