# xD-Reflect - "Multidimensional Reflectometry for Industry" a research project of the European Metrology Research Program (EMRP)

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**The general objective of the xD-Reflect research project is to meet the demands from European industry to measure the overall macroscopic appearance of modern surfaces by developing and improving methods for optical measurements which correlate with the visual sensation being evoked. In particular, the project deals with different attributes of dedicated artefacts, like "Goniochromatism", "Gloss" and "Fluorescence" properties, which will be investigated in three main work packages. Two additional transversal work packages reinforce the structure: "Modelling and Data Analysis" with the objective to give an irreducible set of calibration schemes and handling methods and "Visual Perception", which will produce perception scales for the different visual attributes.**

## INTRODUCTION

The appearance of a product is quite important for diverse industries, e.g. automotive, cosmetics, paper, printing, packaging, coatings, plastics, steel industries, etc., as this is frequently one of the most critical parameters affecting customer choice. For this reason, within the last 20 years, significant effort has been made by the manufacturers to produce new and sophisticated products which evoke specific visual effects, like metallic colours, goniochromatic pigments (Fig. 1), deep matt finishes or sparkle effects for instance [1].

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**Figure 1.** Car painted with a goniochromatic varnishing, according to the visual perspective and the light conditions, the colour impression changes.

Current standards and artefacts proposed by the National Metrology Institutes (NMI) to industry to ensure traceability of their measurements are limited to the visual effects they are able to generate. In colour measurements, only two standard configurations, d:0° and 45°:0°, are approved by the CIE (International Commission on Illumination). This is a really insufficient situation and not adapted for all the novel surfaces that show strong directional effects resulting from metallic, interference or diffractive pigments [2]. The situation is even poorer for the other visual attributes like gloss [3], where the standards have not evolved since 1978 or for fluorescence, where the measurement methods comes from non-fluorescent materials and are today inadequate for application to fluorescent materials.

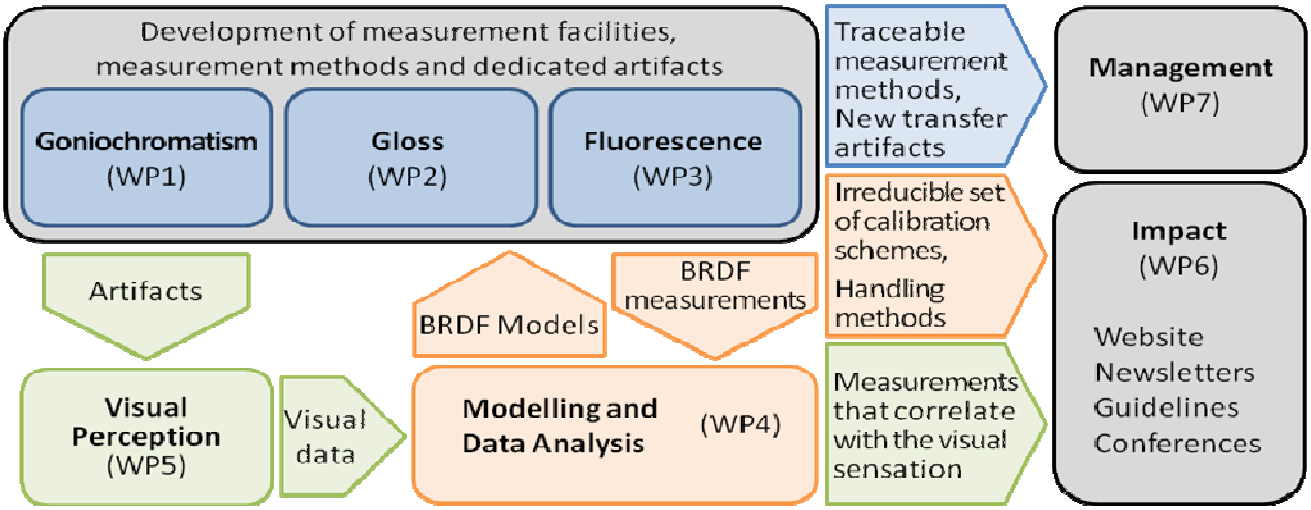


**Figure 2.** Structure of the project: The technical work packages WP1, WP2, WP3 deal with the describing and determining appearance attributes (Colour, Gloss, Fluorescence), WP4 provides data processing tools and the models. WP5 provides the visual scales. The results will create the impact of this project by knowledge transfer, training & dissemination and exploitation.

## SCIENTIFIC AND TECHNICAL OBJECTIVES

The project consortium brings together 7 European NMIs, which have extensive experience and expertise in the field of gonioreflectometry and appearance related measurands. They are complemented by 1 NMI external to the European Community and 3 universities/ research institutes that bring their specific knowledge and experience to the consortium. The Joint-Research-Programme has the following objectives:

- Enhance the spectral and spatial resolution of reference gonioreflectometers developed by each participant, using modern detectors, conoscopic optical designs, CCD cameras, line scan cameras, modern light sources, etc. (WP1, WP2, WP3).
- Reduce the total measurement time that is a significant restriction for calibration capacities (WP1).
- Reduce the measurement uncertainties on BRDF measurements by implementing modern detectors and modern light sources in the concerned facilities and validate the results by a comparison (WP1, WP3).
- Set the optimal geometries for colorimetric measurement of advanced surfaces like metallic colours, or sparkle/graininess effects (WP1 with WP4) and gloss measurement (WP2 with WP4), in particular by the development and characterisation of advanced transfer standards.
- Reinforce the link with industry by creating a BRDF/BSDF public domain database for new advanced functional surfaces such as those used in the automotive industry (WP1).
- Propose a new standard and recommendations for gloss measurements taking into account the visual perception, the background and is adapted to modern surfaces (WP2).
- Propose new types of reference artefacts for calibration and characterisation of goniochromatism (WP1), gloss (WP2) and fluorescence (WP3).
- Improve the uncertainties in the measurement of the luminescent radiance factor of fluorescence standards (WP3).
- Propose recommendations for data handling of the large amount of data generated by BRDF measurements (WP4).
- Evaluate uncertainty and sensitivity coefficients for BRDF measurements and psychophysical measurements (WP4).
- Improve in the comprehension and the definition of the visual attributes such as colour, gloss, sparkle, graininess, fluorescence, from a visual point of view (WP5).
- Correlate visual intensity and response stimuli to the advanced BRDF measurements, material characteristics (structural features) and environment attributes (WP4, WP5).

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## REFERENCES

1. G. Pfaff, Special Effect Pigments: Technical Basics and Applications, 2nd ed., Vincentz Network, Hannover, 2008.
2. CIE 1:2004, "Colorimetry", 3rd ed., International Commission on Illumination, 2004.
3. T. Atamas, K.-O. Hauer, A. Höpe, Appearance measurements of goniochromatic colours, Predicting Perceptions: Proceedings of the 3rd International Conference on Appearance, p. 149 – 154, 2012.
4. G. Obein, K. Knoblauch, F. Viénot, Difference scaling of gloss: Nonlinearity, binocularity, and constancy, J. of Vision 4, 711-720, 2004.