

automated
SURGICAL HEADLIGHT

guide

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IDC



SURGICAL LIGHT

*a medical device to assist medical personnel during a surgical procedure **by illuminating a local area or cavity** of the patient.*

*a combination of several surgical lights is referred to as a **'surgical light system.'***

light source

SURGICAL LIGHT

HALOGEN

METAL-HALIDE

LIGHT-EMITTING DIODE [LED/LB LED]

reduced energy requirement

longer rated battery life

low heat radiation

consistent illumination

XENON

LED LIGHT SOURCE + OPTICAL FIBRE

types

SURGICAL LIGHT

MINIMALLY INVASIVE SURGERY

ceiling/wall mounted light

mobile on-floor light stand

} *diffused ambient light*

uniform spotlight

} *portable headlight*

OPEN SURGERY



advantages

freedom of movement - ease of use - shadow-free

compact - portable - storage friendly

economical

reduce eye strain

{ portable headlight }

types
LOUPES/~~FACE~~HEADBAND MOUNTED



{ portable headlight }

accessories

padding set

sterile light handle cover

curing light filter

Li-ion/LiPo battery packs

USB cable & charger/multi-bay charger

coaxial headlight imaging system

magnifier loupes set

{ portable headlight }

EXAMINATION

scenarios DENTAL

SURGICAL

general surgery

cardio-thoracic & vascular surgery

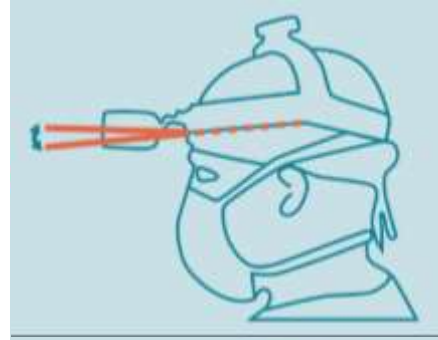
neuro & spinal surgery

transplant surgery

{ *portable headlight* }



scenarios



OBSAEBAC SESTUON REPAIR

surgeons stand with their heads looking down the patient

PRIMARY
surgeons
clinicians
users *proceduralists*

SECONDARY
first assists
scrub nurses
circulating nurses

TERTIARY
servicing technicians

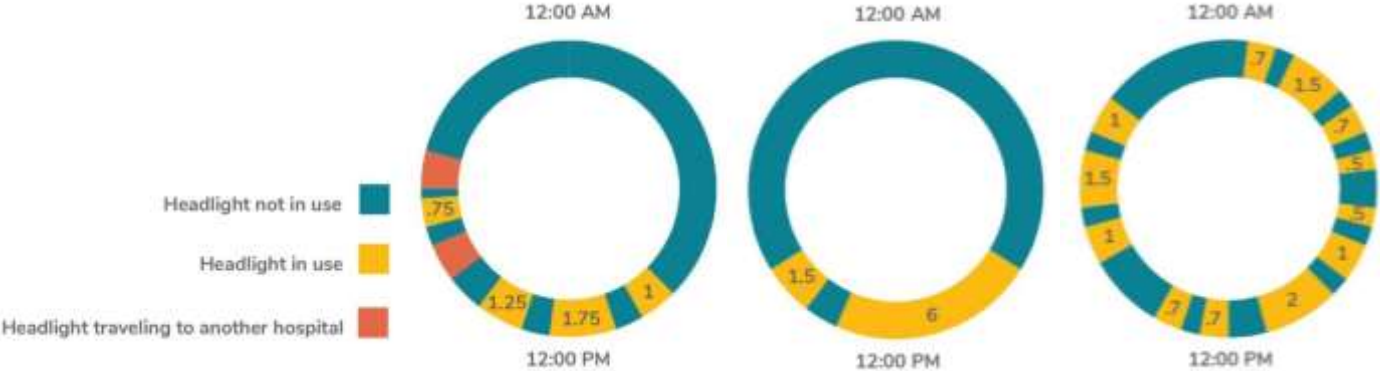
24hr. HEADLIGHT USE PATTERN

users

consulting surgeon

specialist surgeon

*resident general surgeon/
emergency health officer*



user feedback

DR. MANISH AGARWAL, *orthopedic oncologist*



DR. MANIT GUNDAVDA, *orthopedic oncologist*

P. D. Hinduja National Hospital & Medical Research Centre

PROF. B. RAVI & DR. RUPESH GHYAR

BETiC-OrthoCAD Lab, IIT Bombay

user feedback

SURGICAL HEADLIGHT

illuminates surgeon's point of view over varying working distances

not a sterile equipment – after scrub, nurses help to operate

misalignment can occur between loupes, camera, headlight & line of vision

brightness & spot size usually not adjusted – used at max. level

light angle is fixed before surgery & position needs to be secure

face neck and/or back pain from prolonged usage

PRE-OP

task analysis

SURGICAL HEADLIGHT



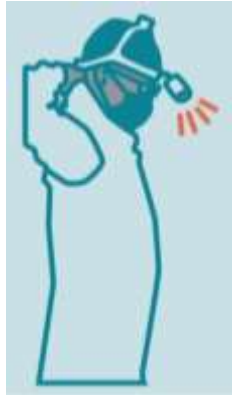
turn headlight including scrub cap & surgical mask & spot diameter

stabilize hands, dry with sterile towel and put on sterile gown & gloves

POSTOPERATION

task analysis

SURGICAL HEADLIGHT

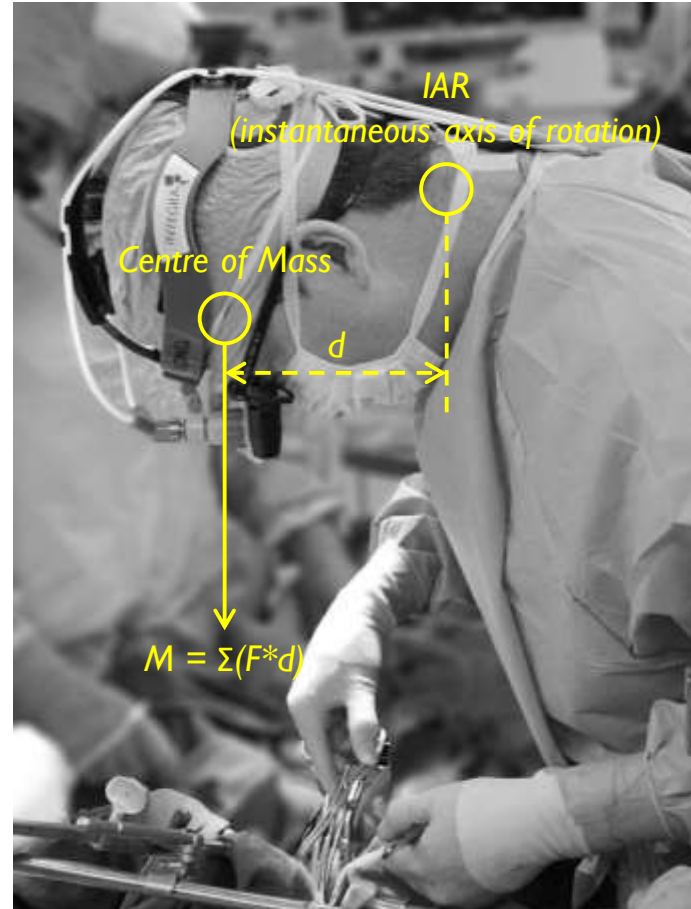


*circulating messages & feedback adjustments & swaps
batteries if required
switch headlight off and remove headlight from head*

*disconnect battery from headlight & plug battery into
charger*

biomechanics

redesign headgear to be *light-weight* with *centre of mass* close to *cervical disc* when surgeon's head is in the most frequently used position.



existing intelligent systems
SURGICAL LIGHT



PROMOTES SURVIVAL

- identifies illumination field pointing device
- automatically activates individual LED products said point

CONSISTENT LIGHTING CONDITIONS

- identifies current working distance
- automatically adjusts illumination level + light field size

interface **SURGICAL HEADLIGHT**

power - on/off

light-head position - adjustable declination angle

brightness – 4 illumination levels + turbo

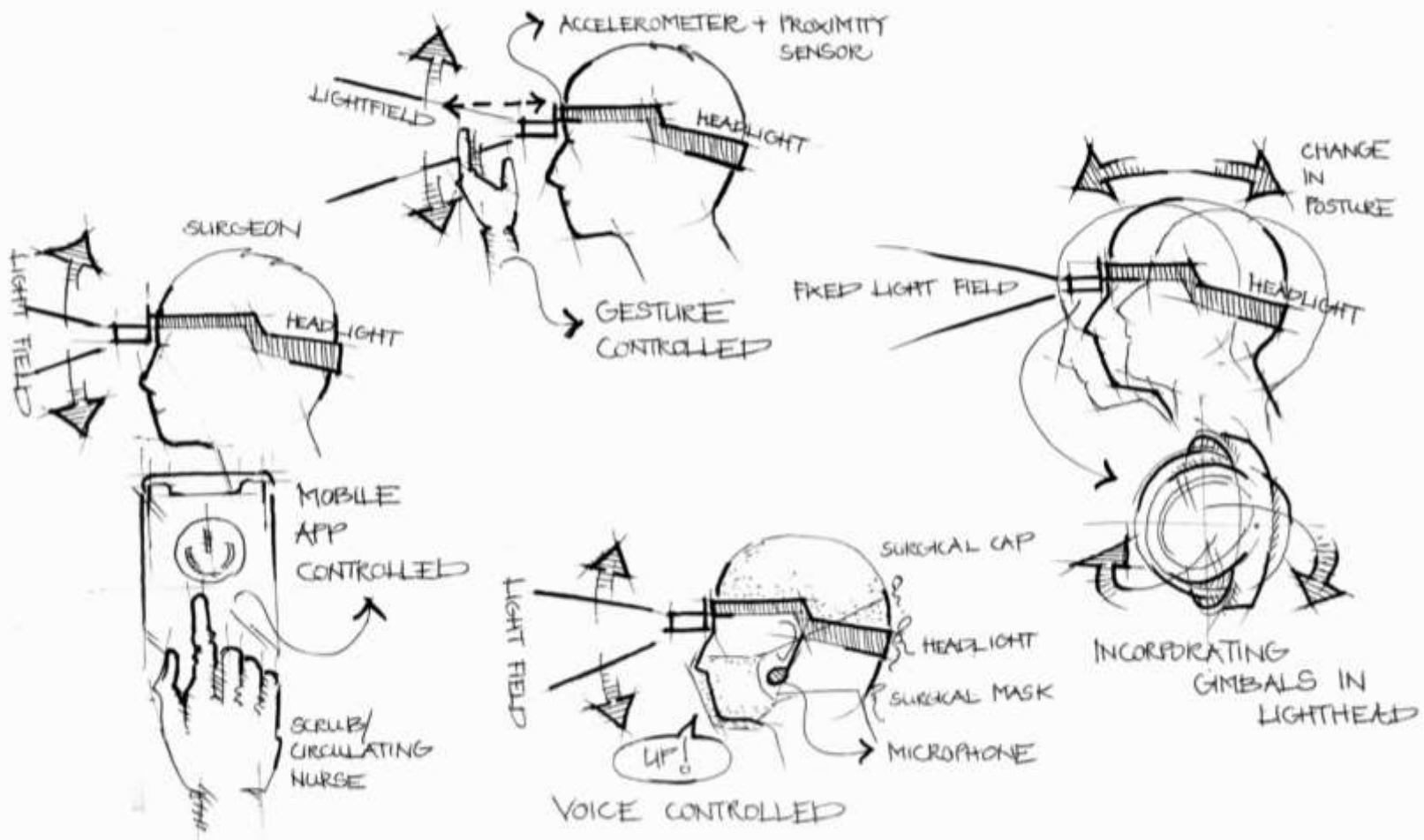
spot size – 3/4 sizes

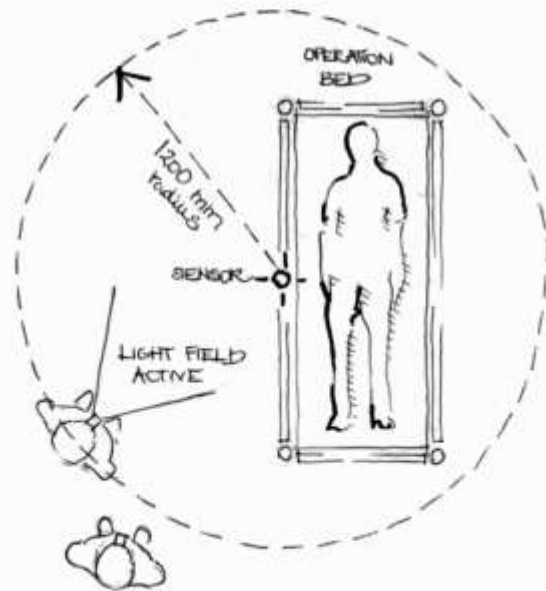
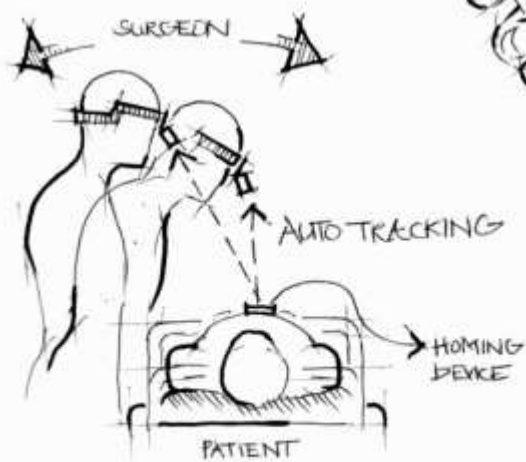
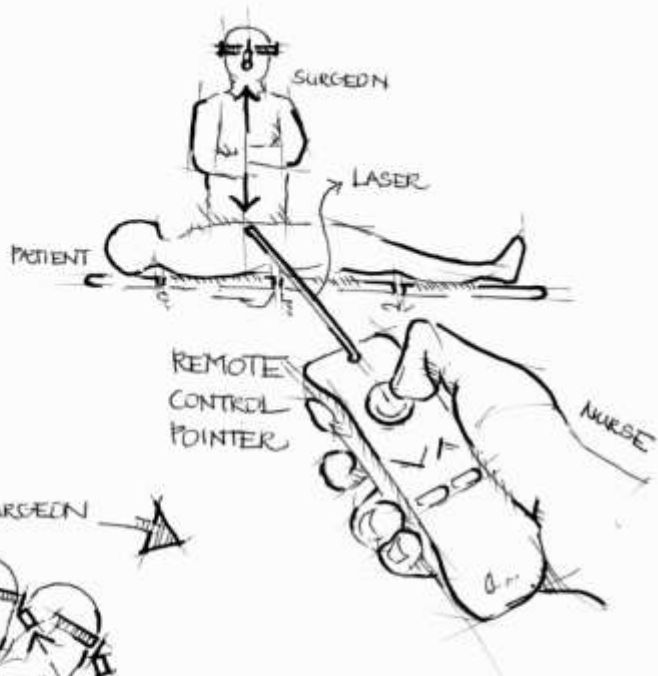
colour temperature – cool white/white/warm white

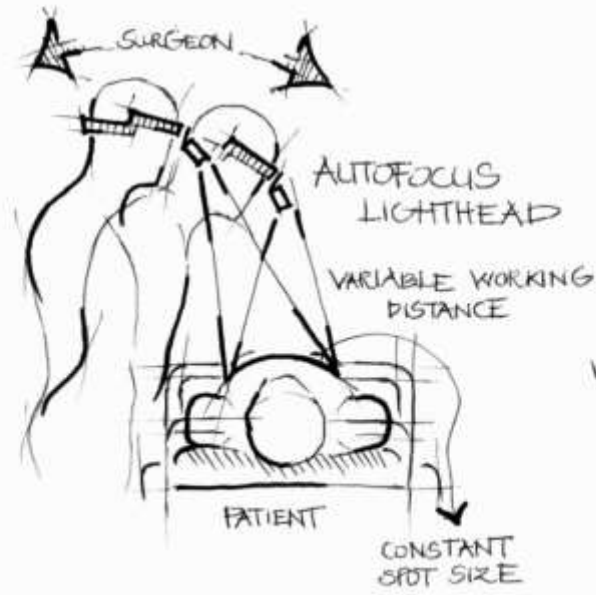
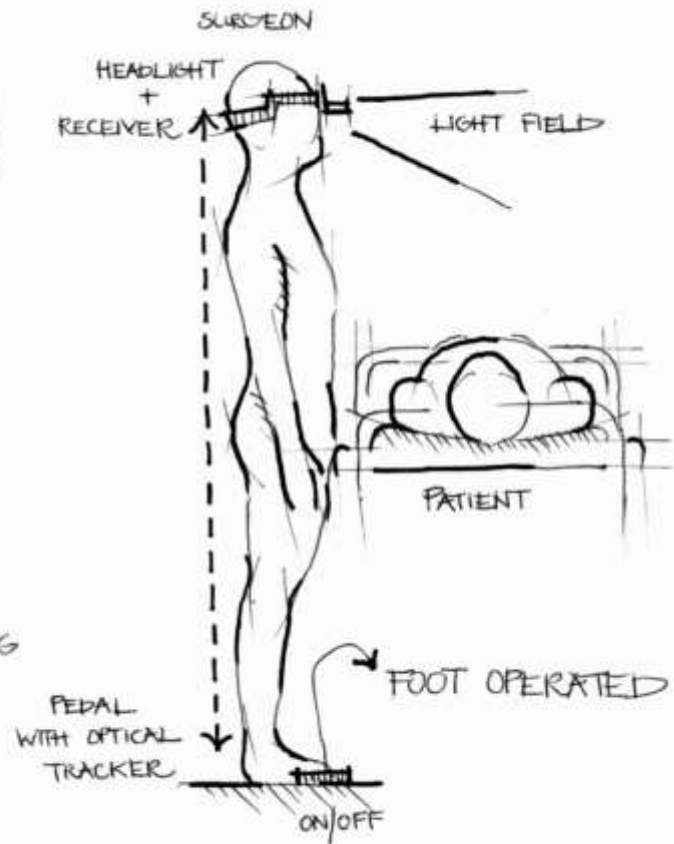
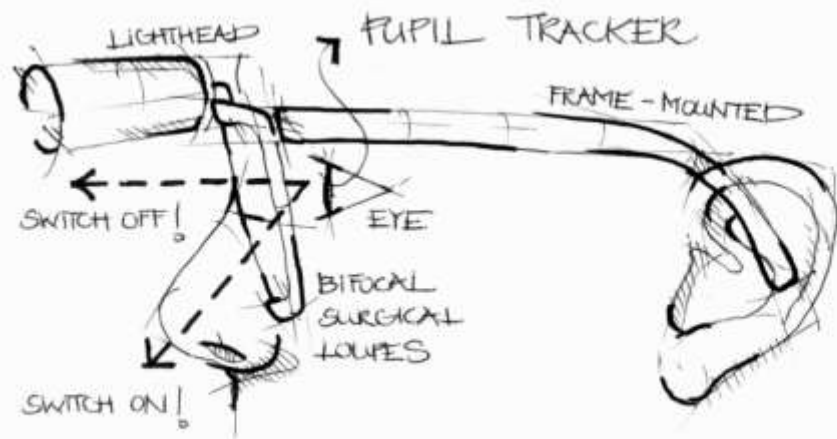
image/video – photograph images

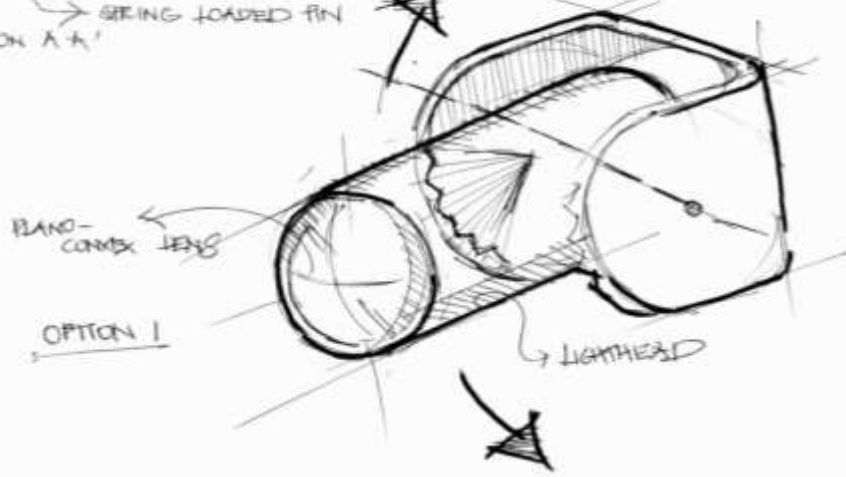
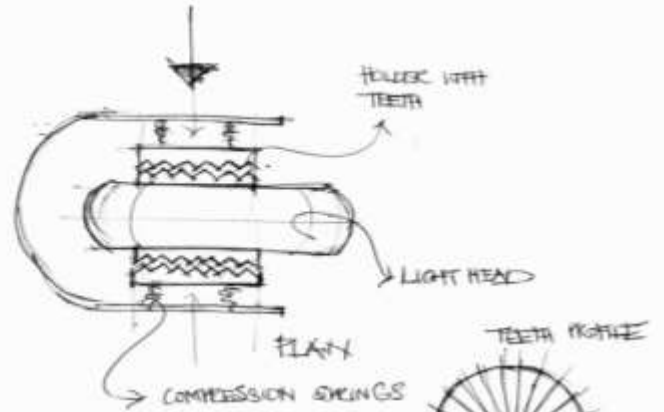
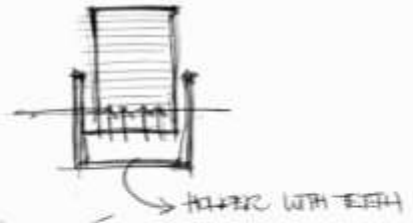
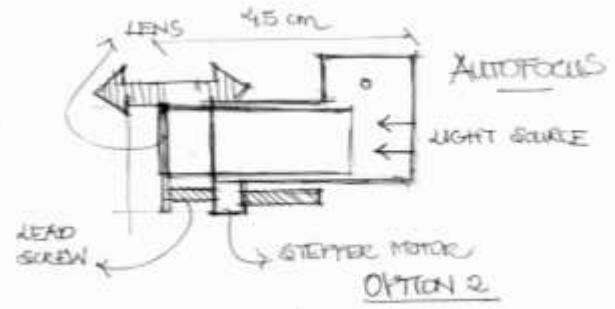
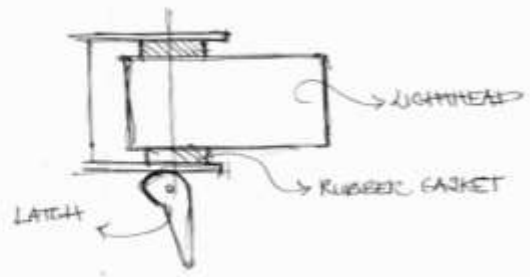
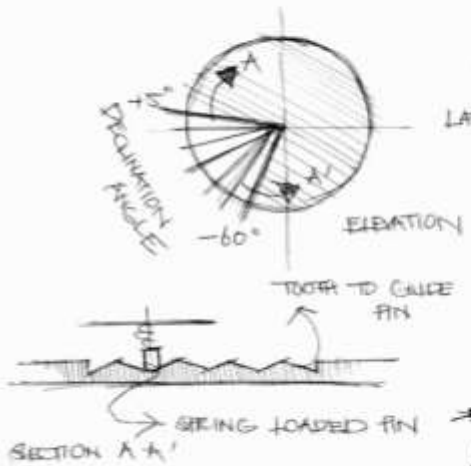
2.5x manual, 16x digital magnification

[coaxial headlight imaging system]









AUTOFOCUS & LOCKING MECHANISM



design statement

*to design a wearable device for **automated illumination of surgery area** in operation theatre*



design brief

'must haves'

should provide a high level of stability and precision of movement. The rig should be able to support a camera with a weight of up to 5kg. The rig should be able to be adjusted to a height of 1.5m to 1.8m. The rig should be able to be adjusted to a width of 350mm to 450mm.



design brief

'may haves'

can be *compatible with other surgical equipments* such as coaxial headlight imaging systems & surgical loupes.

can be *automated to be easily operable* by user with little-to-no assistance.

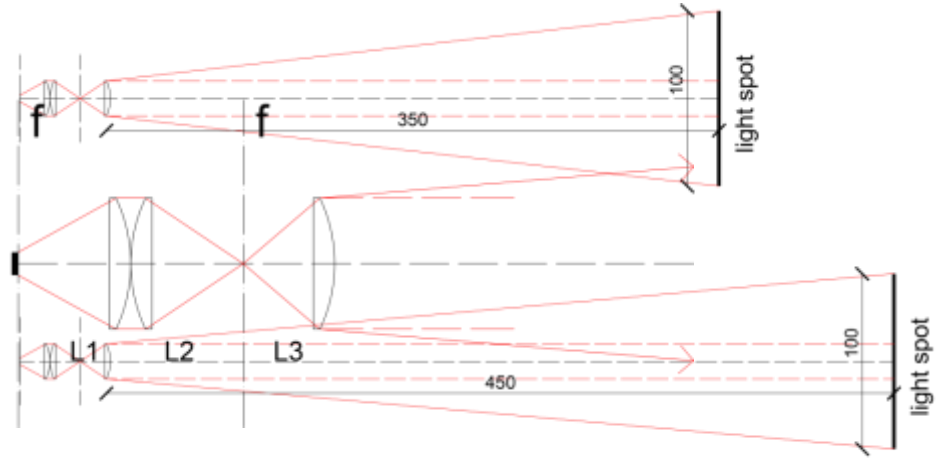
can *provide 'hot-swap' batteries* for uninterrupted usage while swapping batteries during procedures.

PLANO - CONVEX LENS

diameter: 12mm

focal length: 15mm

optics



*all dimensions are in mm.

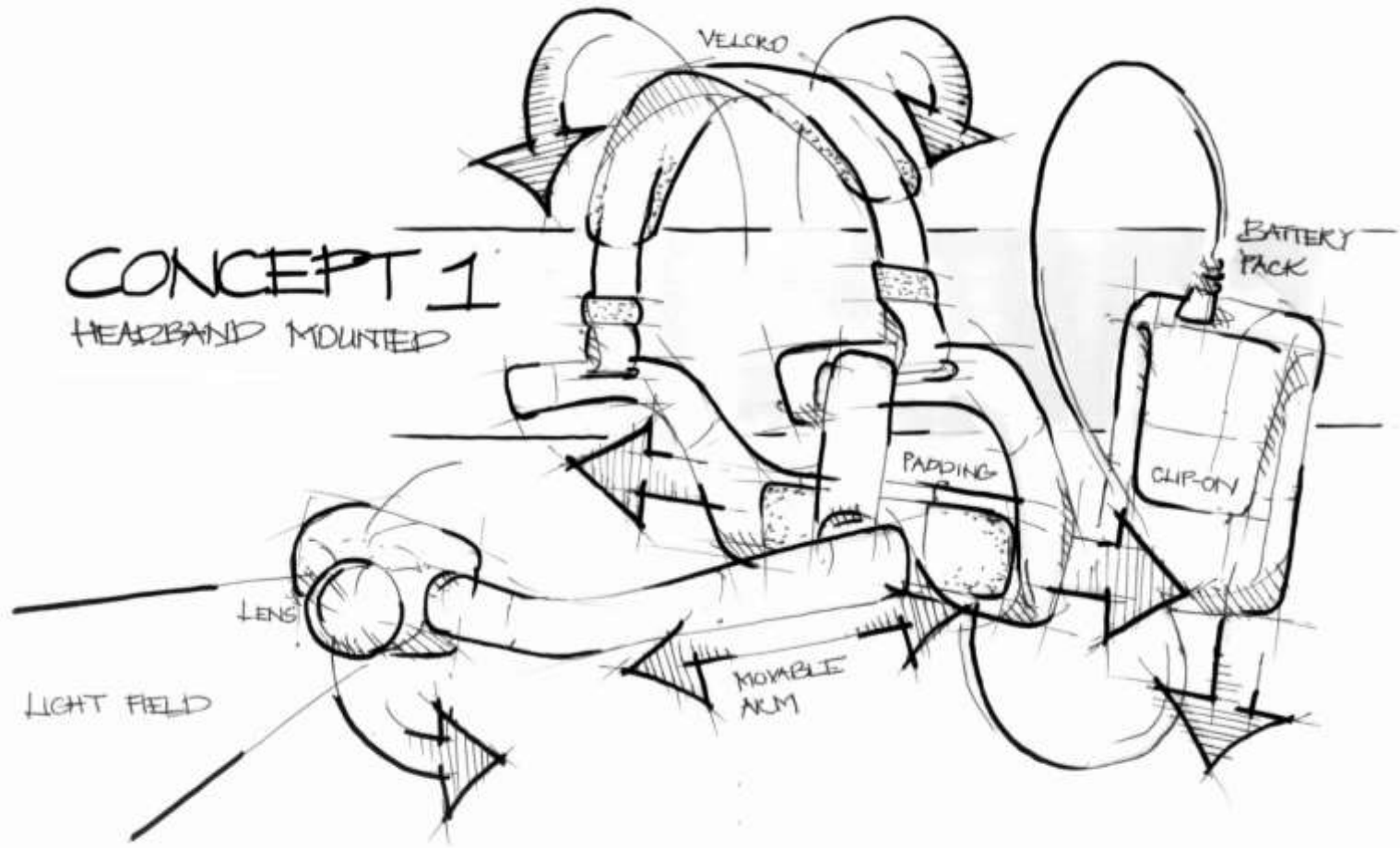
proof-of-concept

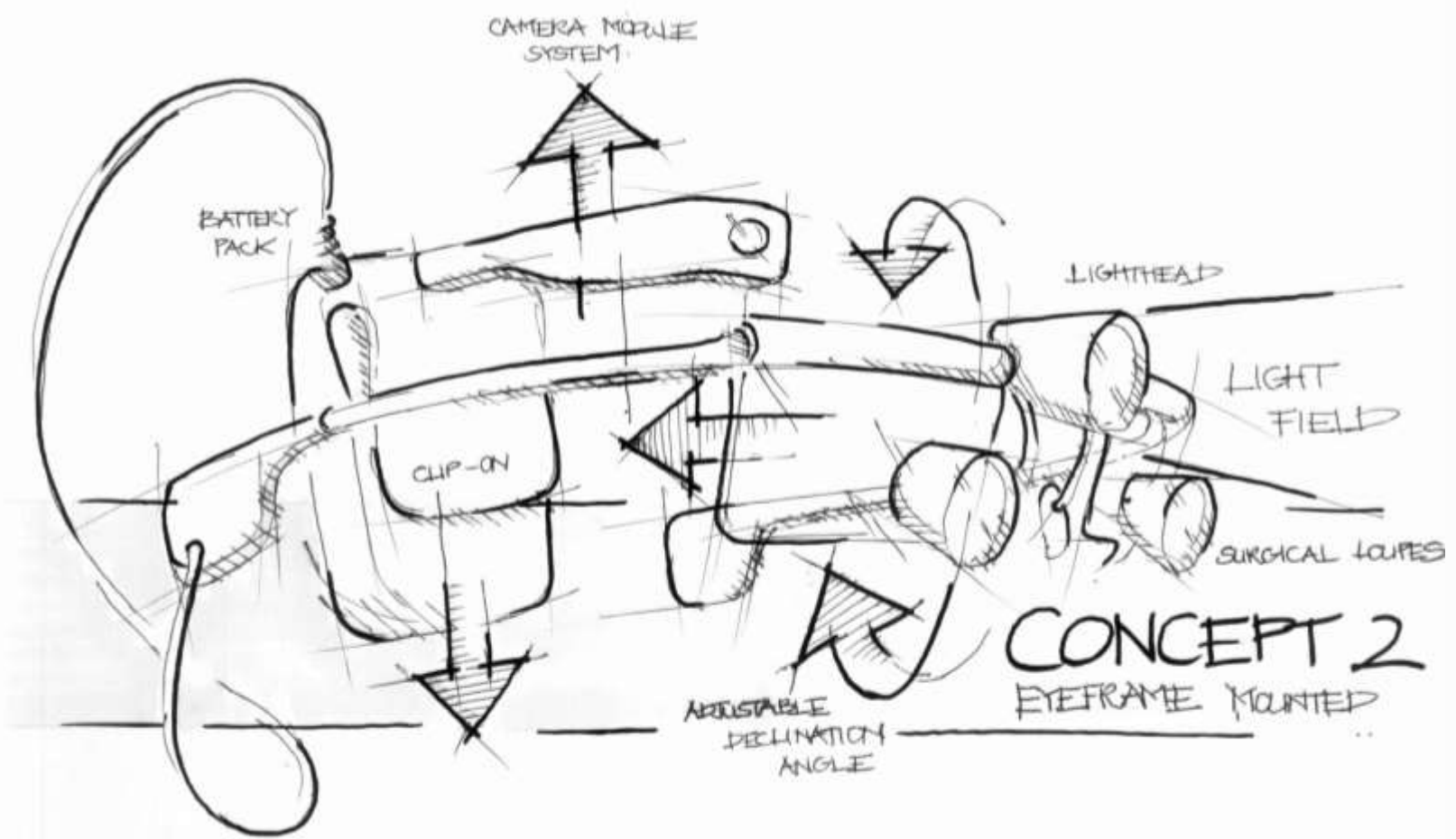


CIRCUIT DIAGRAM

CONCEPT 1

HEADBAND MOUNTED



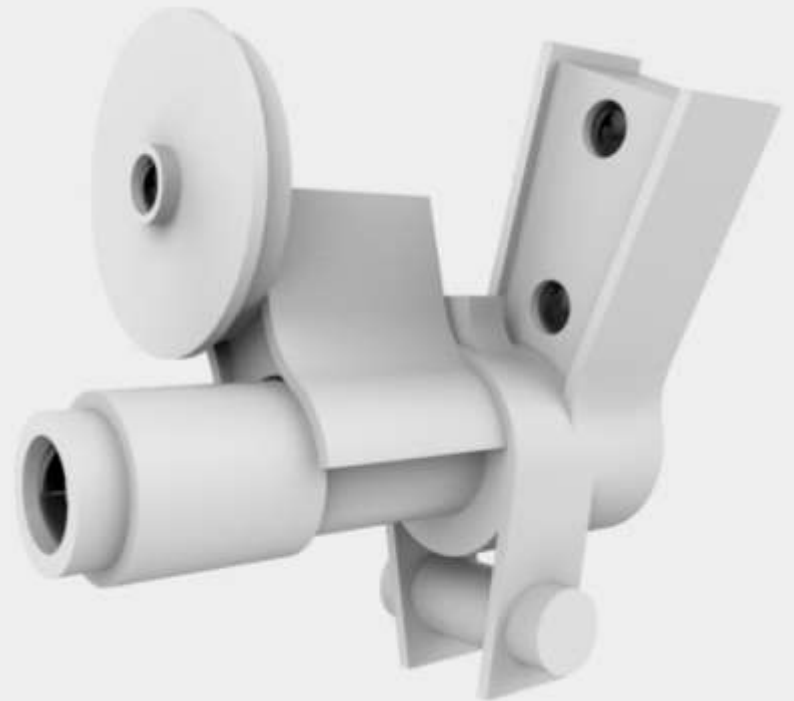
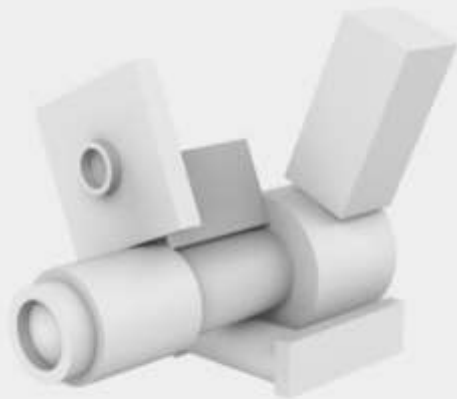


CONCEPT 2
EYEFRAE MOUNTED

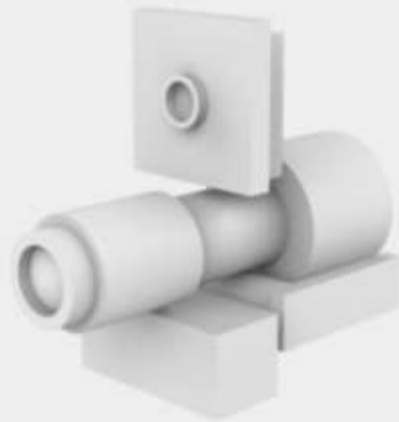
evaluation

Criteria	Concept 1	Concept 2
	Headband Mounted	Eyeframe Mounted
Lightweight Mounting Structure	● ●	● ● ●
Distribution of Weight	● ● ●	●
Provision of Cranial & Occipital Support	● ● ●	●
Compatibility with other Instruments	● ●	● ● ●
Alignment with Line of Vision	● ●	● ● ●

lighthouse configuration - 1



lighthouse configuration - 2



lighthead configuration - 3



evaluation

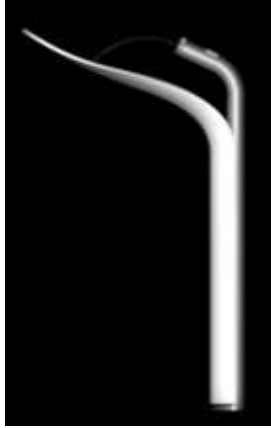
Criteria	Configuration 1	Configuration 2	Configuration 3
Cleanability	●	● ●	● ●
Compactness of Form	●	● ● ●	● ● ●
Integration of Components	●	● ● ●	● ● ●
Visual Integration with Strap	● ●	●	● ● ●
Obstruction of Line of Vision	● ●	● ● ●	● ●

mood board



CLEAN & CLINICAL

mood board



SLEEK & SMART

mood board



LIGHT & MINIMAL



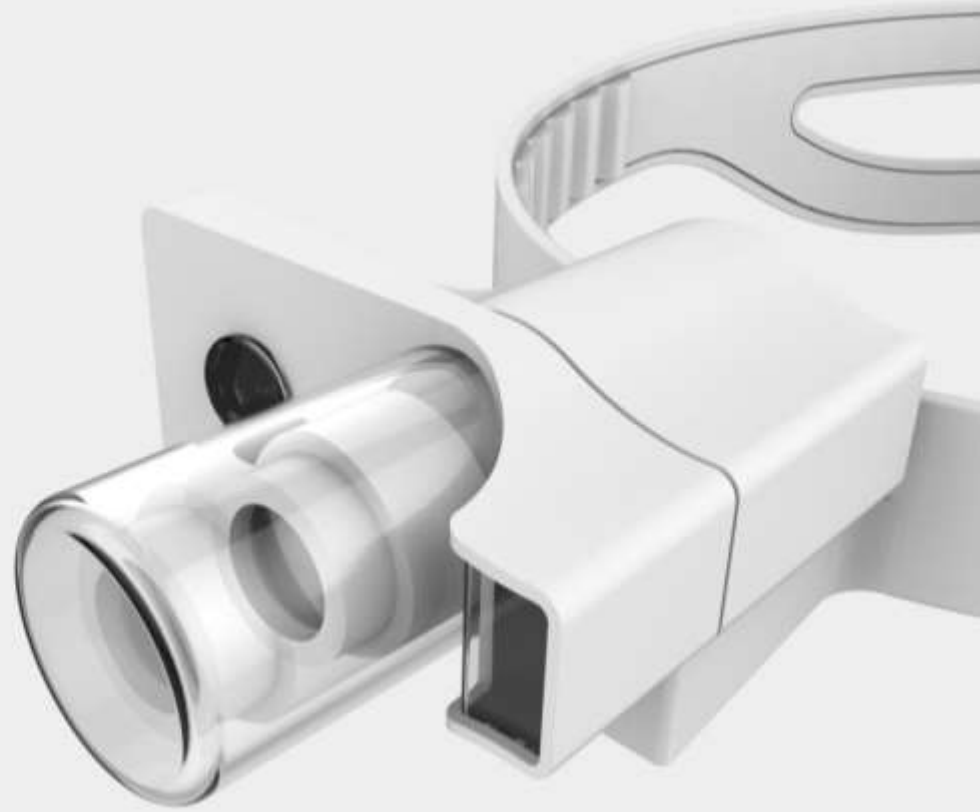
Final Concept

Final form is horizontally articulated - IR sensor to its left, with the transmitter and receiver oriented to the front. The camera sits to its right with the servo motor placed behind it.

The front of the lighthead holds a single lens & moves linearly by 1cm with a rack and pinion mechanism.

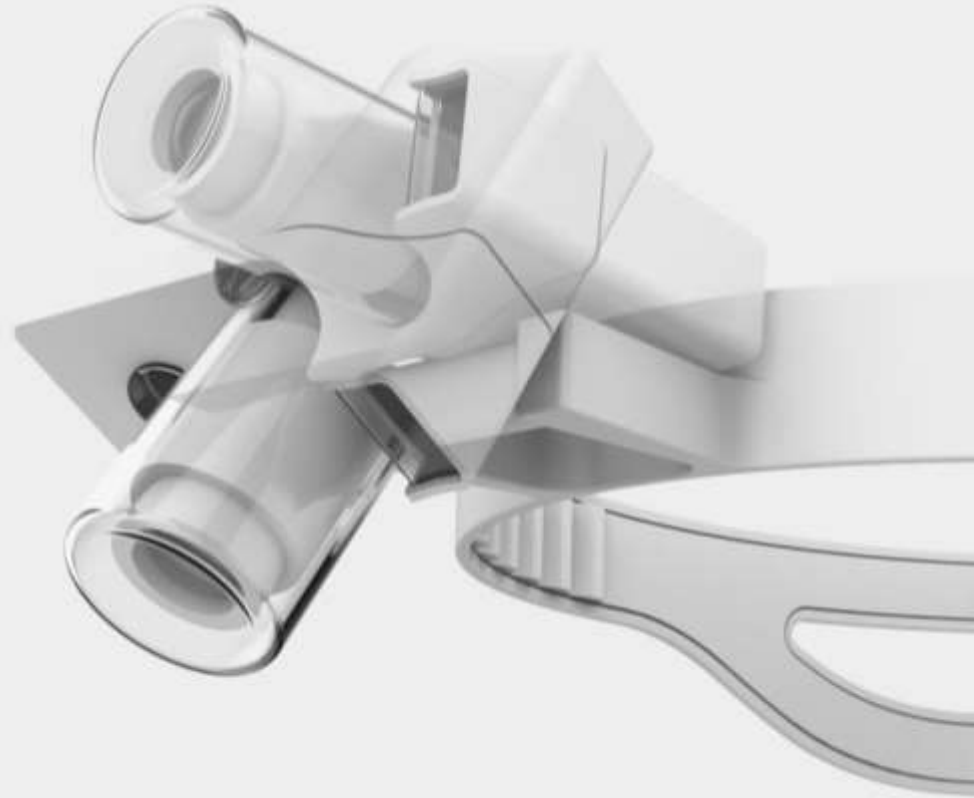
This is enclosed within a transparent removable cover to prevent direct contact with moving part + to allow for easy cleaning.

Also double up as a sterile handle to allow the surgeon to change tilt angle.



Mounted on hinge for an adjustable declination angle between $+5^{\circ}$ & -60° .

Hinge has a pin locking mechanism to secure the set position of the lighthead at 5° intervals.





Lighthouse attached to a Fluoro Rubber strap that is easy to clean and maintain. Extends out below at the rear to stabilize the headlight & provide occipital support to the head.



Inner surface of strap has an indented profile allowing for additional grip & for breathability.

Processor placed at the rear to make headlight back-heavy.

Cut-outs in the rear end of the strap to accommodate a toothed profile.

Two ends of strap pass within casing with a knob to allow for adjustability using a rack and pinion mechanism.



A pair of rechargeable battery packs to be carried in the surgeon's pocket or waistband with the clip provided.

Lower portion is snap-fitted on for power, upper portion contains 'hot-swap' battery for uninterrupted usage.

A cord powers the processor mounted on the headlight.

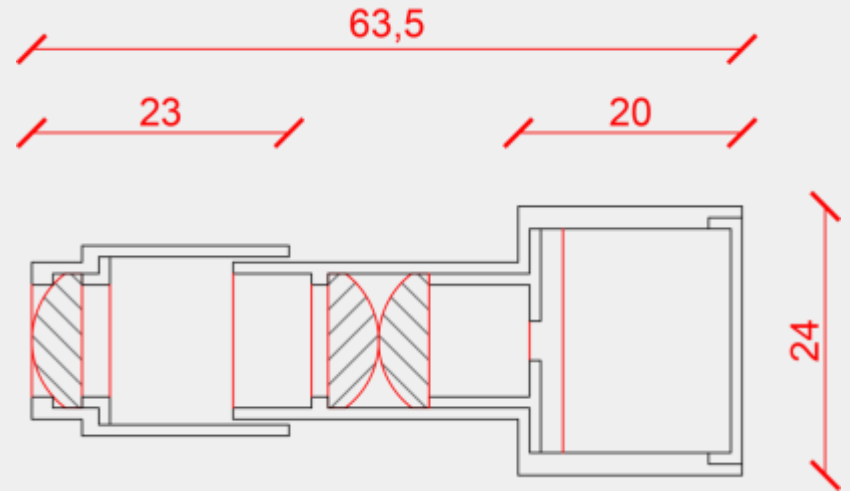
Interface has 3 options: Power OFF / ON & Camera ON
+ LED display for battery level & charging status.



dimensional drawings

**all dimensions in mm*

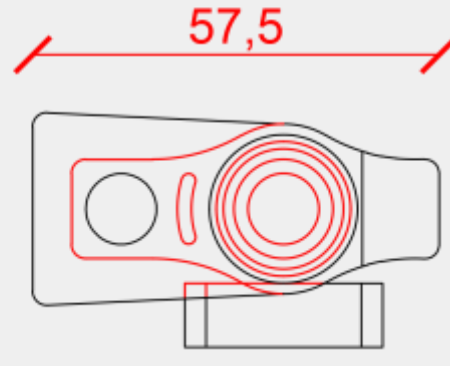
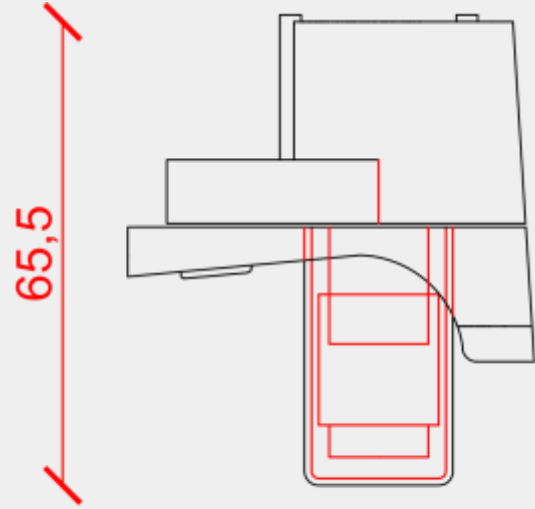
LIGHTHEAD
section



dimensional drawings

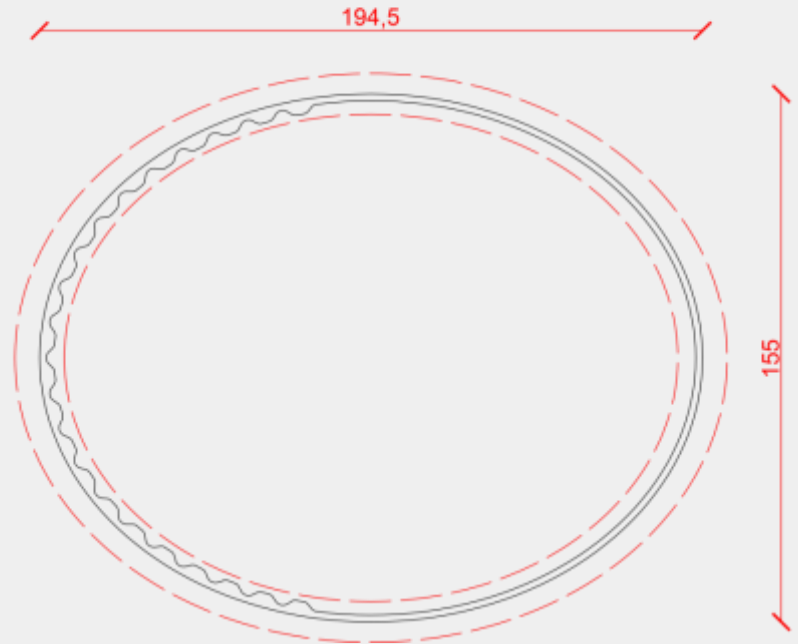
**all dimensions in mm*

LIGHTHEAD
plan & front elevation



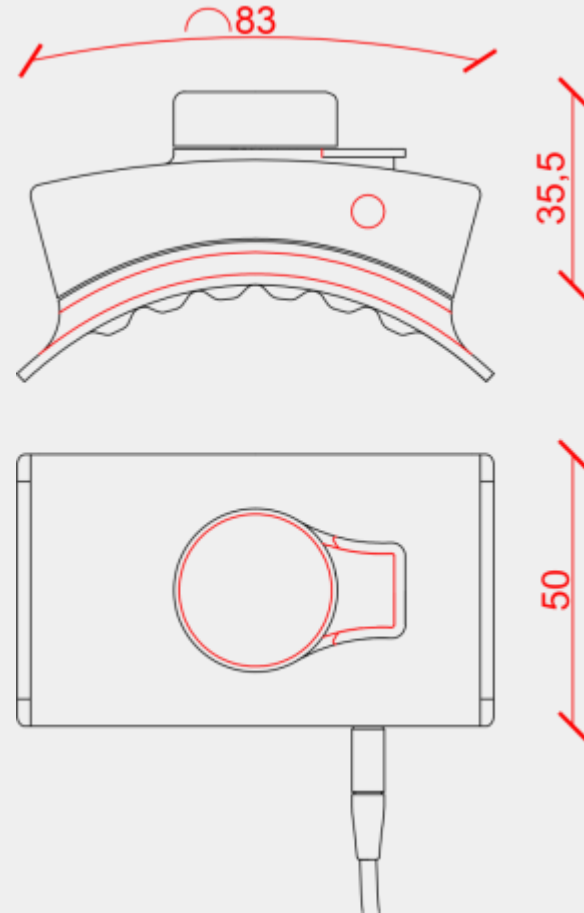


dimensional drawings
**all dimensions in mm*



HEAD STRAP
plan & side elevation

dimensional drawings
**all dimensions in mm*

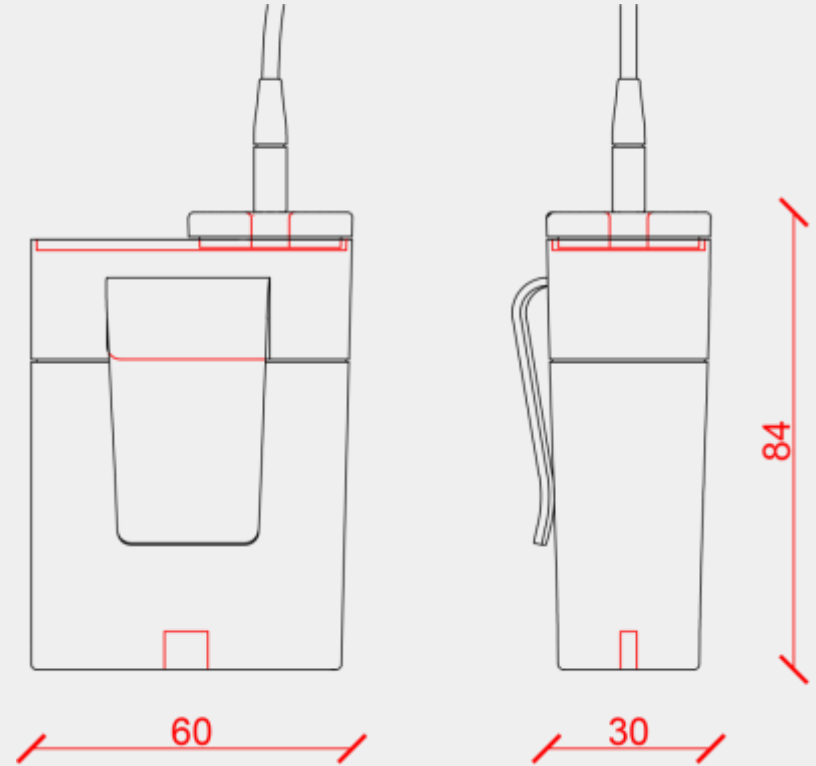


PROCESSOR
plan & front elevation

dimensional drawings

**all dimensions in mm*

BATTERY PACK
plan & side elevation





Oc.LUX
Automated Surgical Headlight

Branded as 'Oc.LUX':

'Oculus' - Latin for 'Eye' & referring to a circular opening
'Lux' - Latin for 'Light' & SI unit for illuminance.

feedback

automatically varying illuminance based on working distance & ambient lighting conditions - added feature

addition of a clip to hold the wire to the back of the surgical gown to prevent it from hanging loosely

mechanism for adjusting the strap requires a locking mechanism to prevent loosening up over time