LIGHTING HELMET FOR FORMULA 1

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Abstract
The paper explains the development of a new helmet concept for racing-drivers based on TRIZ methodology. Resolving of the system contradictions, the usage of SUFIELD models and the appliance of the trends of evolution brought out a brand new technical concept – the lighting helmet. It is shown how the different TRIZ tools where applied and how the technical concept is build up finally. It is pointed out how the basic idea could be enriched very easily due to this basic approach and which practical benefits the car-drivers get. At the end of the documentation the verification of the system concept and the validation of the methodology are explained.
Keywords: Lighting Helmet, Technical Contradiction, Evolutionary Trends, TRIZ methodology

1. Introduction

The basic consideration starts with the fact, that the adaptation of the human eyes due to different conditions as object distances or light intensities can take about one third of energy consumption of a human being. The weariness as a result of eye - adaptation and accommodation (see **Figure 1**) leads to enlarged delayed reaction times and hence to possible failures. The eye-stress will be multiplied if we consider the situations of racing-drivers as in Formula 1 because of changing lighting intensities, difficult racing courses and high speeds. Courses with increased shadowing or tunnels (e.g. Monte Carlo) showed more risk potentials. When we analyze existing helmet constructions we make out that also different parts inside the helmets are not designed for lighting issues perfectly. This lead us to the question, if there are new technical approaches to reduce eye-stress under above mentioned conditions, to reduce failures, to increase the security of racing-drivers and take into account their physical fitness. Since TRIZ can be used for new product concepts very efficiently, the idea for the Lighting Helmet for Formula 1 was covered with the knowledge of TRIZ methodology.

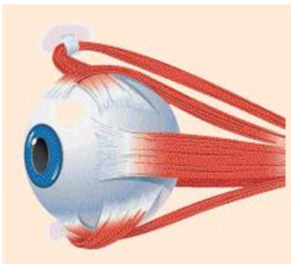

Figure 1: Eye adaptation and accommodation lead to high energy consumption of human being

2. Formulating the Technical Contradiction

If we consider the situation, when a car drives through a tunnel and is getting out of it (end of the tunnel). The lighting conditions are changing very abruptly with lighting intensities ranging from few 100 Lux (unity of the lighting intensity) values up to approximately 100.000 Lux values e.g. at a sunny day. The eyes will need 10-30 seconds to adapt to this change but meanwhile the driver is confronted with a very limited visibility. Blinding effects will enlarge this problem at the transition from dark to bright light.

The first main question we have to ask is: which system parameter has to be chanced to force or reduce the problem? The problem occurs if we change the *speed* of the action. For very slow motions the eye adjustment and the speed of the car are coordinated in terms of time. The contradiction arises with high speeds, where the visibility is getting lost. Therefore we can define SPEED as the improving parameter and ADAPTABILITY as the worsening parameter (SPEED vs. ADAPTABILITY) out of the 39 technical parameters. We used the software Goldfire Innovator from Invention Machine Corporation (USA) to define the problem and finding out new concepts based on the Goldfire Innovator software modules Researcher and Optimizer (see **Figure 2**).

Altshuller's Contradiction Matrix shows us statistically the following three inventive principles to solve this technical contradiction.

A) Dynamic Parts B) Preliminary Actions C) Copying

These principles which are described in more detail in literature and in software programs have the highest probability to solve the formulated contradiction. A technical contradiction can be conveyed into a physical contradiction where only one parameter is in conflict with itself. We'll explain this approach later on in this report.

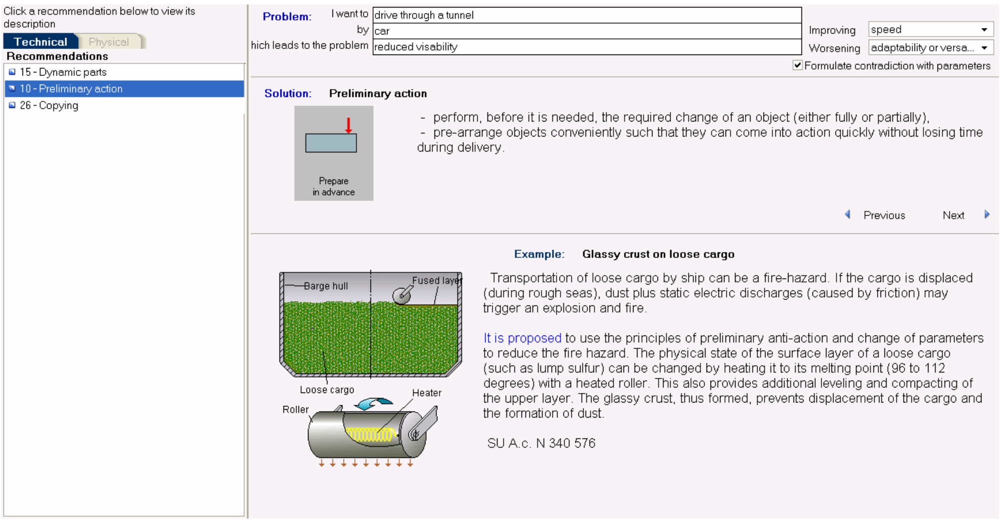

Figure 2: Inventive principles as a result to the formulated technical contradiction (Goldfire Innovator – IMC)

2. Basic Concept Idea based on solving the technical contradiction

Within the next step we try to combine all founded inventive principles into one technical concept, because we're looking for solutions where all inventive principles are included in the invention. To getting rid of all existing thinking barriers, we start from the scratch. The system we are looking at exists out of mainly three elements: room 1 which is a dark tunnel, room 2 which is bright and is outside the tunnel, the eyes which are the passive objects and finally the sun which is the subject. This segmentation we can use for a further SUFIELD model. If we assume there's no existing technical system used at the moment (we have no helmet) and we try to combine the three inventive principles to the zone of operation (light is getting directly to the eyes) we can define a system that should act as following (see **Figure 3**).

1. Dynamism of the light > use artificial light and control it
2. Use the light before > use the artificial light before the transition (end of the tunnel)
3. Copying the daylight > use artificial light and use different light

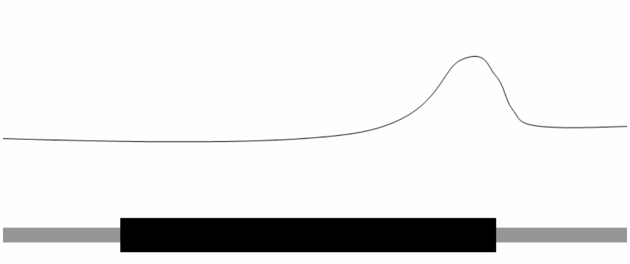
Figure 3: Upper curve shows the brightness of an artificial light source, which is increased at the end of the tunnel; the lower curve demonstrates the street (grey) and the tunnel (black). The driving direction is from left to right side

Using all of these inventive principles (our concept target) we recognize that the human eye is "adjusted" and "prepared" before the change to high illuminations occurs. The pupil is more closed and less light is coming into the eyes (see **Figure 4**). It's important to recognize the fact that this solution will lead to a secondary problem. This problem appears through information losses. The further documentation doesn't go into details in respect to this secondary problem. It can be noticed that due to the increasing illumination at the end of the tunnel (daylight and normally also artificial light) this secondary problem is not a killing factor for the technical concept in the application. An interesting aspect of the technical concept is to mention that the luminaries for tunnels act partly concerning our inventive principles (Nr. 2 und Nr. 3 in the above list). The invention to implement these principles into a much smaller technical system can be seen as a transition from the supersystem to the system level. Miniaturization at lower system levels combined with Dynamism could be recognized as the overall technical concept derived from the inventive principles.

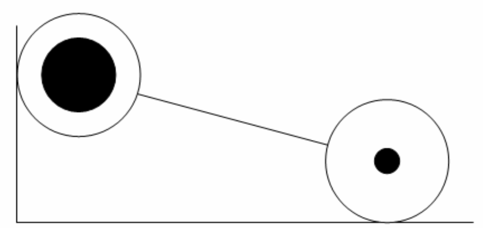

Figure 4: The pupil of the human eye will be changed in size, when artificial light prepare the eye for the light change. On the horizontal axis we define the brightness of the artificial light and on the vertical axis we define the depending pupil size

As a next step within the TRIZ methodology we use the SUFIEL model in the operating zone where the light, the eye and the excessive action blinds are coupled directly. Again we used the Goldfire Innovator Software to model the system. Especially helpful we obtain that the standard solutions are grouped depending on the target issues of the problem. We define "efficiency increase" as the ordering category. Under this aspect the Coordination – Control standard solution is the first item. Additionally the software underlines the evolutionary trends for this solution: Controlling action directly on the object – Action through actuating mechanism – System with feedback (see **Figure 5**). These items are valid for Automatic control which has the highest priority. If we consider the inventive principle Dynamism (Nr. 1 of above list) and the standard solution we are disposed to set up the concept with a fully automatic control of the light sources together with a feedback loop for regulation the lighting intensity.

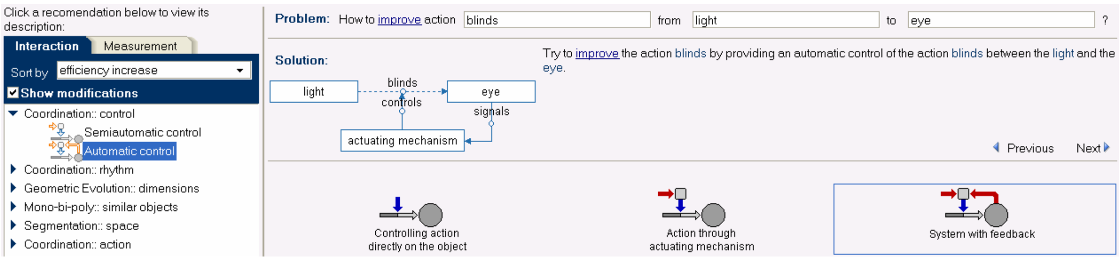

Figure 5: SUFIELD model of the operating zone and evolutionary trends for the standard solution (Goldfire Innovator Software – IMC)

Now let's come to the physical contradiction as mentioned above to verify our concept idea. The critical parameter we've defined SPEED. This parameter should be small for optimal adaptation and high for racing – speed of the car. One of the four separation principles is dividing in system area. We understand that high speed is necessary for the application (supersystem) so low speed has to be achieved on system level. There we've the basic idea again. We've to reduce the speed on system level to enlarge the transition time for the eye – that's the solution.

3. Technical concept of the lighting helmet based on the TRIZ analysis

If we convert these ideas into a technical concept we combine a standard helmet with an additional artificial light source insight the helmet or light which is transmitted into the inner part of the helmet. An outer and an inner lighting sensor detect the lighting intensity. A control unit measures the sensor values and supplies the light sources which are defined as LEDs (see **Figure 6**). The control unit is a PIC microcontroller from MICROCHIP and transmits the lighting intensity information to the LED driver from MAXIM MAX6965 (see **Figure 7**).

The energy supply for the whole electronic circuitry is placed outside the helmet, because the weight of a helmet is a very critical parameter and should not be increased very much due to the additional components. The helmet has an interface for the supply lines (24 Volts) and also an optional digital interface to the Microcontroller. Via this interface information about the lighting conditions can be transmitted to a central controlling station. Vice versa the central controlling station can set predefined values depending on different conditions in the environment.

The controlling schemes are very different and can range from a constant inner light control or mixtures between inner and out lighting sensor values. The inner sensor detects the light in the eye area where the outer sensor detects the light level in front of the car. The detecting angle is an important parameter because the transition form dark to bright light at the end of the tunnel is recognized by the outer sensor on the top of the lighting helmet. The principle of the lighting helmet concept is shown in **Figure 8**.

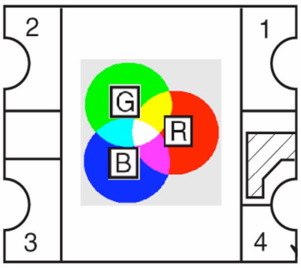

Figure 6: Miniature LED modules as light sources can generate RGB light

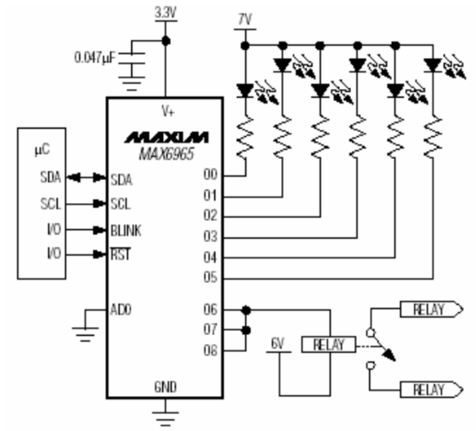

Figure 7: Electronic circuitry with PIC Microcontroller, MAXIM LED driver and LED light sources

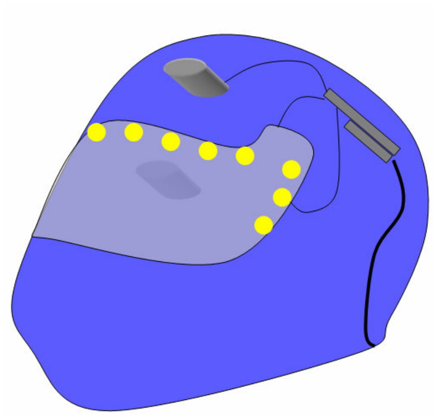

Figure 7: Basic concept of the lighting helmet

4. Further developments based on the lighting helmet concept

Within the field of vision there are parts inside the helmets which influence the lighting contrasts. Now depending on weather, speed or driver psychology the lighting intensity and the lighting colors are changed. These lighting effects are positioned at the outer areas of the field of vision. Due to these effects we can increase the concentration and optimize the lighting contrasts.

For driving into a tunnel the helmet is equipped with an electrical controlled visor. Before driving into a tunnel the visor will be darken, so that the pupil will be opened (reverse action). This eye pre-adjustment helps to get a smoother change when reaching the tunnel area. In the same way the lighting sources will be active if the car reaches the end of a tunnel. The pupil will be closed and pre-adapted to the very high lighting intensities outside. After every adjustment the visor or the lighting sources will be changed to a nominal value.

During constant driving there are always changes in the lighting intensity coming from shadowing of trees, buildings, etc. Especially at high speed this leads to a very high eye stress and hence to energy consumption of the driver. A lighting sensor positioned insight the helmet hold the lighting intensity constant and is able to reduce the pupil adaptation. The amount of compensation is variable and can be optimized to different parameters.

Light has an enormous influence of the human behavior. Light controls the hormone called melatonin and this hormone is responsible for getting tired (see **Figure 9**). We know these influences also together with depressions and jet-lags. The lighting sources within the helmet are used now, to take this relationship into account and focus the driver with light the get the best concentration value e.g. before starting a race or in other critical situations. Newest research in that field showed also, that blue light with a wave length of 446-477nm could control melatonin on the best way.

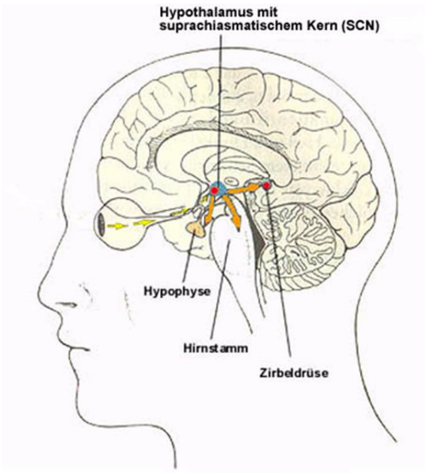

Figure 9: Light controls the hormone called melatonin

5. Overall advantages for racing car-drivers with the lighting helmet concept

- Perfects adjustment of visibility depending on surroundings and driver psychology
- Optimized contrasts and color impressions within the field of vision (see **Figure 10**)
- Improved security due to reduced tiredness
- Improved physical fitness
- Reduced blinding
- Reduced eye stress

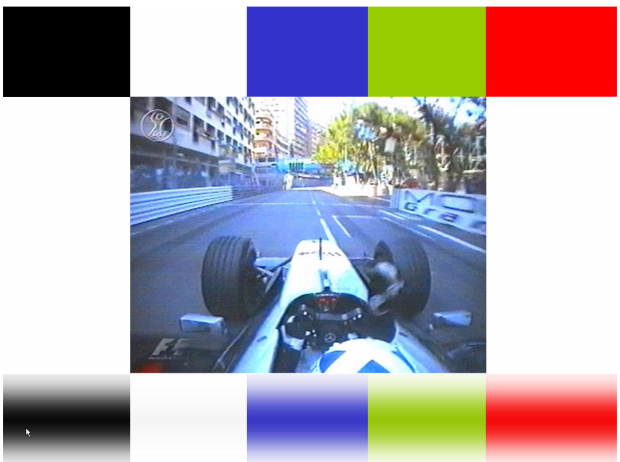

Figure 10: New visibility due to color contrasting with the RGB light sources

6. Conclusion

For concept verification the system was build in a MATLAB / SIMULINK model first. Suitable regulation parameters for the control loop could be evaluated with this simulation approach. To enlarge simulation capacity we set up a "hardware in the loop" tool called LogicLink for high speed digital simulation together with MATLAB / SIMULINK models. The system was build up practically in hardware and software. A development team consisting out of five engineers has designed all necessary components for prototyping the lighting helmet. The lighting helmet concept lead to cooperation with leading helmet manufactures for Formula 1. This TRIZ based concept lead to European patents and afforded new innovation pulses in the helmet industry.

The advantage of using the TRIZ methodology could be seen in skipping out all hindering thoughts coming from existing experiences because we're looking at the problem in a very abstract way first. To open the mind the formulation of contradictions and concept searching based on inventive principles were very important. To analyze the system hierarchically and focusing on the operating zone lead us to a new problem view. Further more it could be seen, that different TRIZ tools, as contradictions, SUFIELD and trends of evolution, forced us to think in similar directions. This gave us the necessary confidence that the approach has a great potential and other companies couldn't find much better alternative systems at the moment. TRIZ has a huge variety in tools. We found out, that the multiple uses of these tools and also the common explanation out of the different tools is most important for secure concept description. Finally the TRIZ methodology is able to invert the customer – product process relationship where the system defines the product first and where the customer needs are matched against the product view later on. At the end the customer is the king, but TRIZ can tell what the customer in his current situation doesn't know. With TRIZ you find essential new ways to create customer needs and find ways to satisfy them. All above – secure long term innovation and market leadership.

7. References

ALTSHULLER, G.S.; The innovation Algorithm
BRAINARD, G.C.; Action Spectrum for Melatonin Regulation in Humans: Evidence for a Novel Circadian Photoreceptor, Journal of Neuroscience, August 15 - 2001
GOLDENBERG, J.; MAZURSKY, D; Creativity in product innovation
HEWLETT PACKARD; LED supplier; www.hp.com
INVENTION MACHINE CORP.; Web-Site, Goldfire Innovator Software, www.invention-machine.com
LUGER RESEARCH; Web-Site, www.lugerreserach.com
LUGER, Siegfried; TRIZ methodology in German language, Web-Site, www.triz-austria.com
MAXIM; LED driver, www.maxim-ic.com
ORLOFF, A.; Grundlagen der klassischen TRIZ
SCHUBERTH Helme GmbH; Web-Site, www.schuberth.com
SPIN network; Web-Site, www.spin-network.net