# SMARTsurg

## SMart weArable Robotic Teleoperated surgery

# CLIP-ON TOOL

# Interchangeability System Concept

**Abstract:** The present document is a specification report for a component of the SMARTsurg project, funded by the European Commission's Directorate-General for Research and Innovation (DG RTD), under its Horizon 2020 Research and innovation programme (H2020). It is not a deliverable

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# Document Status

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# Document Change Log

Each change or set of changes made to this document will result in an increment to the version number of the document. This change log records the process and identifies for each version number of the document the modification(s) which caused the version number to be incremented.

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# 1. Introduction

## 1.1 Objective and Scope

The objective of this deliverable is to describe the design work performed mainly by Cybernétix on the interfacing of the surgical tool (under design by BRL) at the tip of an industrial, off the shelf, robotic arm. This development is based on the choice by the consortium of the robot Kuka IIWA 14 R820 as holder of the surgical tool and driven by the design of the surgical tool.

## 1.2 Reference Documents

1. SMARTsurg Grant Agreement Annex I – “Description of Action” (DoA)
2. KUKA IIWA 14 R820 technical datasheet
3. D4.3: Clip-On Tool Specification
4. Clip-On Tool CAD model: SMS01A-122ENS002.exe

## 1.3 Acronyms and Abbreviations

| Abbreviation | Definition |
|---|---|
| BRL | Bristol Robotics Laboratory |
| D | Deliverable |
| EC | European Commission |
| EU | European Union |
| M | Month |
| MIS | Minimally Invasive Surgery |
| WP | Work package |
| SoA | State of the art |
| DoA | Description of Action |

# 2 Clip-On Tool Functionalities

The clip-on tool box interfaces the surgical tool and the motors+drivers assembly. This box will be mounted at the tip of the slave robot arm. The motors+drivers assembly creates the motions that will be transmitted to the tip of the surgical tool through the capstans and wiring.

## 2.1 List of functionalities

The functionalities identified for the clip-on tool are specified in the table below:

| Functions | Description | Parameters to be defined before design |
|---|---|---|
| Sterile | To ensure a safe sanitary barrier between the slave robot arm (non-sterile) and the surgical field | Interface part:<br>disposable or reusable? |
| Motion transmission | | • Number of degrees of freedom to be actuated<br>• Additional instrument shaft intermediate elbow?<br>• Range of rotation of each DoF<br>• Maximum rotation speed<br>• Maximum angular acceleration<br>• Maximum torque |
| Electric transmission | To cauterize veins with mono or bipolar surgical tool | • Type of current AC/DC<br>• Voltage<br>• Intensity<br>• Maximum power to be transmitted |
| Fast change | To ease the mounting and dismounting of the surgical tools | 30% faster than existing solution requested in D2.2, realistic? Really useful? |

| | | |
|---|---|---|
| Autonomous tool recognition | To allow the Configuration server to identify which tool is installed on the slave arm and adapt to its specific capabilities | Contactless (RFID…) or with contact (electric or mechanical pins…)? |
| Usage count | To count the number of individual tool uses even when not fitted on the same robot and avoid failure of the tool during an operation | EEPROM embedded, RFID tag readable/writable… |

## 2.2 Functionalities studied for the first concept

Not all of the functionalities listed above have been achieved by the first clip-on tool design concept. Among them, the main challenges are:

- the motion transmission
- the quick change
- the electric transmission.

At this step of the project, Cybernétix has focused its design work on the first 2 functionalities. Additional, off the shelf, solutions have been identified and can be integrated easily to the current mechanical design to achieve the third main functionality.

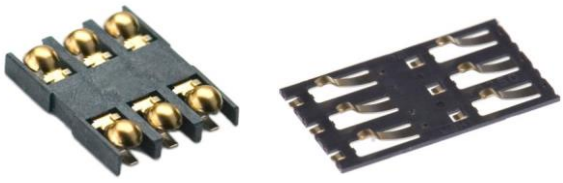

Figure 1: Candidate solution for electric and data transmission

In addition, the implementation of the electric transmission for the first prototype would be useless since the surgical tools that have been designed for the trials do not have cauterizing feature.

## 2.3 Functionalities out of scope for the first concept

It has been considered that the three following functionalities can be postponed and not integrated in the design of the first concept:

- Create a sterile boundary

- Autonomous tool recognition
- Usage count

The 2 latter are of lesser importance since they are secondary features. Cybernétix has already foreseen solutions based on RFID tags to achieve them.

The sterilization functionality is mandatory for any surgical system but it will be developed once the proof of performances of the global SMARTsurg system is completed and the industrialization phase initiated.

# 3 Clip-On Tool Concept Description

## 3.1 Mounting on the flange of the KUKA IIWA robotic arm

The Clip-on interface plate (purple part in Figure 1) is fixed at the tip of the KUKA arm using seven M6 screws and attached with one positioning needle. This solution is compliant with the design of the IIWA media flange available on the robot that is used for this project.

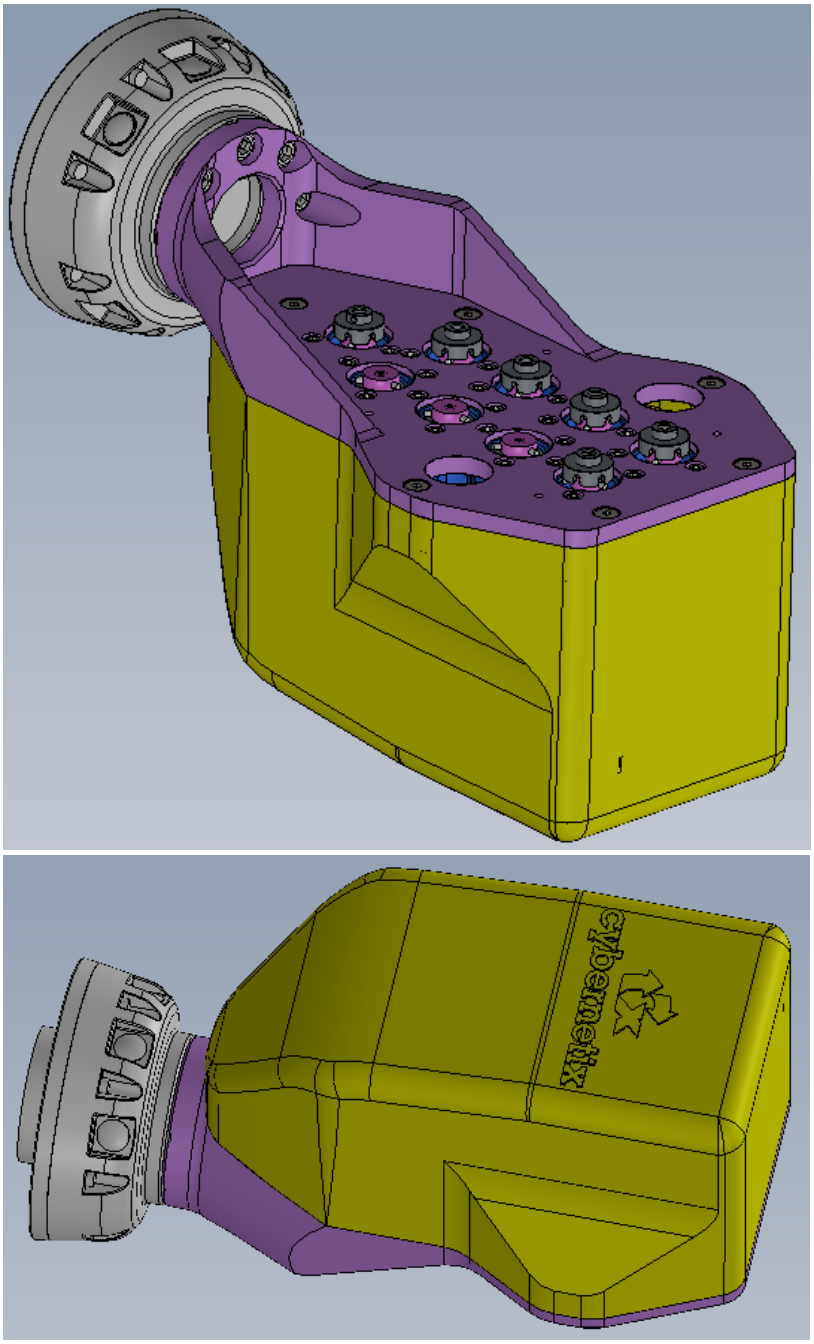


Figure 2: Global views of the Clip-on Tool without the surgical tool

## 3.2 Mounting of the surgical tool

The surgical tool can be placed directly on top of the interface plate. It is attached by 2 positioning needles.

It is clamped on the interface plate by 2 quick, off the shelf, release systems. These quick release systems are mounted through the surgical tool and grip the interface plate once it is installed. It requires minimal manipulation to release the surgical tool (push on buttons).

Figure 3: Quick release system

## 3.3 Motion transmission

The electric motors have been chosen by UWE to be able to deliver the required amount of torque and speed for our application.

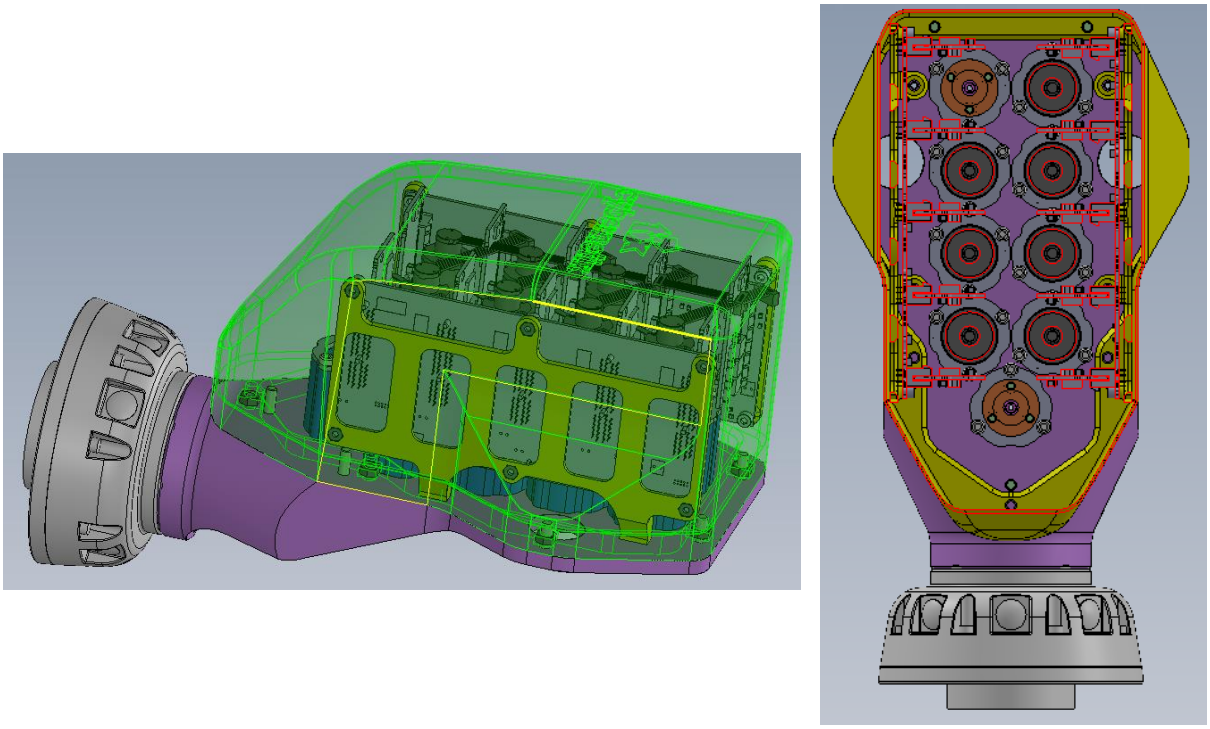

Figure 4: Localization of the 9 electric motors

The relative location of these 9 motors has been defined in reference to the location of the 9 capstans within the surgical tool, defined by UWE.

The motion transmission is achieved by a compliant mechanical clutch between the motor and the capstan. This clutch is composed of a male part (purple part in Figure 4) with 3 needles and a female part that is mounted on the surgical tool.

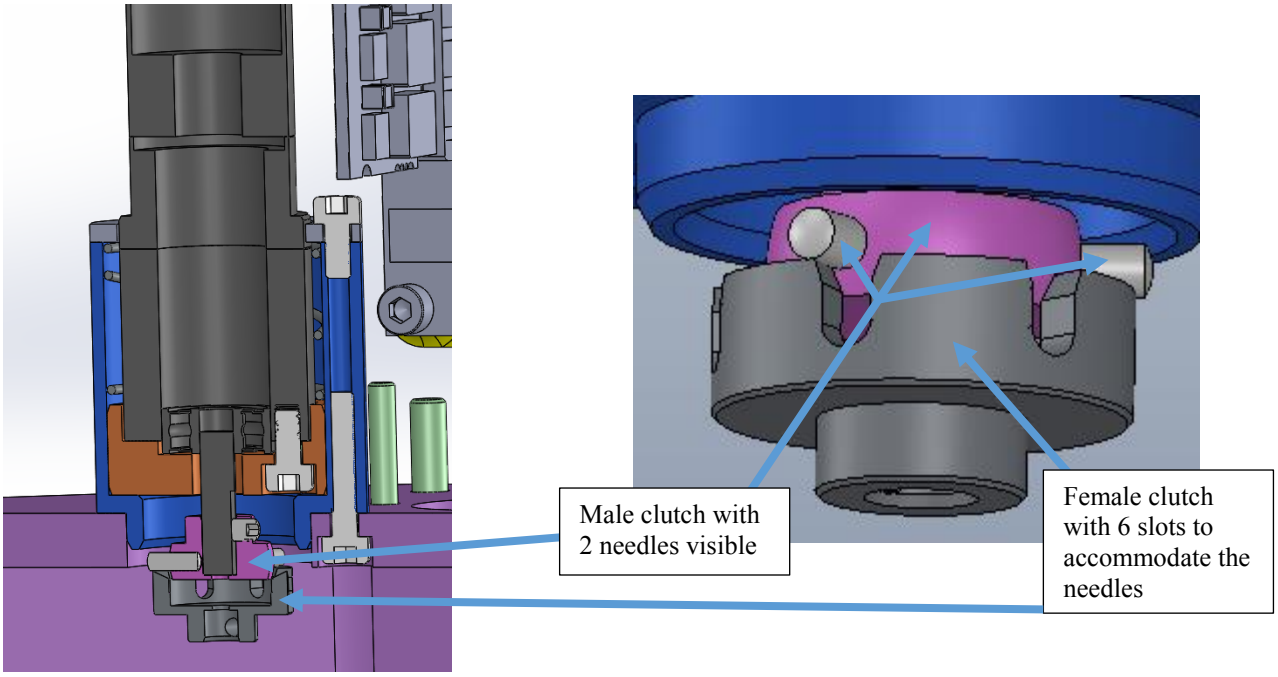


Figure 5: Clutch between the motor and the surgical tool

The motor itself is mounted on springs to allow a smooth installation of the surgical tool on the interface plate. When the surgical tool is pushed on top of the interface plate, if the clutch is not aligned, the motor will be pushed back in its housing (blue part in Figure 5). Thanks to the angular shape at the tip of the female clutch, the needle and the electric motor will slide down to the correct position.

## 3.4 Data transmission and powering

The media flange at the tip of the Kuka robotic arm has electric connectors that will be used to transmit data (driving orders and encoders measurements) and to power the electric motors. Dedicated electric cables are required to connect the Clip-on tool to the media flange.

The rotation of each motor is driven by nine driver cards linked together by 2 CAN bus motherboards, visible in Figure 6: Global view of the motors, drivers and bus cardsFigure 6.

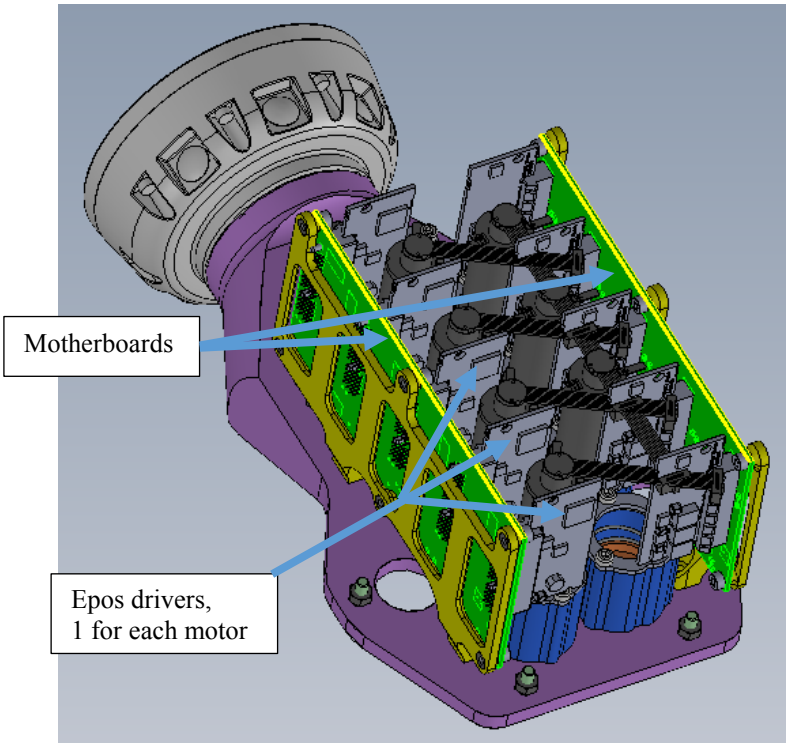


Figure 6: Global view of the motors, drivers and bus cards

# 4 Conclusion and future work

This report demonstrates the work done to design a robust and easy to use system that will enable the SMARTsurg prototype to interface various surgical tools.

It is the result of a lot of communications and effort between BRL and Cybernétix to develop in parallel components that have to interface together correctly.