

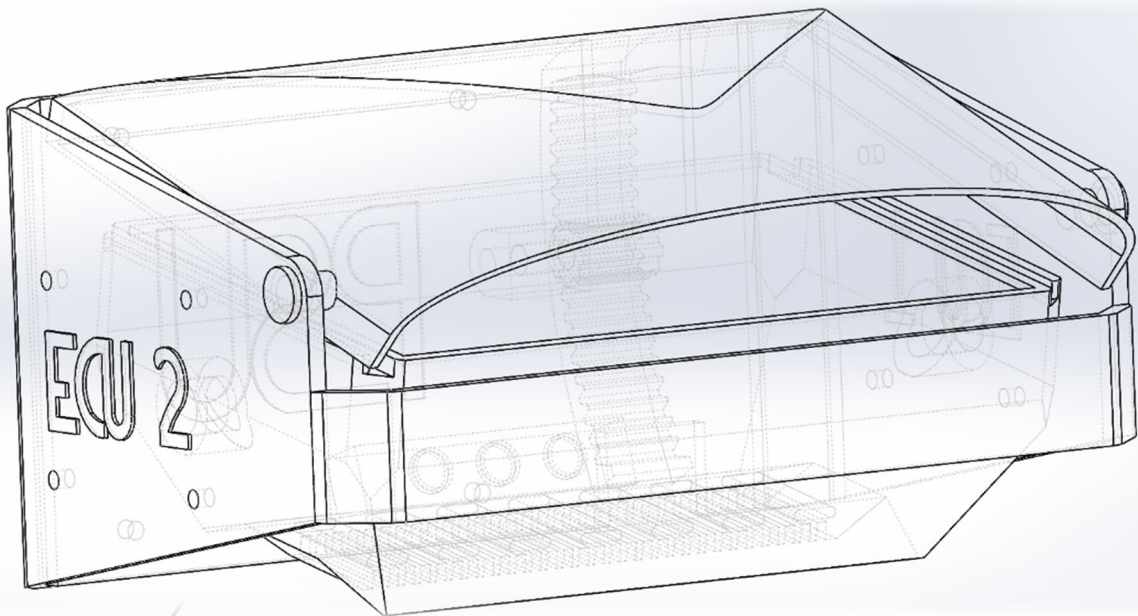
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The Pop-up-LED-Safety Automotive Headlamps

To prevent light-dazzling other motorists – in style.

Workshop & Practice (ACHA4011)



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1 Introduction

The evolution of vehicle lighting has been constant throughout automotive history; from acetylene lamps and halogen sealed beams (Hyundai, 2018) to pop-up headlights and the new craze of HID and LED illumination, all of which have their own benefits and setbacks.

This report will focus on the rise of the new types of automotive headlamps into mainstream market; the benefits of ultrabright lights, their shortcomings, and the challenge in designing the 'perfect' vehicle luminance system. The new Laser and LED headlamps available boast impressive statistics in night-time illumination, however survey responses from (RAC, 2019) show a rising occurrence of late-night 'dazzling' by other motorists.

2 Research

Light emitting diodes (LEDs) have existed since the early 1960s (Bellis, 2021) as a two-terminal electrical representative: base-2, on or off like binary. Although at this point its use was purely computational, development in the technology from then has created a suitable rival to bulbs; their brightness has steadily surpassed bulbs and an LED's luminance to energy consumption is astounding compared to old-school filaments.

The first vehicle pioneering LEDs, in the form of daytime running lights was the Audi A8 in 2004, then two years later Lexus incorporated a high-beam filament with an LED dipped light on the LS600h. Audi shined through again in 2007 with the V10 R8's fully LED headlight cluster (Cassey, 2015) and something in common with all these vehicles is their wealthy price tags, focusing on the luxury side of the market. Following this, the costs to mass-produce the lights dropped (Technavio, 2020) and availability widened, opening the floodgates for the mainstream automotive manufacturers.

However, their high brightness and sharp colours may be great for the haves in night-time vision, but oncoming drivers pay the price with a rising occurrence of eye strain (RAC, 2019) when in sight of them. Studies into colourimetry highlight the problem: "Blue light can also induce photoreceptor damage so it is important to consider the spectral output of LED-based light sources to minimize the danger that may be associated with blue light exposure". (Tosini, et al., 2016)

Table 1: Spectral Colours (Bruno & Svoronos, 2005)

Colour	Wavelength (nm)	Frequency (THz)	Photon Energy (eV)
Violet	380 – 450	670 – 790	2.75 – 3.26
Blue	450 – 485	620 – 670	2.56 – 2.75
Cyan	485 – 500	600 – 620	2.48 – 2.56
Green	500 – 565	530 – 600	2.19 – 2.48
Yellow	565 – 590	510 – 530	2.10 – 2.19
Orange	590 – 625	480 – 510	1.98 – 2.10
Red	625 – 750	400 – 480	1.65 – 1.98

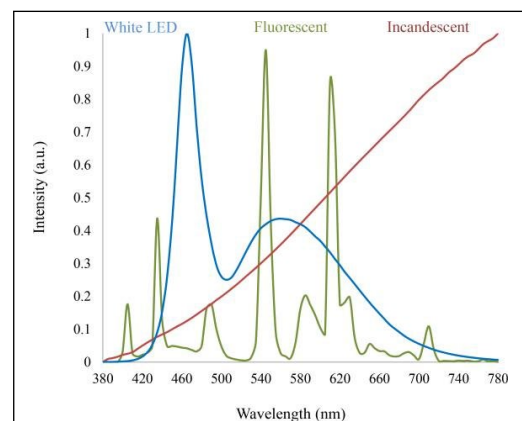


Figure 1: Power spectrum analysis of different sources (Tosini, et al., 2016)

Modern mobile phones often have a 'night mode' feature so that the screen shifts to the warmer side of the colour spectrum, giving an orangey-yellow hue to white, away from the blue to help the eye's ocular health when in a dark room or in bed. The warmer the colour emitted by the light source, the lower the risk of eye irritation: headlights at night obey this. What about brightness?

Traditional halogen bulbs emit around 700 lumens on dipped and 1,200lm on full (HLRestore, 2020) with a yellow tint, meanwhile a HID can be as blinding as five thousand lumens, as well as offering a whiter light. Colour temperature can be altered, although it's for aesthetics beyond CCT 6000K as the blue light slowly becomes less effective, as well as harsher to the eye.

Vehicles are manufactured and sold daily with potentially harmful headlights, but aftermarket HID kits with high-power bulbs installed by amateurs will likely be the bigger issue in situ. (C, 2020)

The ideal solution is therefore a dipped light that performs like a familiar halogen bulb to oncoming motorists, and a full beam that can be ultrabright and white or Xenon-blue when the road's quiet.

3 Development

The team to create the Pop-Up-LED-Safety headlight, codenamed the Sun, would consist of a colourimetry analyst, an electrical engineer and Paul Davies for fabrication and assembly.

The source of illumination is Aputure's Nova P300c; a studio-purpose light source with impressive brightness and beautiful colour clarity, both of which are the variable aspects utilizable to help prevent the light dazzle effect to other motorists.

Table 2: Aputure Nova P300c technical specifications

Dimensions	562 x 457 x 166mm (LxWxH w/ lamp head)
Power Supply	AC 100~240V 50/60Hz
Operating Current	4 Amps
Power Input/Output	360W/360W Maximum
Control Methods	On-board, SidusLink, 5-Pin DMX512
Battery Voltage Range	DC 24-48V 15 Amps (4-Pin XLR)
Photometrics @CCT 4300K (off-white)	8,600lux @1m, 1,000 @3m & 395lux @5m, all at 120° beam angle

<https://www.aputure.com/products/nova-p300c/>



These figures show how power-hungry this light can be at maximum brightness, as well as the challenge of powering it from the vehicle's battery. A transformer is needed to amend the 12V-DC into either 24-48V-DC or 230V-AC, as well as enough current and wattage for 100% brightness even if this is far from reached during operation. The Mean Well A301-1K0-F6 Power Inverter is perfect; capable of the Nova's peak requirements with a (high

performance) lead-acid car battery.

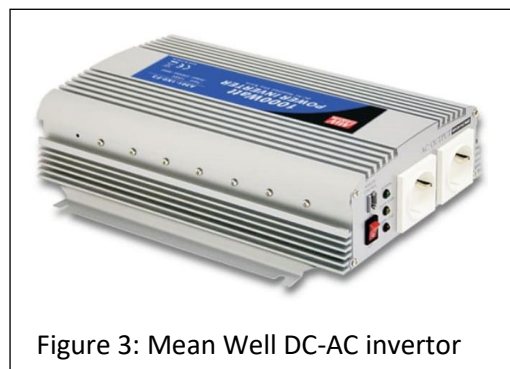


Table 3: Mean Well A301-1K0-F6 technical specifications

Dimensions	310 x 210 x 85mm (LxWxH)
Power Input	12V DC (10 ~ 15VDC), 110A (max)
Specific Current	$110A \div (1000 \div 360W) = 39.6A$ (max)
Rated Output	230V AC, 4.35A, 1000W (max)
Output Type	Modified Sine Wave
Operating Temp. Range	0°C to 40°C @ 70% load
Efficiency	~82%
Protection	30A*5 Fuse, 15~16V shut-off

<https://docs.rs-online.com/8358/0900766b8164393b.pdf>

The row in blue's result is calculated from the maximum input/output of the Nova P300c relative to its current draw; a less powerful version could be used but running the converter well below its maximum ratings will benefit long-term longevity of the transformer, and neither Mean Well or anyone offers a suitable 12V-DC>24/48V-DC power supply.

Supplying these components with electricity needn't be difficult, despite headlights being plural; two of them. The battery must be capable of operating both power converters and lights simultaneously upon the driver's command.

Table 4: Yuasa YBX5005 technical specifications

Dimensions	232 x 175 x 225mm (LxWxH)
Voltage	12 volts
Capacity @ 20h Rate	65 Amp hours
Cold Cranking Performance	580 Amps
Mean Weight w/ Acid	15.7 kilograms

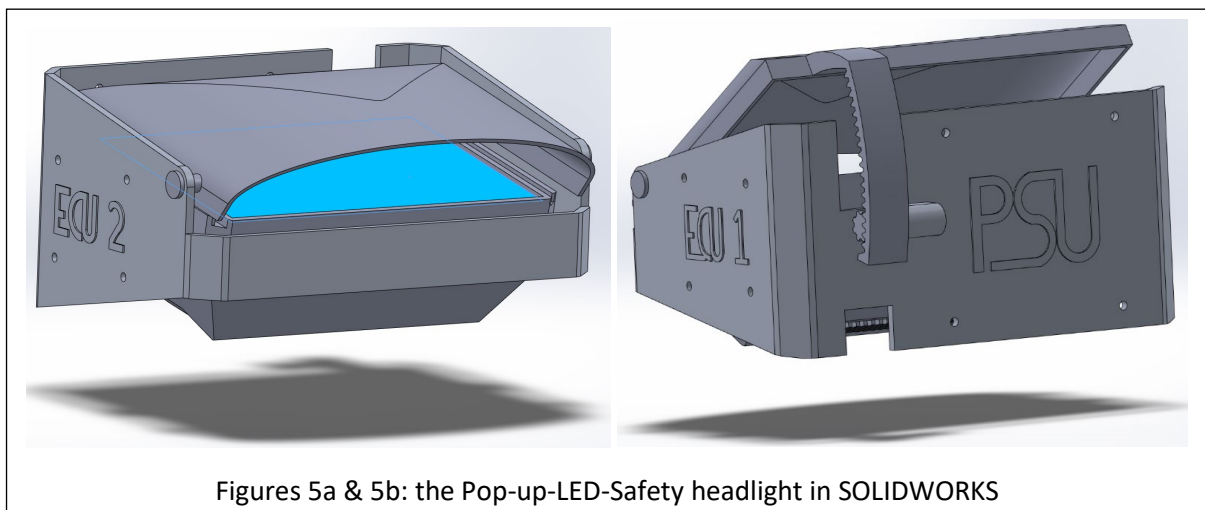
<https://www.yuasa.co.uk/batteries/automotive/ybx5000-silver-high-performance-smf-batteries/ybx5005.html>



Figure 4: Yuasa YBX lead-acid

Another component of importance is the vehicle's alternator; it needs to replenish the battery throughout operation of the lights and all other electrical systems of a car, therefore needs to be capable. Modern alternators should suffice well but an ageing unit may need replacing (if this headlight kit was to be retrofitted to an older car).

These are the off-the-shelf components to make the Sun, the mounting assembly will be custom. Material options include metals like steel; great strength and rigidity but high mass, or carbon reinforced plastics; an untouchable specific strength but expensive and difficult to work with. The material chosen is Aluminium for its balance of all these properties; the main frame supports the Nova light, Mean Well PSU, control units and the mechanism to move the mirror.



Figures 5a & 5b: the Pop-up-LED-Safety headlight in SOLIDWORKS

The mirror and its moveability are the last pieces of the puzzle; it's directing the beam of light safely to the road and a styling feature. A small 12V DC motor is the source of movement; rotating a gear along a track gives the vertical travel to the rear of the mirror, to which the front pivots allow for movement and light-angle control as well as minimal protrusion from the vehicle's body.

This is the Sun, now what parameters should it operate within? The illumination colour, angle and brightness must be defined so that the driver gets the late-night vision of the road they require without irritating oncoming motorists.

The Nova P300c can emit the off-white colour of a halogen bulb at CCT 4300K, this will be assigned to dipped beam operation for adequate visibility and for oncoming motorists' ocular health, harmed by the >5000K CCT offered by HIDs, Laser lights etc. The Sun can provide this and high brightness on full beam operation for use when no one is oncoming. Day-running light won't impede eyes, allowing creativity.

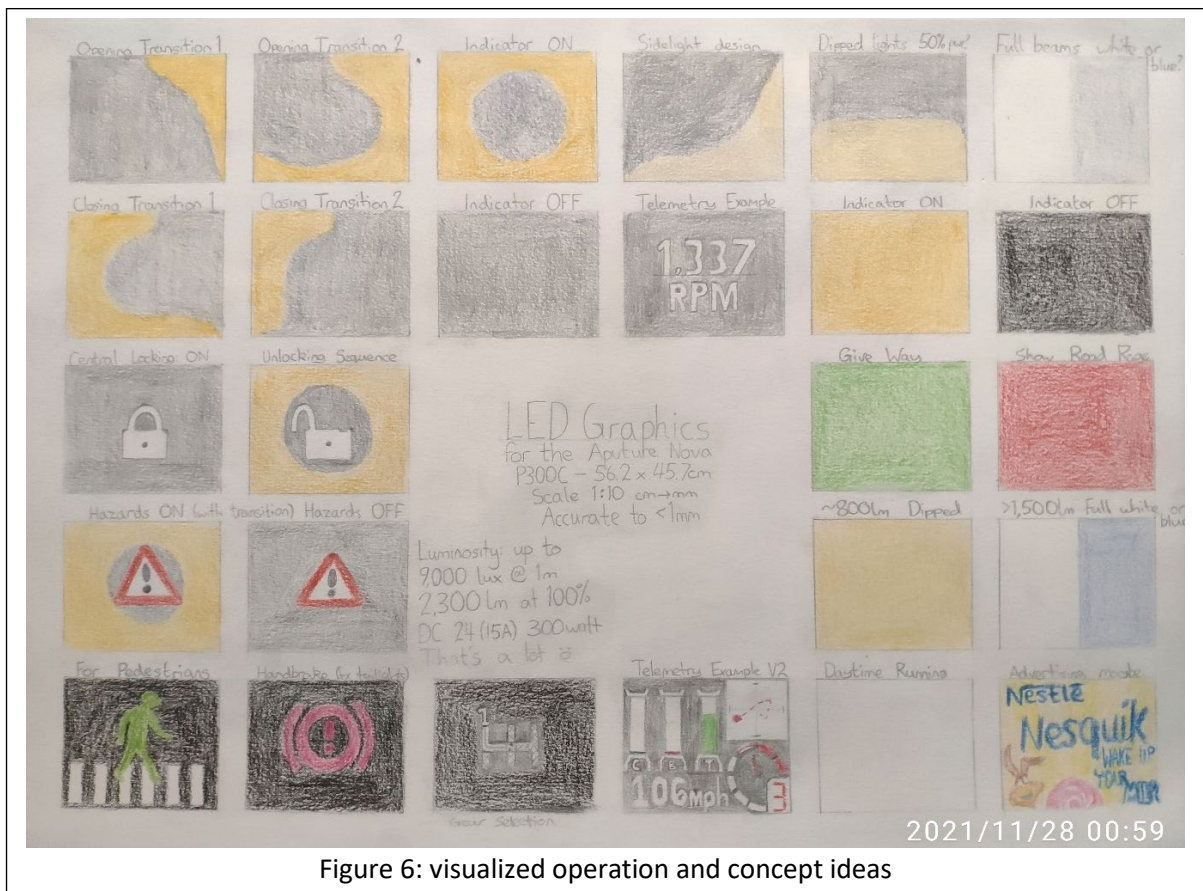


Figure 6: visualized operation and concept ideas

The native beam angle of the Nova is 120°, but when enclosed in the assembly that focuses the light to a much smaller range, determined by the mirror's track length and pivot radius. The large mirror travel offers plenty adjustment so there's ample control of the light beam, ensuring other road users are not dazzled.

4 Discussion

The Sun may well be the solution to combat light-dazzling other motorists, but there's an achillea's heel: moving parts. History contains some beautiful examples of pop-up headlights, but in 2004 production of the Corvette C5 (General Motors, 2005) and the Esprit (Lotus, 2009) concluded, and hidden headlamps have not reappeared since. Reasoning includes engineering time and cost relative to static lights, and the ever-rising importance of safety; EuroNCAP's automotive crash tests have a large influence on a brand's image therefore the some-40 manufacturers (Bergallanj, 2021) who implemented them to their vehicles, some for decades, haven't reintroduced moving headlamps since.

Pop-up headlights have not been made illegal despite this (U.S. Gov, 2004) but scoring well to comply with the European New Car Assessment Program and its Pedestrian Safety test is what makes design and development of moving headlight assemblies uneasy. As the Sun uses a more 'vertically subtle' approach unlike as seen on a gen.1 Mazda MX-5 for example, the perpendicular surface area relative to the car body is drastically reduced when the lights are on/deployed, therefore if the scenario was to occur the impact should be less damaging both to the pedestrian or the vehicle.

However, the Sun is costly: material costs are £2,000~ each! Including engineering/assembly time, this is far from feasible on mainstream vehicles, even if the costs were halved, therefore focus is on the expensive automotive market: supercars or ultra-luxury, for example Lamborghini or Rolls Royce. As this is where the fancy headlights were first pioneered and now are mainstream, this could become a future trend of cybernetic automotive design and vehicle illumination. The mirror's travel could be increased to give a large frontal surface area, to which could be programmed to potentially benefit cornering and or braking via aerodynamic pressure on those areas in performance scenarios.

5 Conclusions

The automotive industry has always undergone change in uncountable aspects; headlights are receiving this treatment from the old-school halogens to the new HIDs, Lasers and LED lights. However, these new super sources of illumination have caused a new issue regarding other motorists, to which the Sun not only gives the best of both worlds, but also sees the return of moving assemblies on the front of a vehicle, therefore can be considered cool.

The product development in this report has explored a new-found issue with modern vehicles, analyzed the technology involved, identified the parameters to comply with and produced a solution. Compared to halogen bulbs or HIDs, it's in another league of complexity and cost, but further refinement and technological advance may see this becoming mainstream in decades to come.

Personal development can target this aspect of automotive engineering, as well as many other ideas of improvement that may become industry standard in the future.

Modern problems require modern solutions: the Sun.

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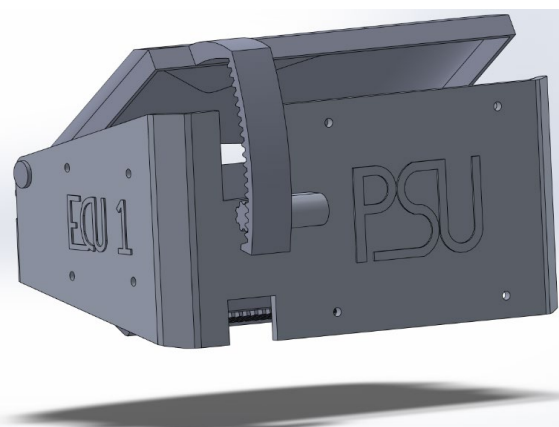
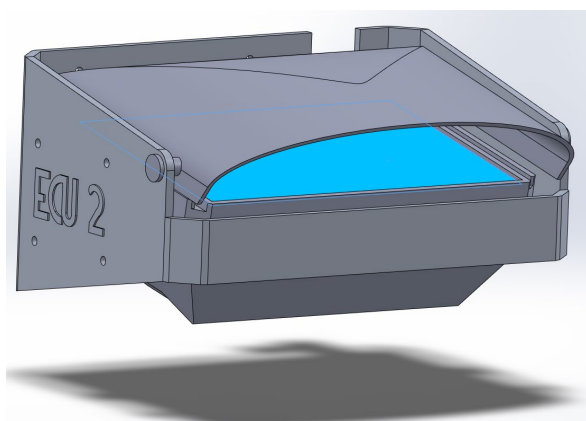
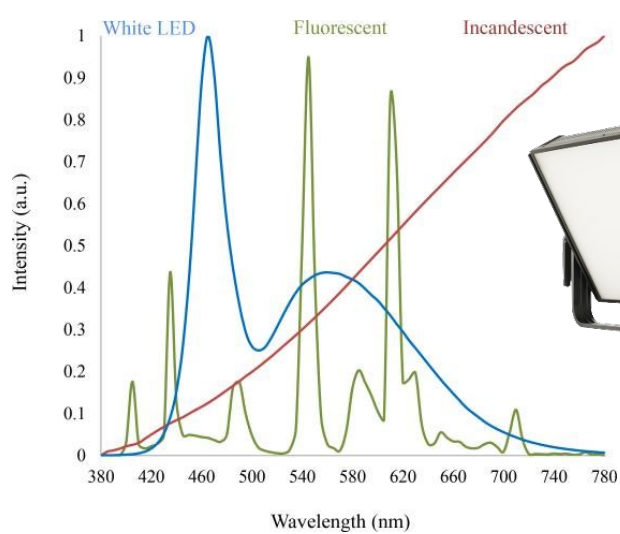
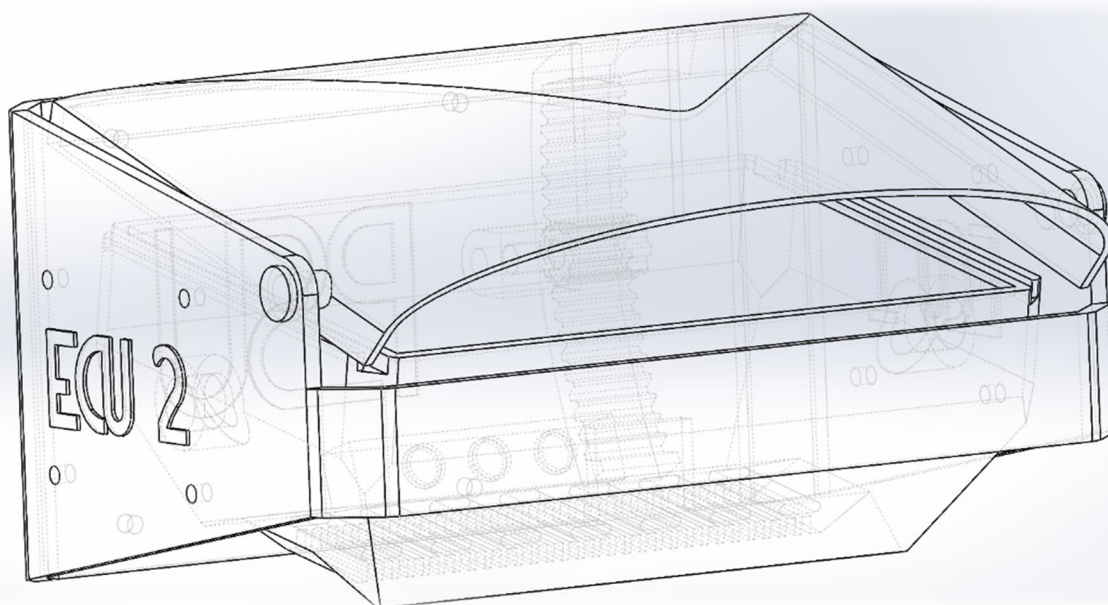
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7 Gallery

In order of appearance.





End of report, thank you for reading.