# EVOLAP

## Design and realization of a new backdrivable laparoscope manipulator

**Benoît Herman**

Université catholique de Louvain – Belgium
Centre for Research in Mechatronics

# Collaborations

**CEREM** (UCL – Belgium)

Pr B. Raucent (advisor), K. Tran Duy, B. Dehez

**Gynaecology Unit** (UCL – Belgium) → ***medical partner***

Pr J. Donnez (co-advisor), Dr R. Polet

**Medsys SA** (Belgium) → ***industrial partner***

**LIRMM** (France)

Pr E. Dombre, Ph. Poignet, F. Pierrot, S. Krut, O. Company

**IRCAD/EITS** (France)

# State of the art

Commercially available **laparoscope manipulators**:

**AESOP 3000**
(~~Computer Motion~~, USA)


**EndoASSIST**
(Armstrong Healthcare, USA)

**LapMan**
(Medsys, Belgium)

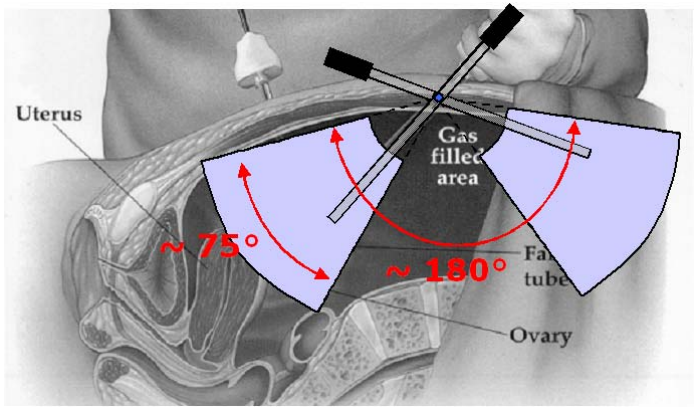
**Drawbacks** of these robots:

- **Weight and size**
- Lack of ergonomics: **simple motions only** (no diagonal)
- **Long set-up** procedure (depends on type of surgical procedure)
- Few programming possibilities
- No manual manipulation

# **Main goals** of the project

Design of a new **laparoscope manipulator**:

- **Ergonomic**, compact and lightweight
- Quick and **easy to install**
- Requiering **no set-up** (large workspace)




- **Backdrivable** (manual manipulation)
- With more **programmable functions** (manual definition of the maximum workspace, memorization of positions and automatic repositionning, automatic speed variation …)

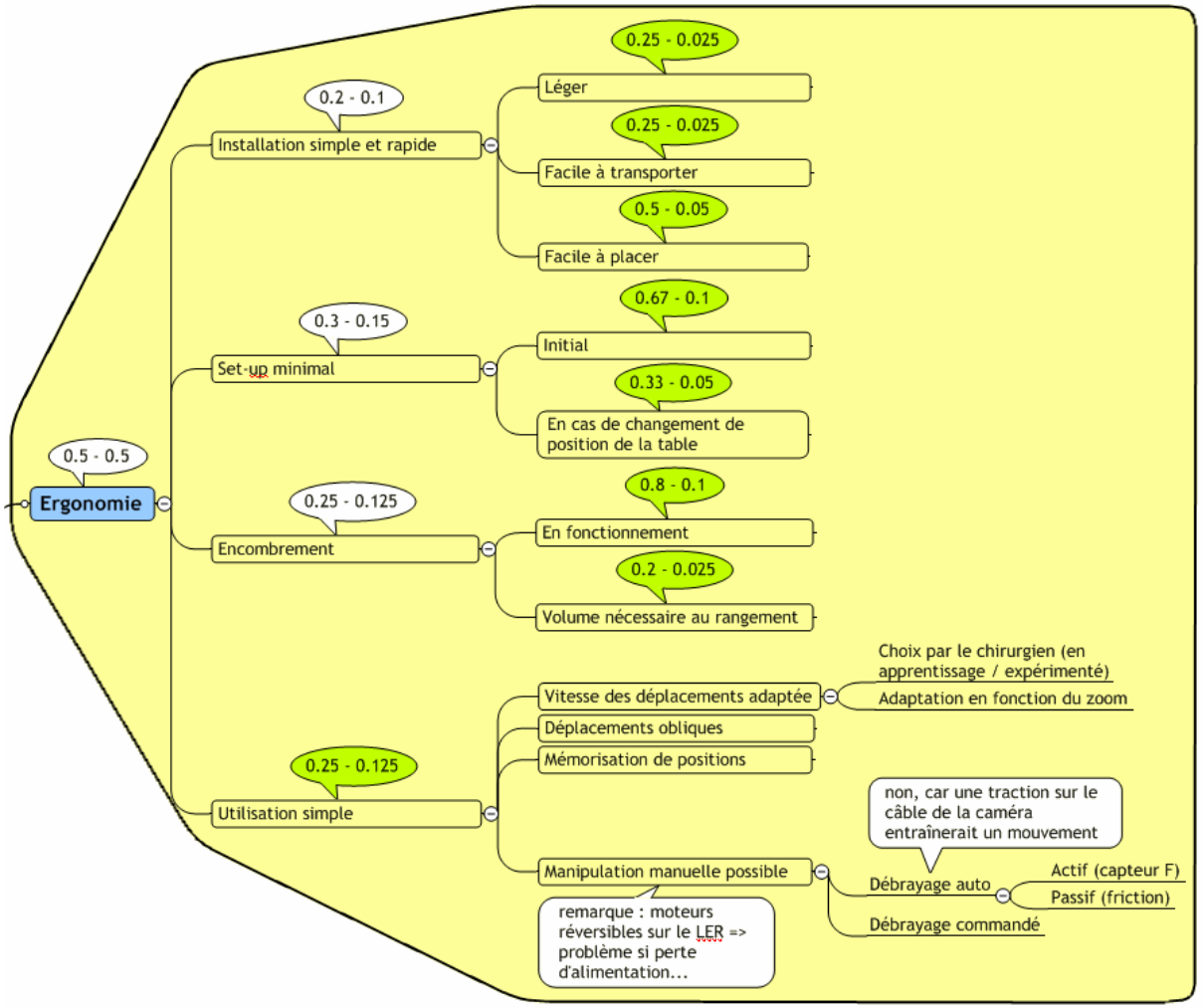
➔ **Smarter, more universal and easier to use**

# 1st step: **Analysis of laparoscopy**

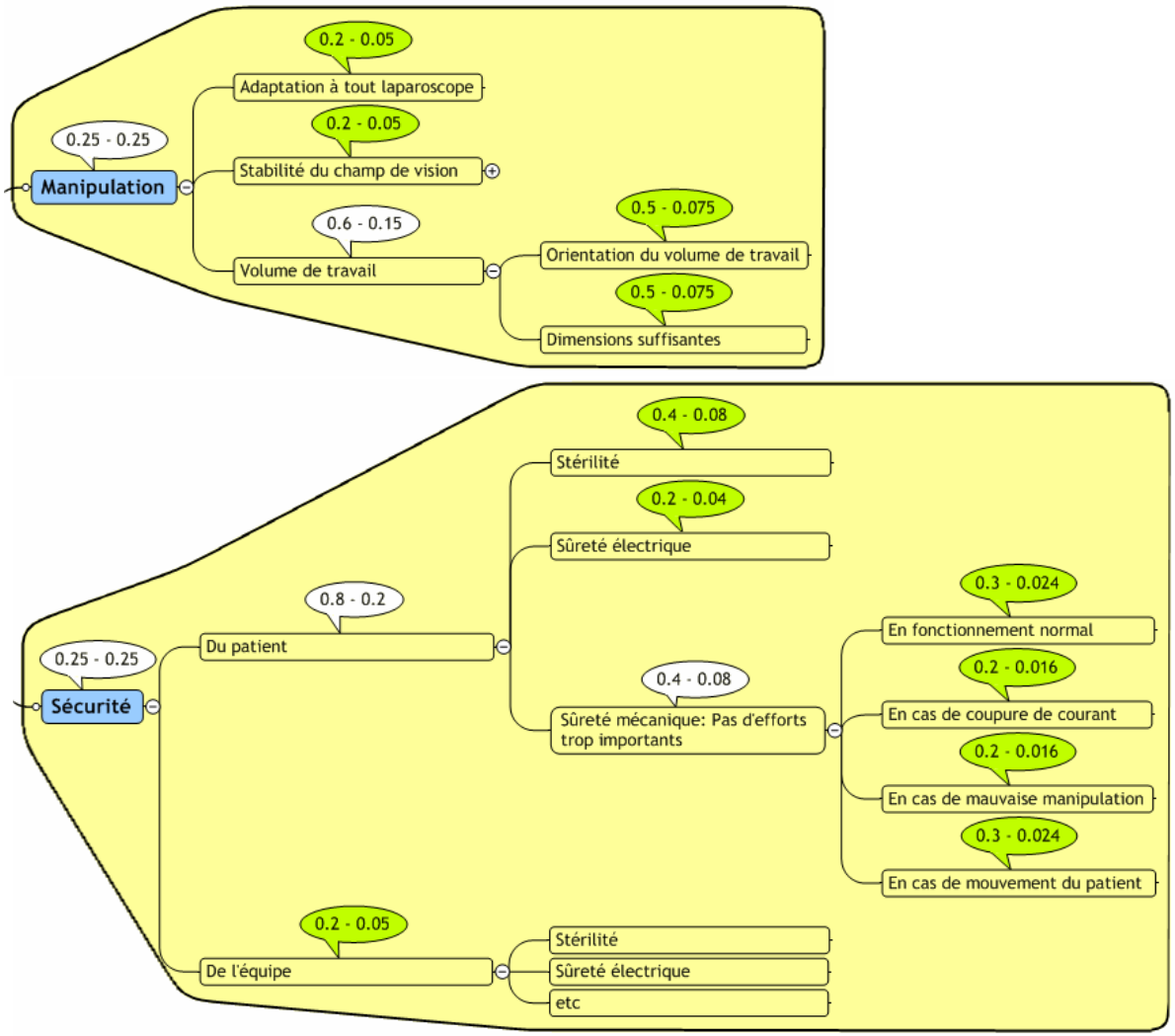
**Speciality** **Disease** **Procedure** **Trocars** **Placement of staff**

| *Domaine* | *Organe* | *Pathologie* | *Intervention laparoscopique* | *Trocars* | *C* | *A1* | *A2* | *Commentaires* | *AESOP* | *EndoAssist* | *LapMan* | *ZEUS/LAP* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chirurgie générale et digestive** | *Paroi abdominale* | *Hernie inguinale* | TAPP | 3 | D | G | / | | | X | X | X |
| | | | TEP | 3 | D | G | / | | | X | X | X |
| | | *Hernie périnéale* | Hernie périnéale | 4 | ? | ? | ? | | | | | |
| | *Appendice* | *Appendicite* | Appendicectomie | 3 | G | GC | / | | | X | | X |
| | | *Péritonite* | Péritonite | 3 (+1) | G | GC | / | | | | | X |
| | *Voies biliaires* | *Lithiases du cholédoque* | Cholédocotomie | 5 | J | D | G | | | | | |
| | | | Exploration transcystique | 5 | J | D | G | | | | | |
| | *Côlon* | *Cancer du côlon / diverticulite* | Colectomie droite | 4 (+1) | J | G | D | | X | | | X |
| | | | Sigmoïdectomie | 3 à 6 | G | GC | J | | X | | | X |
| | *Œsophage* | *Achalasie* | Myotomie (Thoracoscopie) | 3 (+1) | D | G | / | DLD | | | | |
| | | *Diverticule* | Résection (Thoracoscopie) | 4 | G | D | / | rare, DLG | | | | |
| | *Vésicule biliaire* | *Cholécystite aigue / lithiase* | Cholécystectomie | 4 (+1) | J | D | G | | X | X | X | X |
| | *Rectum et anus* | *Cancer du rectum* | Résection totale | 3 à 6 | G | GC | J | | | | | |
| | | *Prolapsus rectal* | Prolapsus rectal | 5 | ? | ? | ? | | | | | |
| | | *Prolapsus rectovaginal* | Prolapsus rectovaginal | 5 | ? | ? | ? | | | | | |
| | *Intestin grêle* | *Obstruction de l'intestin grêle* | Obstruction de l'intestin grêle | 4 | D | GC | / | | | | | |
| | *Rate* | *Pathologie de la rate* | Splénectomie (antéro-postérieur) | 4 proches | G | D | / | DLD lombotomie | X | X | | (X) |
| | | | Splénectomie (postérieur) | 3 | G | D | / | DLD lombotomie | X | X | | X |
| | *Estomac et duodénum* | *Cancer de l'estomac* | Gastrectomie distale | 5 | J | D | G | AT10 à 30 | | | | |
| | | *Hernie hiatale volumineuse* | Traitement | 5 (+1) | J | D | G | AT30 | | | | |
| | | *Reflux* | Oesophagogastropexie de Hill modi | 5 | D | G | / | | | | | |
| | | | Fundoplicature de Nissen | 5 | J | D | / | AT30 | X | X | X | X |
| | | *Obésité morbide* | Anneau gastrique | 4 ou 5 | J | G | D | AT30 à 45 | | X | X | X |
| | | | Dérivation gastro-jéjunale | 6 | J | D | G | AT30 à 45 | X | X | | X |
| | | | | **puis** | D | DC | G | AT30 à 45 | | | | |
| | | *Ulcère* | Gastrectomie distale | 5 (+1) | J | G | D | AT10 à 30 | | | | X |
| | | | Perforé + péritonite | 4 | J | D | / | T léger | | | | |
| | | | | **puis** | D | J | / | AT léger | | | | |
| | | *Tumeur de l'estomac* | Gastrectomie segmentaire | 5 (+1) | J | D | G | AT30 | | | | X |
| **Chirurgie endocrine** | *Glandes surrénales* | *Tumeur surrénale gauche* | Surrénalectomie gauche | 4 | G | D | GA | DLD lombotomie | | X | | X |
| | | *Tumeur surrénale droite* | Surrénalectomie droite | 4 | D | G | DA | DLG lombotomie | | X | | X |
| | *Parathyroïde* | *Hyperparathyroïdie* | Parathyroïdectomie | 4 | G | D | / | Difficile | X | | | |

# 2nd step: **Functional analysis**



# 2nd step: **Functional analysis** (cont'd)



# 3rd step: Restriction of **solutions**

## **Position** of the robot

| | $W_i$ | Ground | | Table | | Patient | |
|---|---|---|---|---|---|---|---|
| **Weight of robot** | **0.025** | **Heavy** | **1** | **Light** | **3** | **Very light** | **4** |
| **Easy transport** | **0.025** | **Difficult** | **1** | **Easy** | **3** | **Very easy** | **4** |
| **Easy installation** | **0.05** | **Very easy** | **4** | **Easy** | **3** | **Difficult** | **1** |
| **Bulk** in the OR | **0.1** | **Big** | **1** | **Small** | **3** | **Asverage** | **2** |
| **Bulk** if not used | **0.025** | **Big** | **1** | **Small** | **3** | **Small** | **4** |
| **Initial set-up** | **0.1** | **Average** | **2** | **Fast** | **3** | **Fast** | **3** |
| **Set-up** if motion of table | **0.05** | **Long** | **1** | **/** | **4** | **/** | **4** |
| **Mechanical stability** | **0.05** | **Very good** | **4** | **Good** | **3** | **Poor** | **1** |
| **Absolute Total** | | 46.8% | | **78.1%** | | 71.9% | |
| **Weighted Total** | | 48.5% | | **77.9%** | | 64.7% | |

# Future works…

## Next steps:

- Realization of a **passive prototype**
- **Trials** (stiffness, transparency, static balancing etc.)
  → **optimization** of the proposed design
- Choice of the **actuation** → active prototype
- Conception of the **control program** → Matlab/dSPACE
- Design of the **remote control** (joystick, voice control, head control, …)
- Trials ad **validation**