Specmanship & Display Standards

Michael E. Becker

Specmanship: The escalating hype of dizzying performance specifications (known as specsmanship) has created a bazaar-like atmosphere where manufacturers' claims of contrast, response times, brightness, "crispness of colors", etc. sound like those of common market barkers. This atmosphere unfortunately penalizes those companies that want to stay honest and reasonable, since they are running the risk of perishing in that cacophony of marketing blatancy.

Far from their innocent appearance and our, sometimes, naive perception of standards as being a basis that e.g. helps to mate an electrical plug with a socket (just travel to a foreign country to verify this presumption), standards have become a serious matter of competition in the electronics business these days.

The ballyhoo of manufacturers and vendors confronts the customer with choices between a contrast ratio of 10,000 for a PDP-based TV set and a contrast ratio of 500 for an LCD TV (both measured but not used in a completely dark room). Digital still cameras are rated by the millions of pixels that are integrated on their opto-electric transducer chip neglecting the fact that there is an optical system in front of the transducer that has some effect on what is finally captured from a given scene. Data and video projector manufacturers have introduced a new unit of measurement in photometry which is called "ANSI lumen", and LCD monitors recently feature "response times" (unspecified characteristic quantity) of 2 ms.

The seriously exerted user of electronic display devices wants to have a reliable (unbiased), understandable and reasonable basis of data describing the performance of the product according to its application as a solid basis for a purchasing decision without ensuing hangover and regrets. At the same time the customer has to realize that some products just have become so sophisticated that their performance cannot be simply measured and characterized by one integral "figure of merit" rating.

Usability: Depending on which application we have in mind (office work, video and movies, graphics and design, computer games, home cinema, nomadic ICT devices, etc.) we must place emphasis on different individual aspects of performance, at least as long as the *ideal display* is not available at affordable prices. This simply means that the user has to continue the process of education and learning. This continuing education process is of even more importance for all those that are involved in the making of public opinion by publishing technical articles, websites, TV shows and other educational measures.

There are more responsibilities on the side of those who publish performance specifications: they have to stay realistic and perform their measurements and evaluations with due care and responsibility and those who make standards according to which the performance is assessed and characterized must make sure that they provide standards and measurement procedures that are e.g. non-ambiguous, robust and yielding significant results.

These days, it is not a lack of standards that is contributing to the current confusion of the public (from the interested layperson to the ambitious specialized journalist), but rather the variety of not (or badly) synchronized, sometimes even contradictory standards.

Everyone planning the purchase of a visual display device would like to carry home a product that is fulfilling the requirements as well as possible and at an affordable price. The degree the display fulfils the requirements of the user is named "usability". Usability is the measure and multidimensional attribute of "ease and efficiency" with which users of a product can employ that particular device in order to carry out specific tasks. Usability of visual displays, should comprise the hardware, the software and its interfaces, (the documentation, packaging, etc.) and any other aspect that affects the user. Also the "context of intended use" (i.e. the task to be carried out and the application situation) has to be taken into account in the process of usability rating. ISO 9241 defines usability as follows:

> *The effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments.*
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> - ***Effectiveness:*** *the accuracy and completeness with which specified users can achieve specified goals in particular environments.*
> - ***Efficiency:*** *the resources expended in relation to the accuracy and completeness of goals achieved*
> - ***Satisfaction:*** *the comfort and acceptability of the work system to its users and other people affected by its use."*

Context of use: In the process of defining a list of required or wanted performance features for the "optimum display" for a specific purpose we should start with an analysis of the "context of intended use".

"Intended context of use" definition according to ISO 9241-307:

> *Attributes concerning user, environment, tasks and the use of the technology are derived by an analysis of the intended context of use as they are essential and prerequisite for the compliance assessment. Therefore, different context elements of those described in this method could influence the pass/fail criteria. The supplier shall specify the intended context of use as well as the value or value range of an attribute. The values specified shall match with the intended context of use. The intended context of use is part of the compliance report.*

While the context of use was well defined and delimited in the title of the standard ISO 13 406-2 as: "*Ergonomic requirements for work with visual displays based on flat panels*", this is not so easy in the successor standard series ISO 9241-300 "*Ergonomics of human-system interaction - Ergonomic requirements and measurement techniques for electronic visual displays*" which covers all display tasks and applications (from office work and mobile work to entertainment) and all available display technologies.

Usability of electronic displays can be rated from modeling (i.e. from a detailed model of the intended use together with suitable performance specifications for the display and the user, also comprising the task and the environment) and it can be rated by application of well-defined standardized in-situ assessment methods.

It is a common misconception that (numerical) modeling will eventually replace measurements, but all models are based on generalized experimental results (rules and laws expressed in mathematical formalism) and any model can only be as good as its components are described completely and accurately in terms of physical quantities that have to be measured. The convenience of modeling is the accurate control of parameter values and the flexibility for modifications once the basics are defined. This general statement can be illustrated by the evaluation of a display in various ambient illumination conditions.

> *Alternative 1*: The display is placed in the "context of use" (e.g. on the desk in an office) and the ambient illuminations sources are placed, fixed adjusted, and given time to warm up before the measurement is carried out.
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> *Alternative 2:* The BRDF (i.e. bi-directional reflectance distribution function) and other electro-optical characteristics of the display are measured and then the context of use is put together in simulation software and the desired result (e.g. contrast in the presence of reflections) is evaluated numerically. While the experimental approach requires new measurements every time a parameter is changed (e.g. luminance of light sources), the modeling does the same with just one modified parameter value. A further advantage of the modeling is the easy separation of otherwise coupled parameters, e.g. the variation of the spectrum of emission of incandescent bulbs (i.e. correlated color-temperature) with varying luminance.

Role of international standards organizations: Since especially in optical metrology the instruments used and their settings, and the arrangement with respect to the object of measurement may significantly affect the results (e.g. BDRF), such measurements and related evaluations have to be described unambiguously and in detail by (international) standards and application of these standards should be mandatory throughout the world whenever performance characteristics are evaluated that are influencing purchasing decisions.

These days it is not only the lack of up-to-date standards in certain areas (standards are created much slower than the respective products!), it is also the multitude of different and sometimes contradictory standards that is easily exploited to confuse the customer with meaningless numbers that are jerked out of context. This unpleasant situation could be improved by two measures:

- The most prominent international standards organizations ISO and IEC must take action to monitor and adjust the process of standards-making and to synchronize the contents of the standards, especially measurement methods, definition and evaluation of the final characteristics and terminology.

- Those who are bamboozling and cheating with product performance specifications in order to present their product from the "sunny side" to gain commercial advantages must be exposed and doomed in public. Consumer protection organizations in cooperation with other parties should publicly denounce such misbehavior in order to improve the ethics in this field.

Role of the customer: In addition to my naive postulation above, I have one more "candid" claim for all of us: we, the customers, have to continue improving our knowledge about technical devices and technology if we want to become or stay able to make solid purchasing decisions. The increasingly complex electronic devices in our world just cannot be rated by a single figure-of-merit any more, but we have to learn to judge the usability for our context of use even if there is more than a single performance characteristic involved in the rating process. This applies above all to those with responsibility toward the public (e.g. specialized journalists) because of their multiplier function in the formation of public opinion.

With the current convergence of applications (e.g. mobile communication merging with data-processing, computing, web-services, games and video entertainment, etc.), performance requirements for multipurpose displays have the tendency to become more severe. However, as long as the ideal display is not yet available at reasonable prices, the price/performance ratio can still be optimized for limited ranges of the context of use.

Even though display manufacturing has moved out of the western part of the world, this region has positioned itself in the meantime as the world's biggest market for electronic displays. In addition to that, the north America and Europe have established industries that are purchasing raw displays from Asia and refine and improve them in specific aspects for use in special applications (e.g. industrial, medical, etc.) or integrate them into highly sophisticated systems (e.g. control room display-walls, 3D displays, etc.). It should therefore be of vital interest for western industry that is buying displays for their products as well as for the customer (both private and corporate) to actively contribute to the making of standards.

The international standard ISO 13406-2 shows that a standard can actually help to advance technology and the quality of products to which we are exposed for many hours every day. If the European Union, for example, really wants to provide contributions to the well-being of its citizens in the information society of today and of the future, it should eventually take action and support European contributions to international standards making bodies by funding of travel expenses and expert resources (after identification and prioritization of the needs).

The functional requirements of standards have been specified by the ISO and IEC as follows (ISO / IEC Directives, Part 3: *Drafting and Presentation of International Standards*):

> *The objective of a data sheet is to define clear and unambiguous provisions in order to facilitate international trade and communication. To achieve this objective, the data sheet shall be as complete as necessary; consistent, clear and concise; and comprehensible to qualified persons who have not participated in its preparation.*

Appropriate display measurement methods: We can compile a list of basic performance requirements for metrology standards in the field of electronic display devices with the following one being based on a proposal of Edward F. Kelley. Measurement methods described in standards and used in industry have to be: reproducible (basic requirement for any metrology), robust (most important for realizing reproducibility), unambiguous, extensible, distinct, honest, accommodating, accessible, simple, and meaningful. I would also add that "In case of doubt, repeat the measurement until all doubt is dispersed!"

The market of large-area TV sets has recently advanced to be champion with respect to continually increasing growth rates, thus duplicating the success of LCD computer monitors in the last couple of years. Besides CRTs, which are hardly suited for display diagonals beyond 32 inches, there are three major technologies readily available: LCDs, PDPs and rear-projection TV sets.

The customer in his attempt to make a decision for one of the technologies may also wonder about the power consumption of the three technologies. Amazingly (or not) it turns out that the power consumption of PDPs (and CRTs) is a function of the visual information that is displayed on the screen. The power is maximum for a full-white screen and minimum for a black screen. But what is the average power required for a typical TV-program image content? The power consumed by LCD TVs on the other hand does not depend on the displayed information. So how could these technologies ever be compared by a layperson?

Since power consumption has now become a topic of national and global relevance, sufficient momentum has been created to initiate a joint working group in the ICE to bring together experts from the TC100 (multimedia equipment) and TC110 (flat panel display devices) to work out a measuring method for objective evaluation of the power input of TV sets with both LCD and PDP screens.

This horizontal synchronization between technical committees and working groups in the IEC that are taking care of different display technologies and different applications is a very encouraging start that should be expanded to also cover other urgent topics. It has been proposed that measuring methods for key visual characteristics like contrast, color gamut, etc. should be included in the agenda of such a horizontal working group, especially when it comes to measurement of these quantities under ambient illumination. Up to now, the contrast of a PDP panel is measured in a way that is different from the contrast measurement of LCDs and the contrast measurement method under ambient illumination for PDPs (and, derived thereof for OLED displays) is using an arrangement that does not support reproducibility. Three new work items have been introduced, discussed and worked on during the TC110 meeting in Delft in September 2005:

- IEC 61747-5-2: Liquid crystal display devices – Visual Inspection of Active Matrix Liquid Crystal Displays.
- IEC 61747-6-2: Liquid crystal display devices – Measuring methods for liquid crystal display modules – Reflective type.
- IEC 61747-6-3: Liquid crystal display devices – Motion Artifact Measurement of Active Matrix Liquid Crystal Display Modules.

"The measurement methods for reflective LCDs" (new work item in IEC TC110 61747) will have to specify comprehensively and in detail several arrangements for illuminating the device under test during measurement which is quite a demanding task, especially since the variation of reflectance is to be measured as a function of the viewing-direction. Such a compendium of illumination geometries however, once established, introduced, and accepted could be most useful for any kind of display for evaluation of electro-optical characteristics under well-defined ambient illumination and thus eventually fill a current gaping vacancy in metrology for electronic display devices. Up to now, only some display manufacturers occasionally publish contrast values that are measured under ambient illumination conditions, however without specification of the illumination geometry (e.g. inclusion or exclusion of specular components, etc.).

This is mainly done in order to promote the advantages of LCDs under ambient illumination in comparison to PDP screens (PDP screens produce contrast values of up to several thousands in a completely dark room which however decreases to about 1/10 of the contrast of LCD screens at illuminance values of 100 lx and 300 lx).

Marketing departments in their never-resting efforts to establish special distinguishing features for their products sometime pass beyond all limits of reason, just for the sake of the show:

- Replacement of the anti-glare layer of LCD screens by a specular surface (sometimes even anti-reflection coated) and pretending that these measures increase contrast and color saturation in bright surrounds (which is even true, but only for quite special conditions).
- Create a coupling between the intrinsically separated controls of backlight intensity ("brightness") and "contrast" in LCD-monitors to step back to the contra-intuitive situation we have with CRTs.
- Improve the response-times of the LCD screen by a factor of two by specifying "gray-to-gray transition times" instead of "image formation times" according to ISO 13 406-2. While this could be basically OK, only one transition time is now entered into the datasheet instead of the two transitions according to ISO 13 406-2 and the result is being yelled out proudly.

Final advice to the customer: Remain critical and skeptical, trust your eyes! Collect substantial information (sometimes not easy to separate the wheat from the chaff) before you choose and buy. Return the goods if they should not perform at the final destination as advertised, expected or promised. Be a discerning customer (this applies to private and even more to corporate customers).

Abou the author

Michael E. Becker is the founder and CEO of Display-Metrology & Systems (DM&S) in Karlsruhe, Germany (http://www.display-metrology.com), a company providing customer specific and off-the-shelf hard and software solutions for measurement and rating of electronic display visual performance. After completion of his PhD at the University of Karlsruhe and prior to the establishment of DM&S he worked for autronic-Melchers (1985 - 2001), first as section head, and from 1993 on as a managing director, developing and marketing a range of instruments for measuring LCD visual performance and LCD material and device properties and a software package for numerical modeling of LCD electro-optical performance (DIMOS).

Michael has been actively contributing to a variety of international standards for electronic visual display devices (IEC TC110 and ISO TC159/SC4/WG2). In 2006 he received the IEC-1906 Award for his contributions to the IEC standardization activities. He invented a variety of German, European and international patents in the field of optical metrology instrumentation, and he has authored and co-authored numerous technical and scientific papers.