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

LED LIGHT SOURCE + OPTICAL FIBRE

low heat radiation

consistent illumination

XENON

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 AND HEAD MOUNTED

fabric headband
elastic headband
flexible plastic/rubber headband

{ *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
accessories carrying case

{ *portable headlight* }

scenarios

EXAMINATION

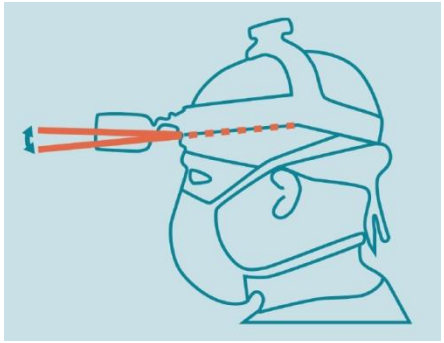
DENTAL

SURGICAL

general surgery
cardio-thoracic & vascular surgery
neuro & spinal surgery
transplant surgery

{ *portable headlight* }

scenarios



OBSTETRIC SECTION REPAIR

surgeons stand next to patient looking down on patient

users

PRIMARY
surgeons
clinicians
proceduralists

SECONDARY
first assists
scrub nurses
circulating nurses

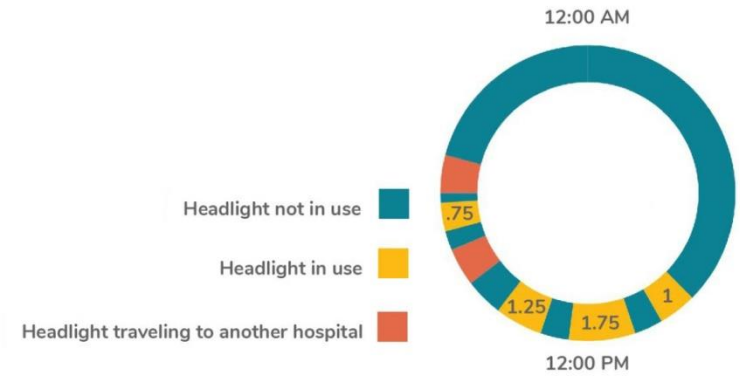
TERTIARY
servicing technicians

24hr. HEADLIGHT USE PATTERN

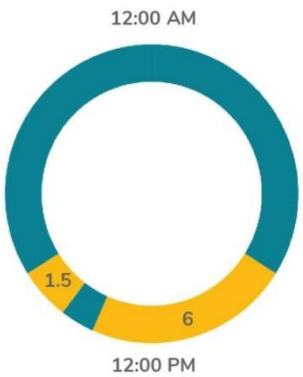
.

users

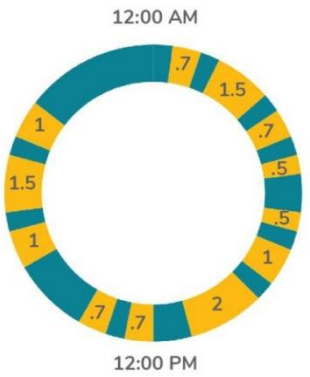
consulting surgeon



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

put on scrubs including scrub cap & surgical mask

turn headlight on to adjust illuminance, tilt angle & spot diameter

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

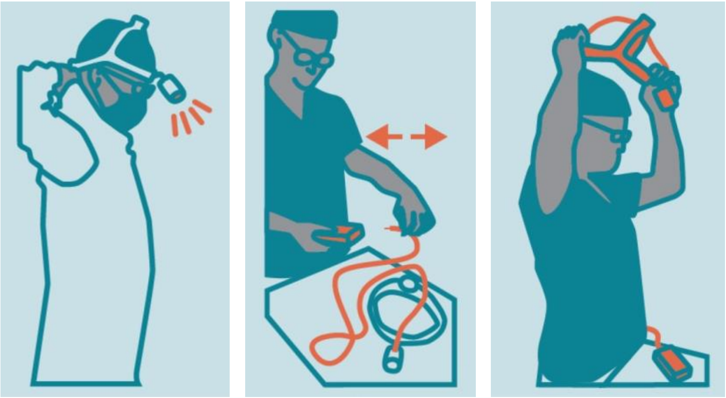
place and adjust headlight to fit on head

DURING

POST-OPERATION

task analysis

SURGICAL HEADLIGHT



circulating nurse makes headlight adjustments & swaps batteries if required

remove gloves, gown & face mask

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 SURGICAL ASEPSIS

- *surgeon identifies illumination point using pointing device*
- *automatically directs individual LED lights to said point*

CONSISTENT LIGHTING CONDITIONS

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

interface

SURGICAL HEADLIGHT

power - *on/off*

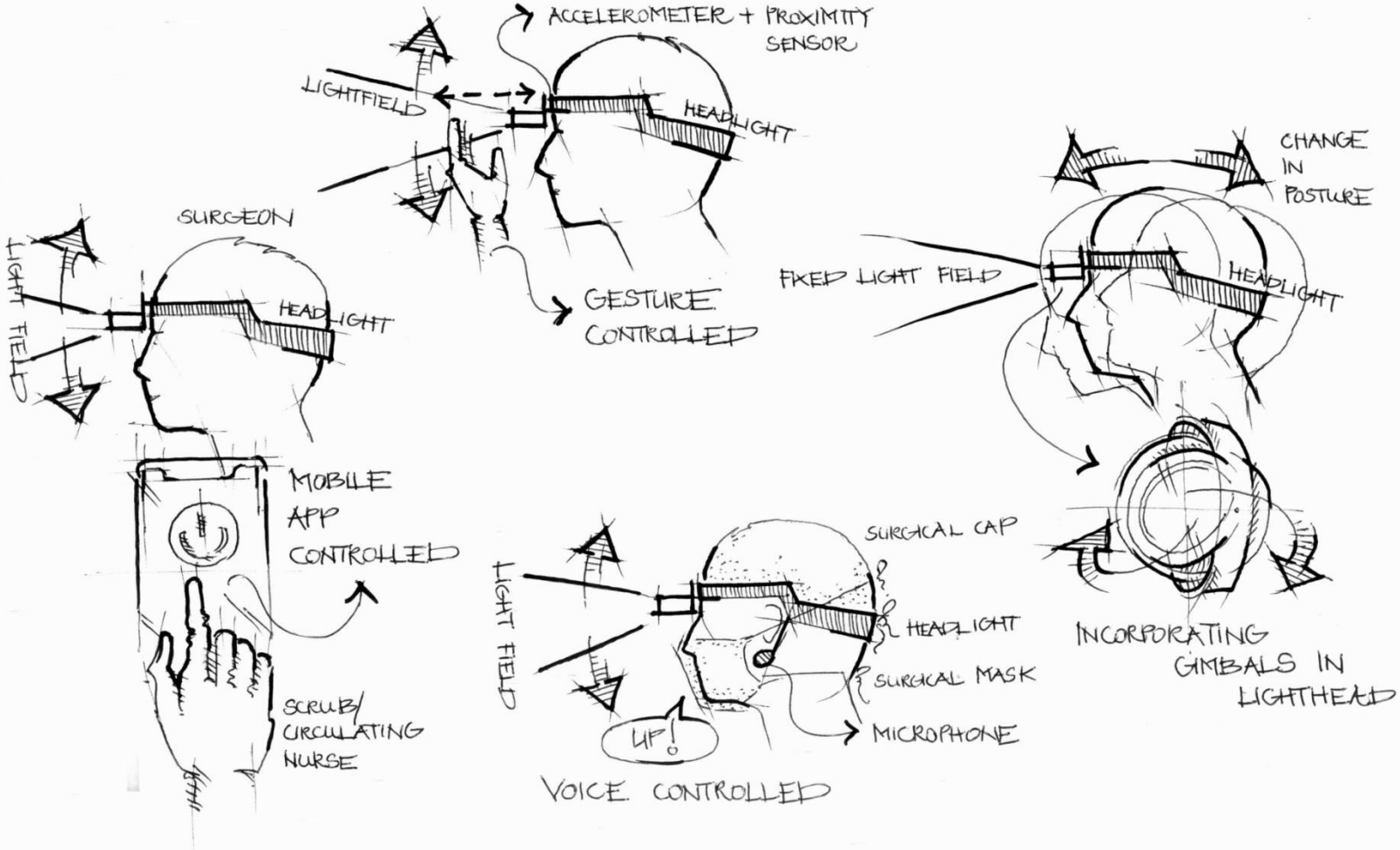
light-head position - *adjustable declination angle*

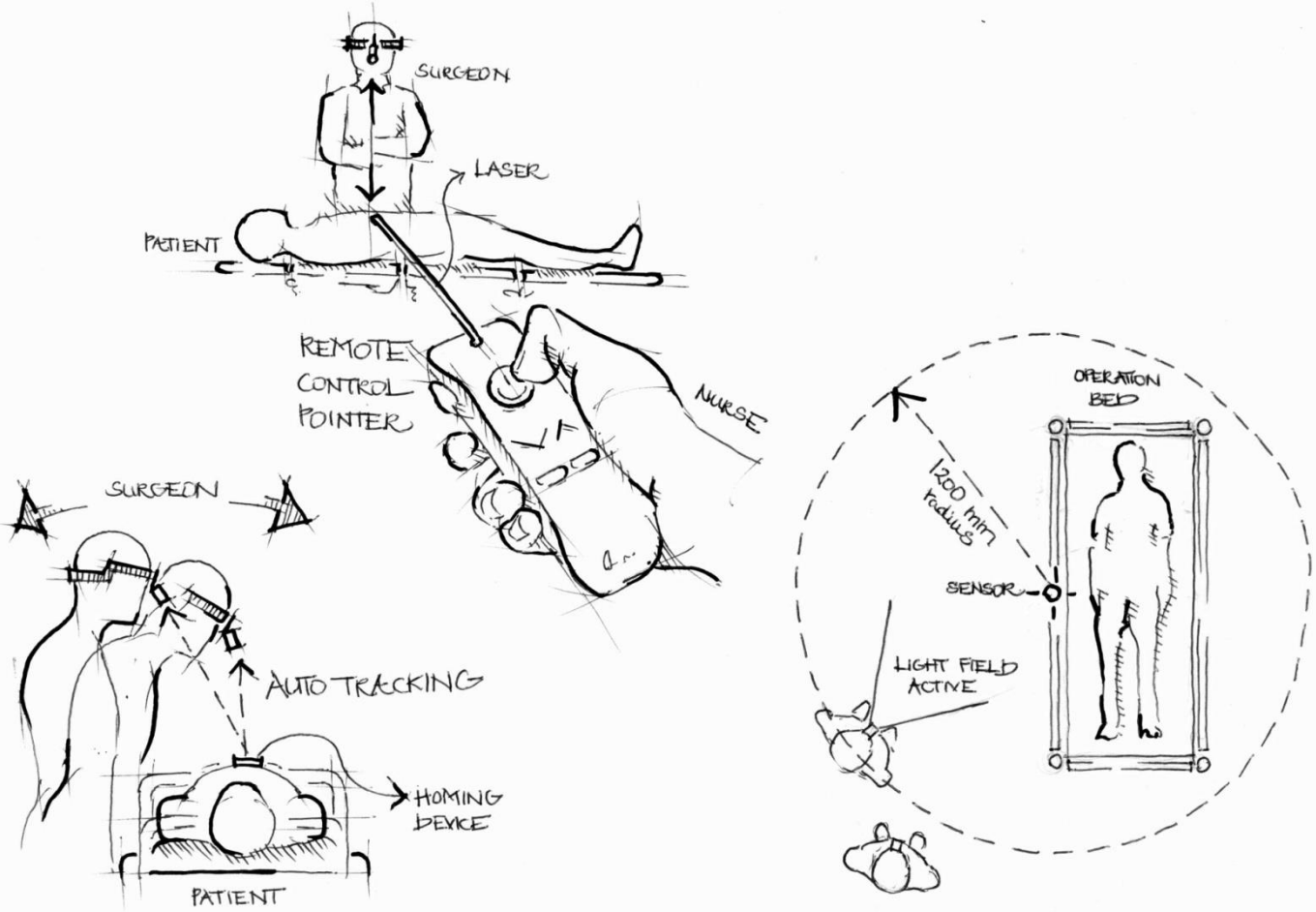
brightness – *4 illumination levels + turbo*

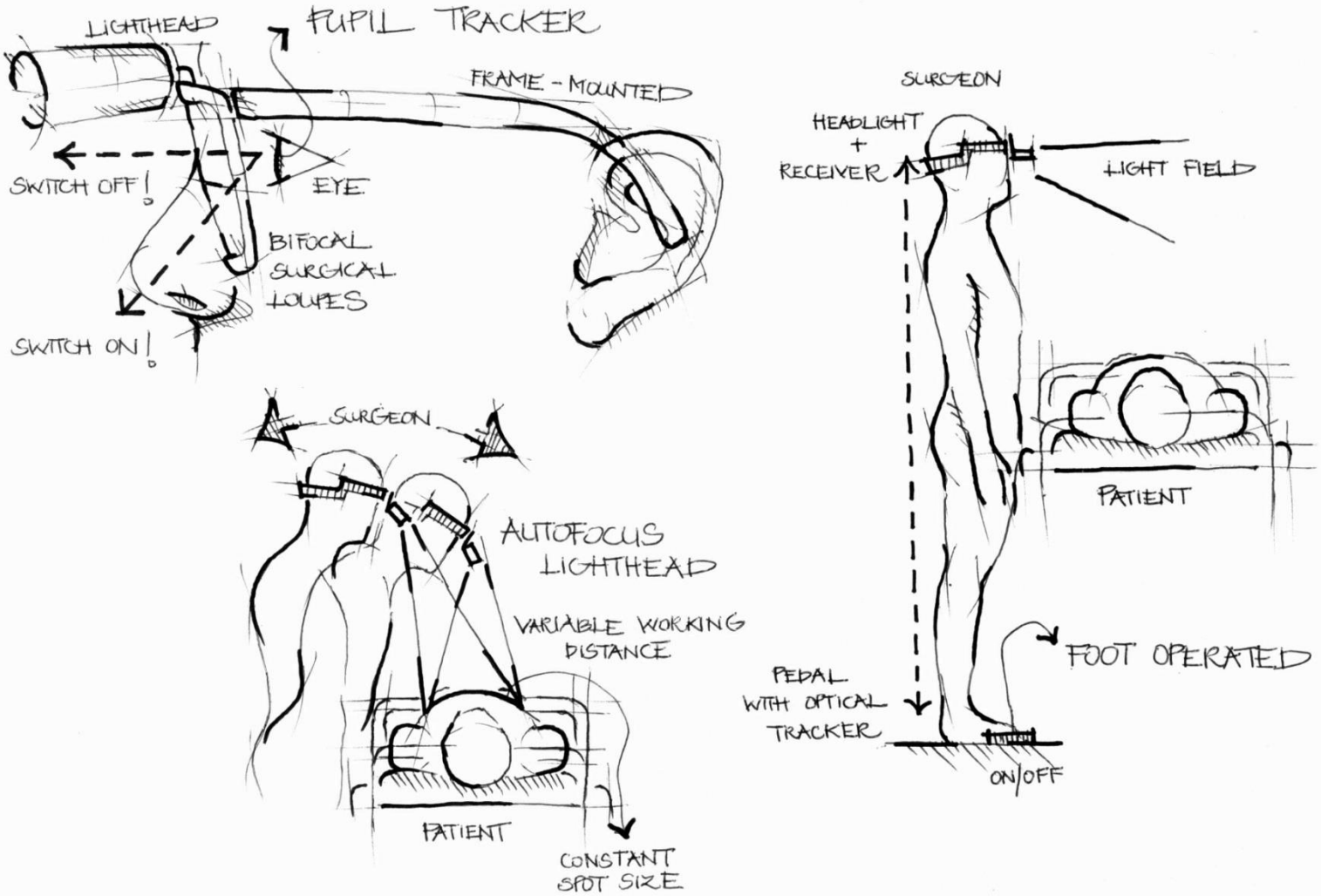
spot size – *3/4 sizes*

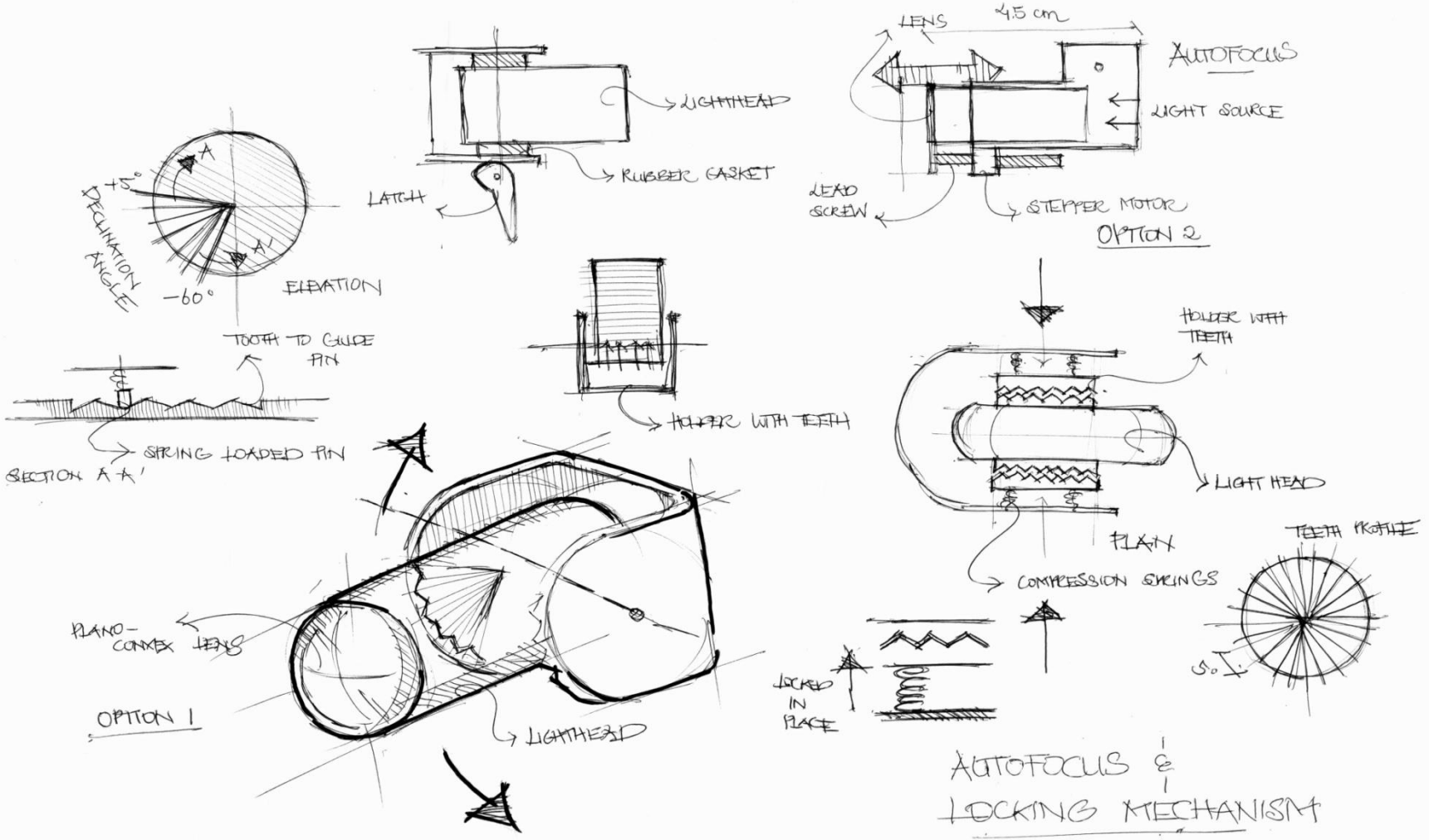
colour temperature – *cool white/white/warm white*

image/video – *photograph images*
2.5x manual, 16x digital magnification
[coaxial headlight imaging system]


ACCELEROMETER + PROXIMITY SENSOR
LIGHTFIELD
HEADLIGHT
GESTURE CONTROLLED
SURGEON
LIGHT FIELD
HEADLIGHT
MOBILE APP CONTROLLED
SCRUB/ CIRCULATING NURSE
CHANGE IN POSTURE
FIXED LIGHT FIELD
HEADLIGHT
INCORPORATING GIMBALS IN LIGHTHEAD
SURGICAL CAP
LIGHT FIELD
HEADLIGHT
SURGICAL MASK
MICROPHONE
UP!
VOICE CONTROLLED


SURGEON
LASER
PATIENT
REMOTE
CONTROL
POINTER
NURSE
SURGEON
AUTO TRACKING
HOMING
DEVICE
PATIENT
OPERATION
BED
1200 mm
radius
SENSOR
LIGHT FIELD
ACTIVE


LIGHTHEAD
PUPIL TRACKER
FRAME - MOUNTED
SWITCH OFF!
EYE
BIFOCAL SURGICAL LOUPES
SWITCH ON!
SURGEON
AUTOFOCUS LIGHTHEAD
VARIABLE WORKING DISTANCE
PATIENT
CONSTANT SPOT SIZE
SURGEON
HEADLIGHT + RECEIVER
LIGHT FIELD
PATIENT
FOOT OPERATED
PEDAL WITH OPTICAL TRACKER
ON/OFF


LENS
4.5 cm
AUTOFOCUS
LIGHT SOURCE
LIGHTHEAD
RUBBER GASKET
LATCH
LEAD SCREW
STEPPER MOTOR
OPTION 2
+5°
DECLINATION ANGLE
-60°
ELEVATION
TOOTH TO GUIDE PIN
SPRING LOADED PIN
SECTION A-A'
HOLDER WITH TEETH
HOLDER WITH TEETH
LIGHT HEAD
PLAN
COMPRESSION SPRINGS
TEETH PROFILE
5°
PLANO-CONVEX LENS
OPTION 1
LIGHTHEAD
LOCKED IN PLACE
AUTOFOCUS & LOCKING MECHANISM

design statement

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

design brief

‘must haves’

should [illegible]

of 350 - 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.

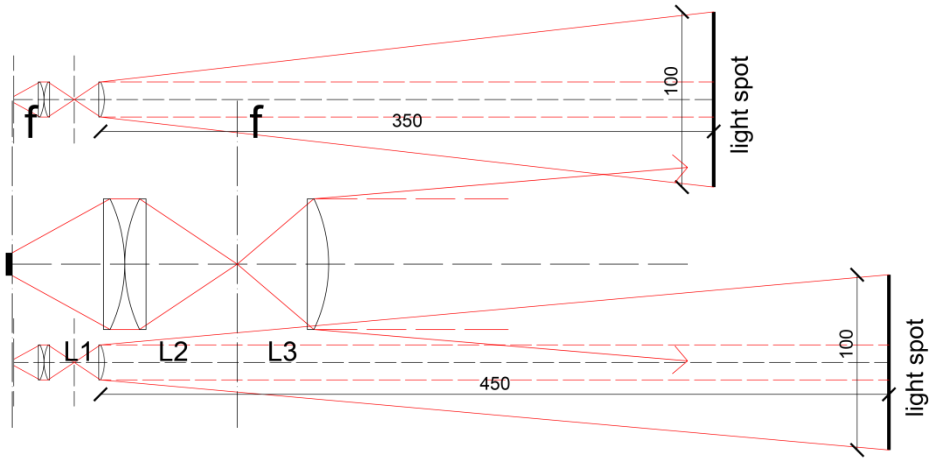
can provide 'hot-swap' batteries for uninterrupted usage while swapping batteries during procedures.

PLANO - CONVEX LENS

diameter: 12mm

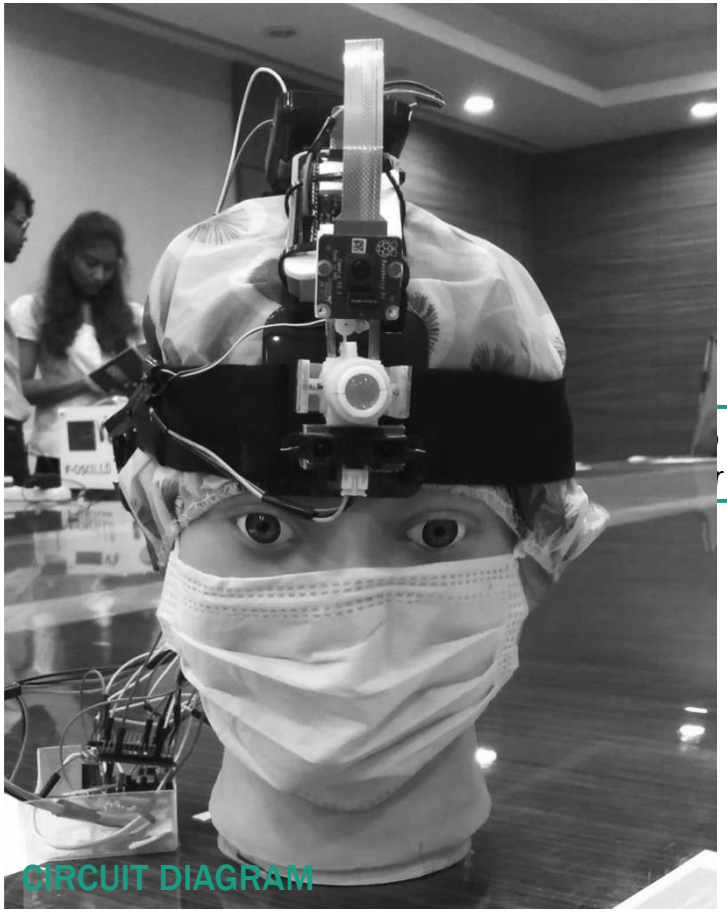
focal length: 15mm

optics

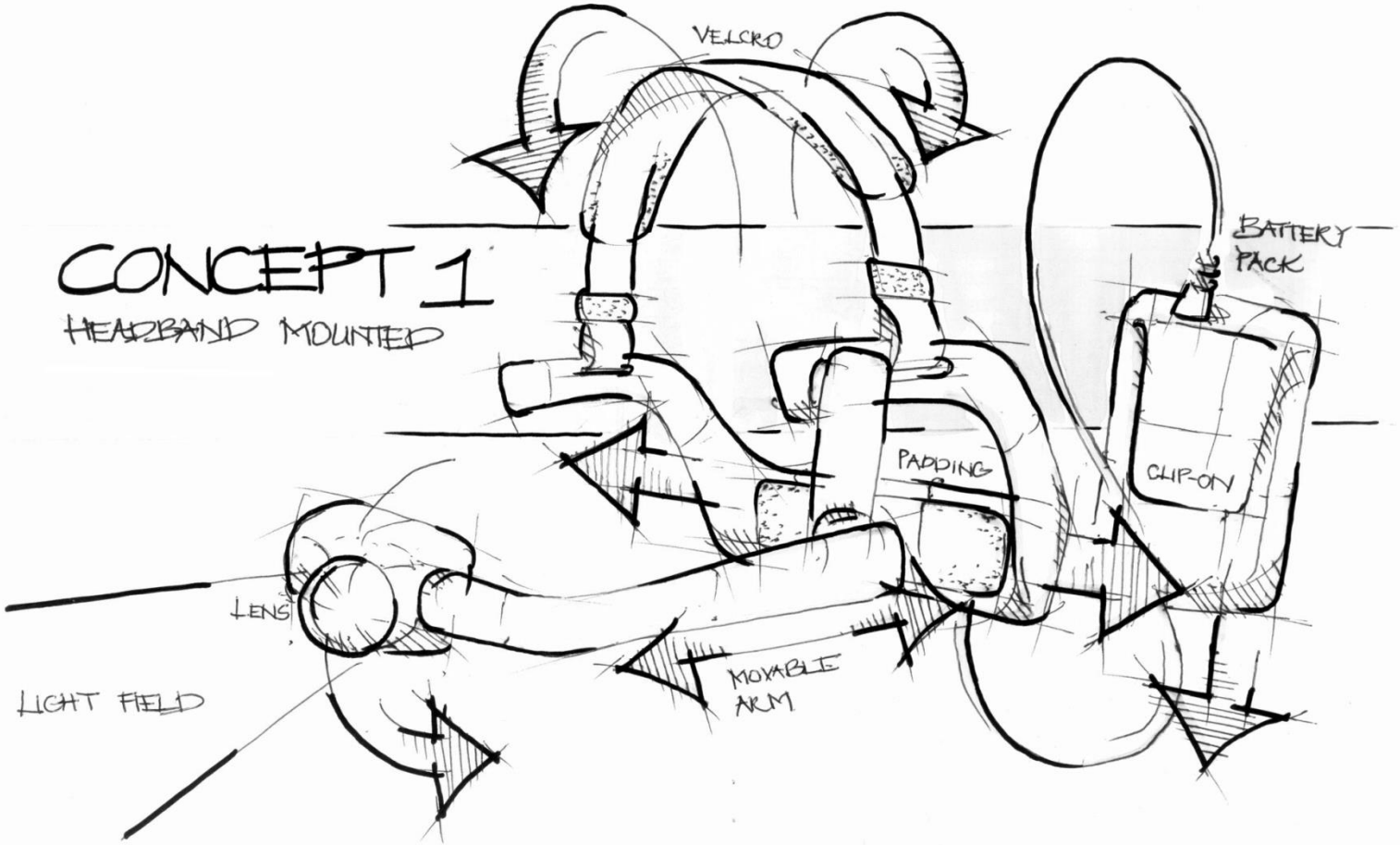


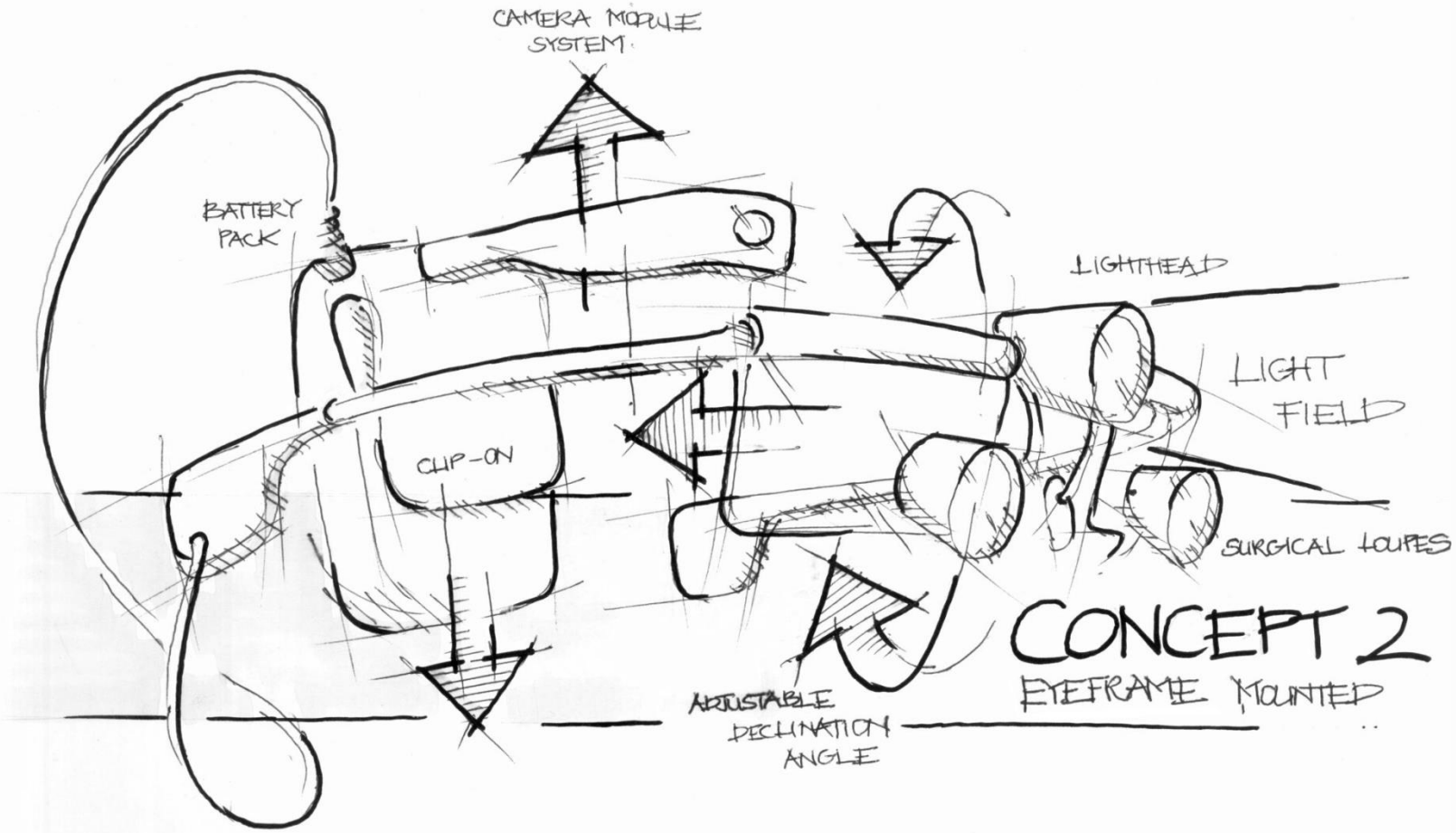
*all dimensions are in mm.

proof-of-concept



CIRCUIT DIAGRAM

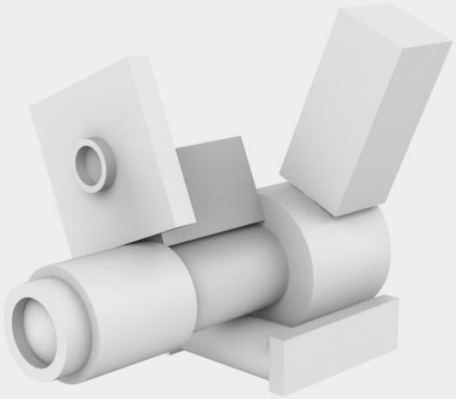

CONCEPT 1
HEADBAND MOUNTED
VELCRO
BATTERY PACK
PADDING
CLIP-ON
LENS
LIGHT FIELD
MOVABLE ARM

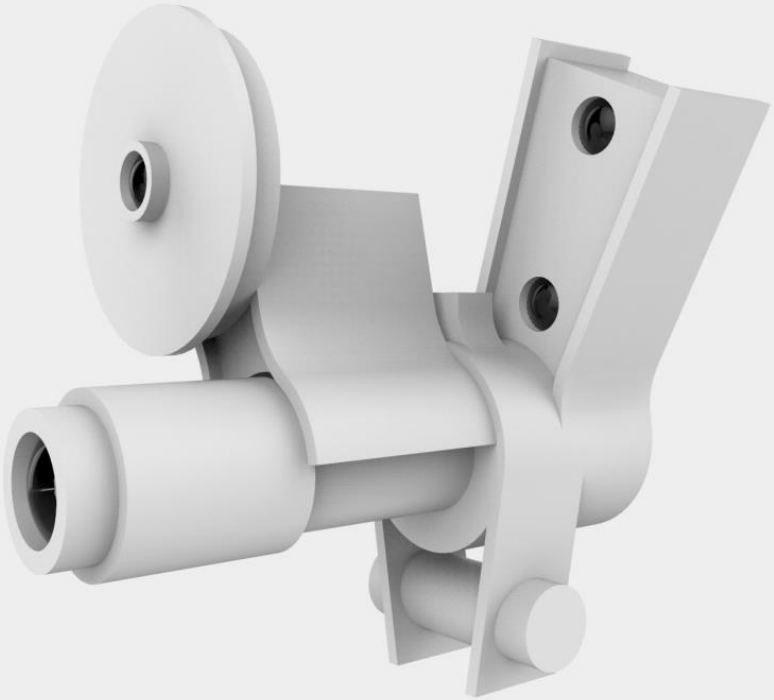

CAMERA MODULE SYSTEM
BATTERY PACK
CLIP-ON
LIGHTHEAD
LIGHT FIELD
SURGICAL LOUPES
ADJUSTABLE DECLINATION ANGLE
CONCEPT 2
EYEFRAME MOUNTED

evaluation

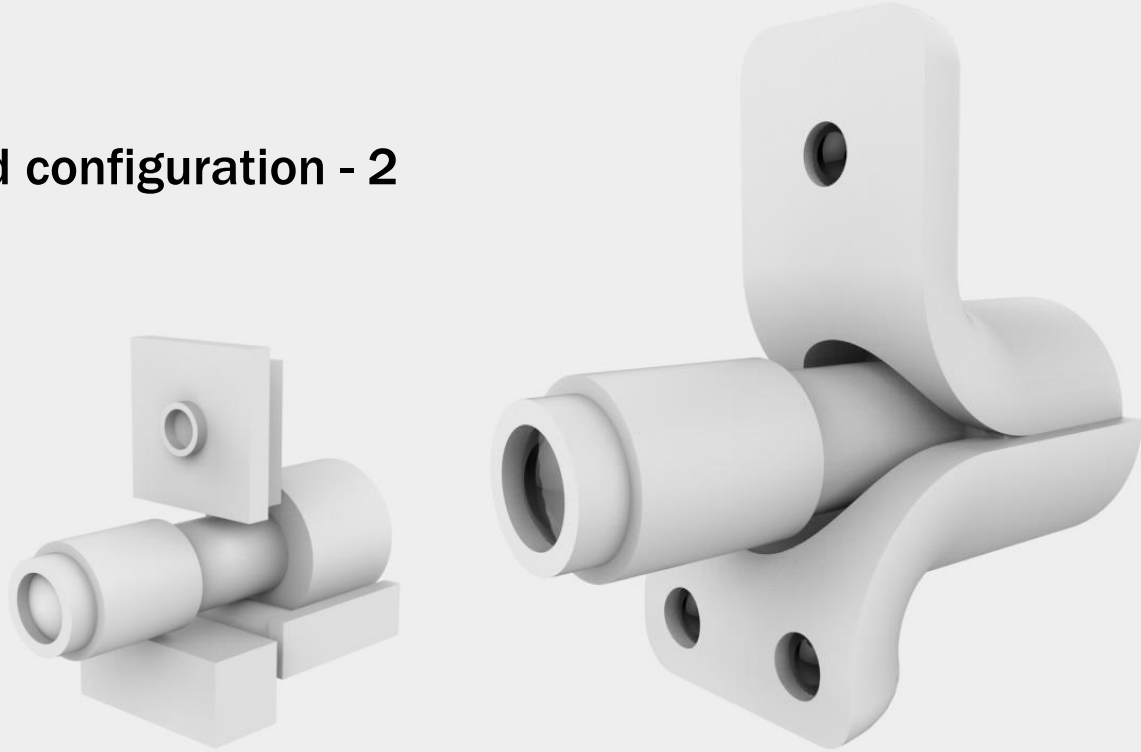
Criteria	**Concept 1**	Concept 2
	Headband Mounted	Eyeframe Mounted
Lightweight Mounting Structure	● ●	● ● ●
Distribution of Weight	● ● ●	●
Provision of Cranial & Occipital Support	● ● ●	●
Compatibility with other Instruments	● ●	● ● ●
Alignment with Line of Vision	● ●	● ● ●

lighthead configuration - 1

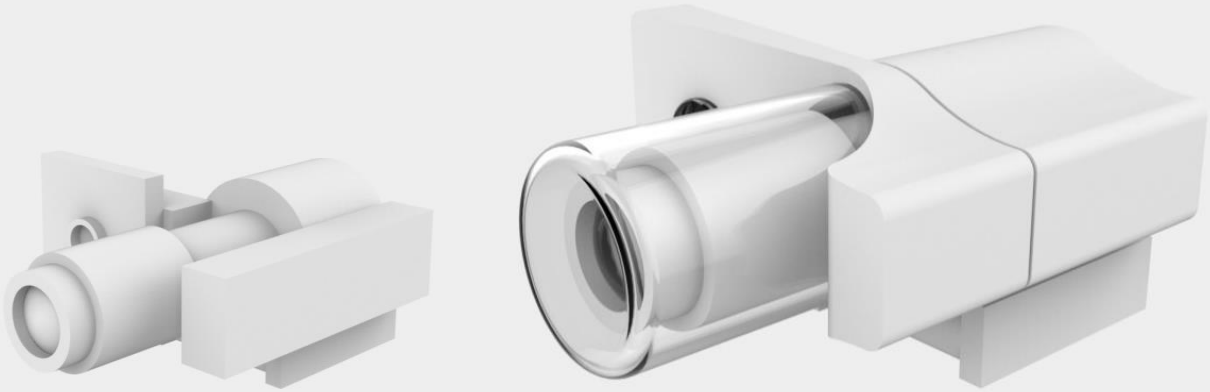




lighthead configuration - 2



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

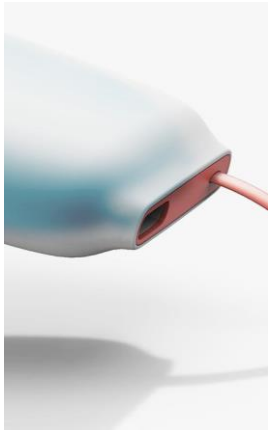
mood board






SLEEK & SMART

mood board






LIGHT & MINIMAL

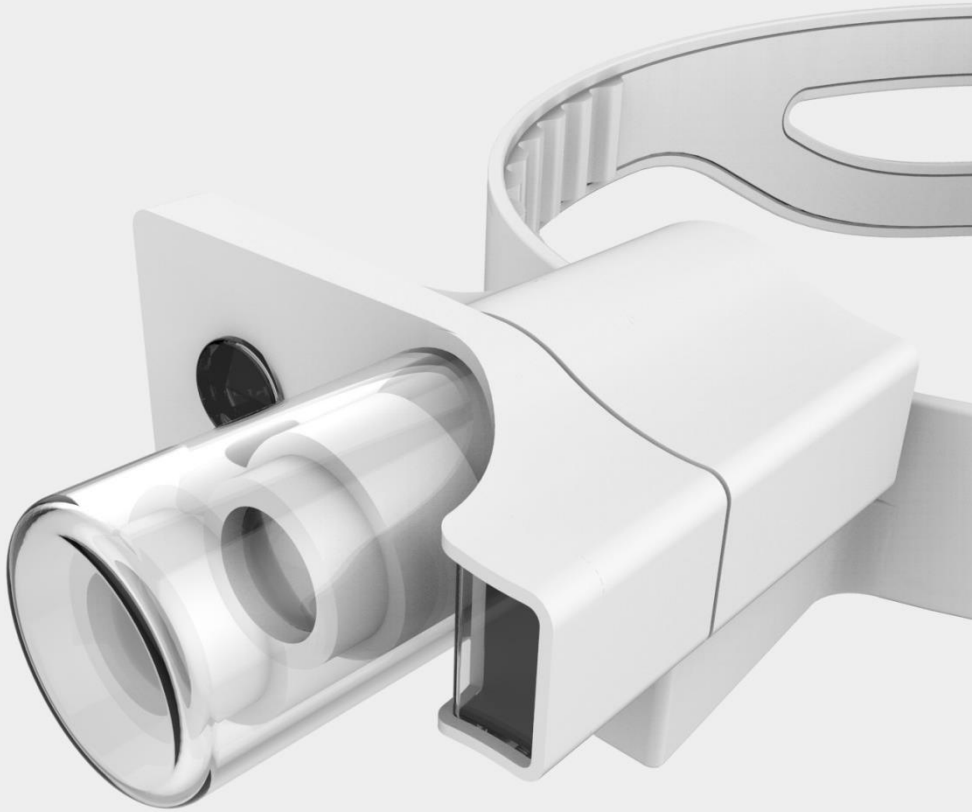
Final Concept

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.

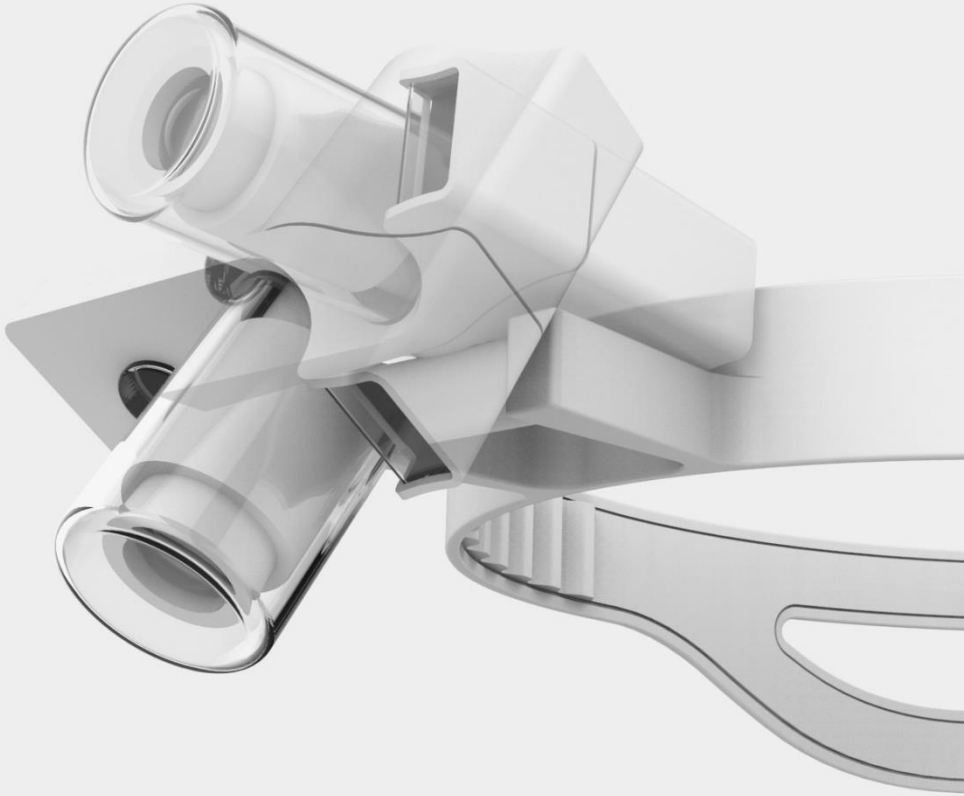
This is enclosed within a transparent removable cover to prevent direct contact with moving part + to allow for easy cleaning.

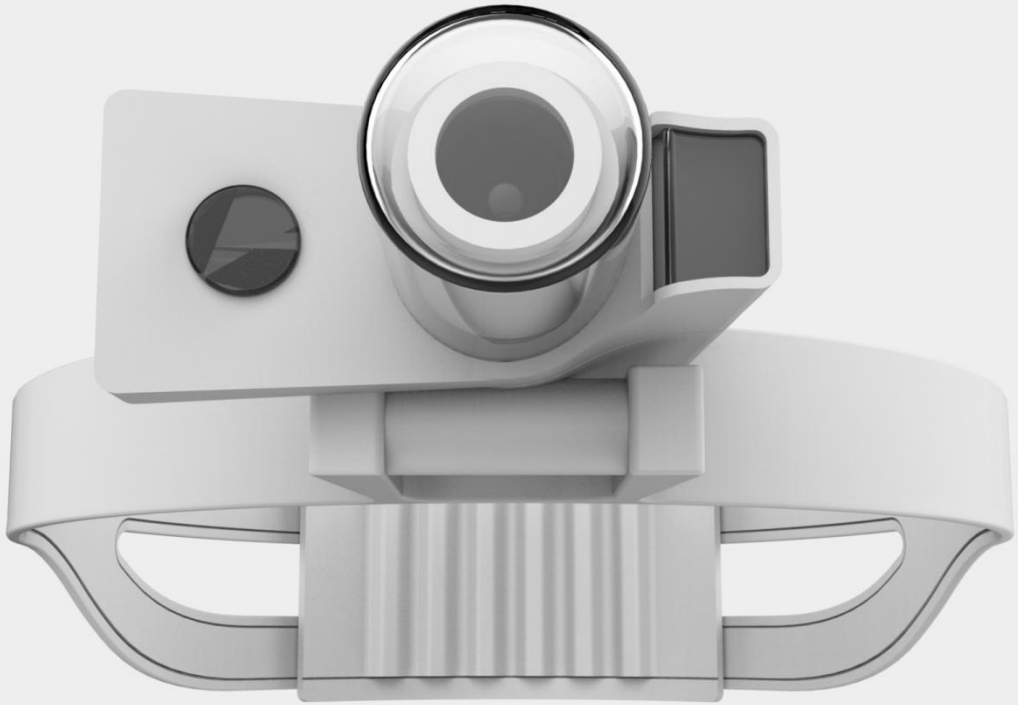
Also double up as a sterile handle to allow the surgeon to change tilt angle.



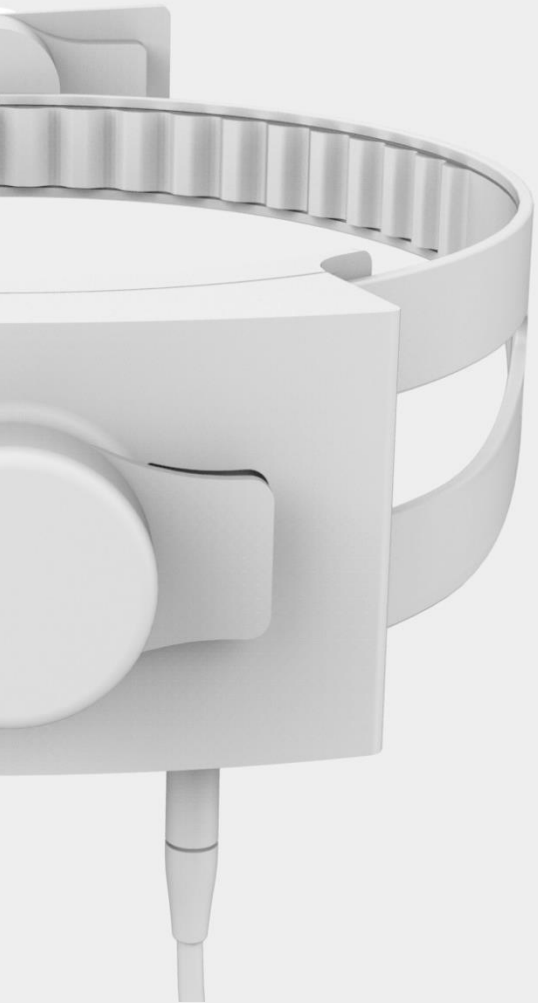
Mounted on hinge for an adjustable declination angle between +5° & -60°.

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





Lighthead 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.

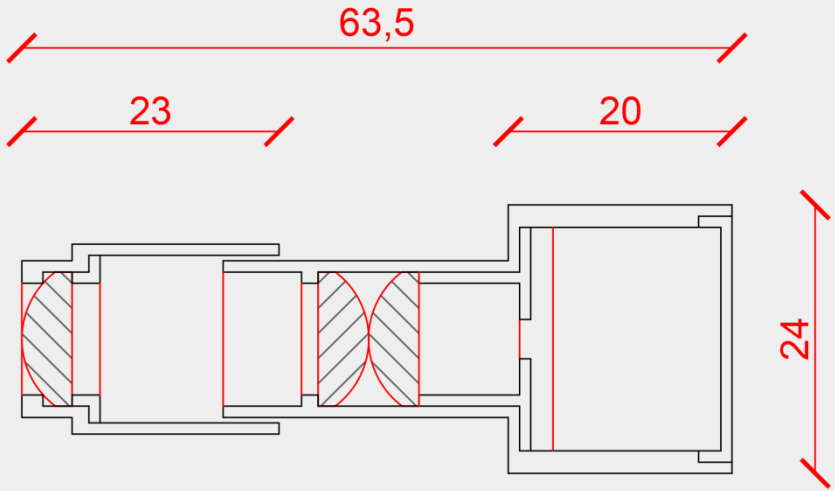
Lower portion is snap-fitted on for power, upper portion contains 'hot-swap' battery for uninterrupted usage.

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*

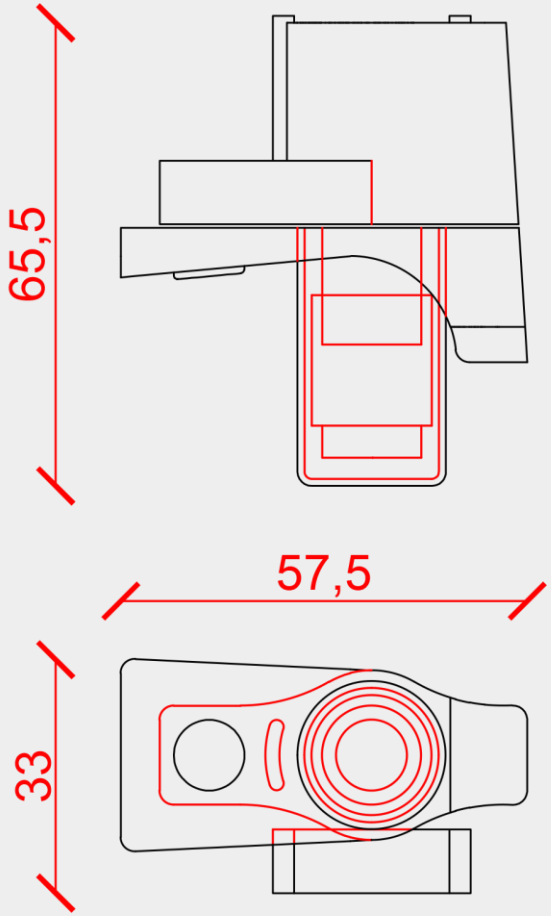


LIGHTHEAD

section

dimensional drawings

**all dimensions in mm*

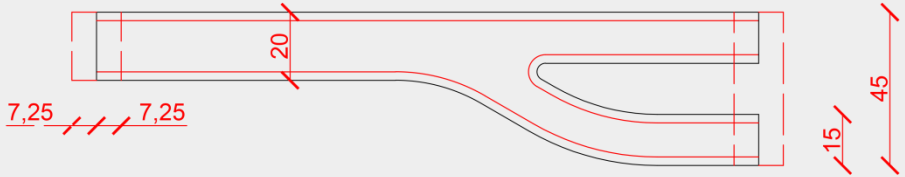


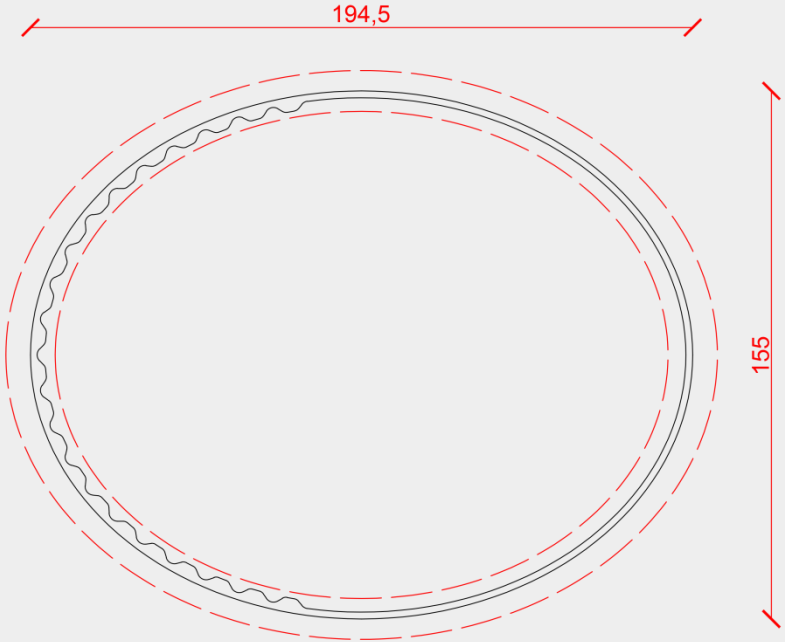
LIGHTHEAD

plan & front elevation

dimensional drawings

**all dimensions in mm*



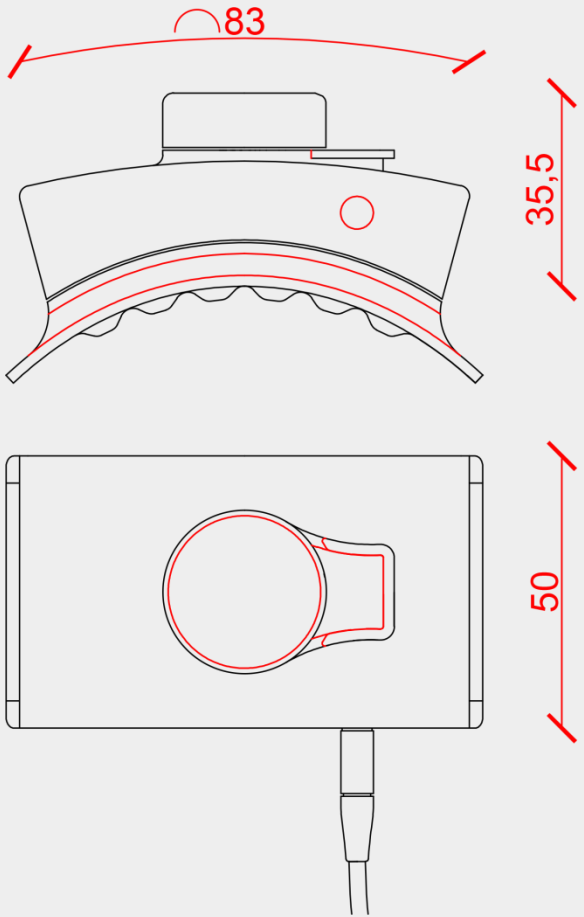


HEAD STRAP

plan & side elevation

dimensional drawings

**all dimensions in mm*

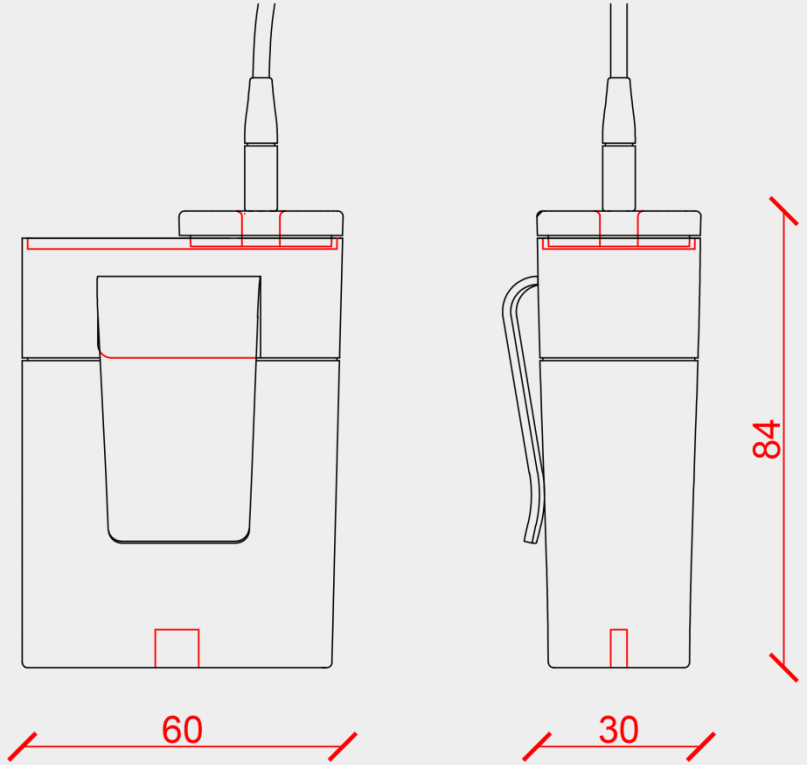


PROCESSOR

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