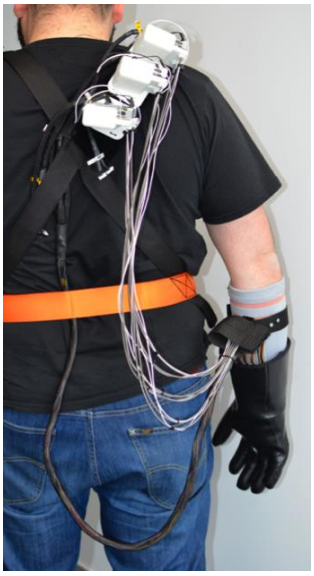
HAND SUIT DATASHEET

STAMAS

Smart technology for artificial muscle applications in space

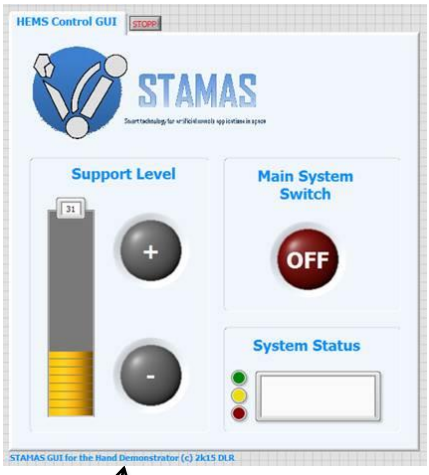


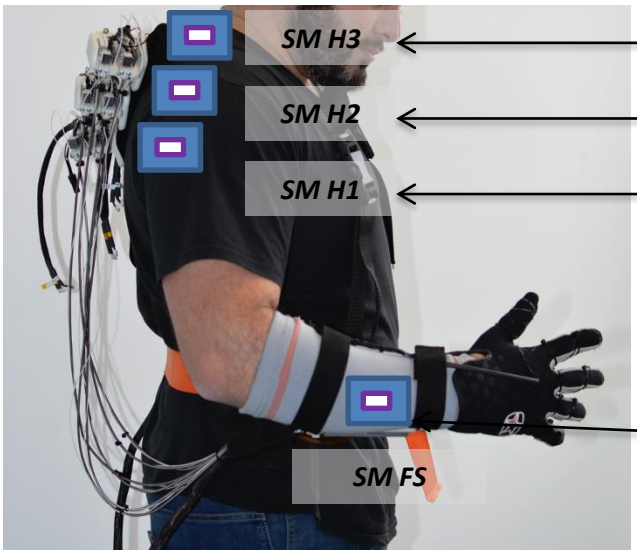
Description – Main functionalities:

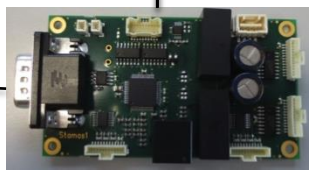
- Extra Vehicular Activities (EVA) performed by astronauts are limited by several factors. The gloves are internally pressurized to protect the astronaut from the vacuum of Space. The internal pressure increases the stiffness of each joint of the glove, making the astronaut to exert great forces to overcome this stiffness. The stiffness also leads to other problems, such as premature hand fatigue, damages in the nails, difficulties to move with dexterity and lack of control about the applied strength on the objects.
- The objective of the **hand demonstrator** o is to reduce the effect of the stiffness of the glove by counteracting the force exerted by the pressurized glove. These forces are generated by aims of several linear actuators connected to the gloves.
- The device predicts the user's movement intention and acts over the glove to reduce the stiffness.

Modules:

- **Hand Exo-Muscular System (HEMS)** – actuating system that reduces the stiffness of the spacesuit glove. 6 SMA flexible actuators connected to the fingers (1 for each finger and 2 for the thumb).
- **Finger Sensors (FS)** – 6 force sensors located on the fingertips (2 for the thumb)
- **Central Control Unit (CCU) / GUIs** – overall behaviour of device, monitor of parameters, security and safety.
- **Sensor Module (SM)** – transmitting information from sensors to other components.

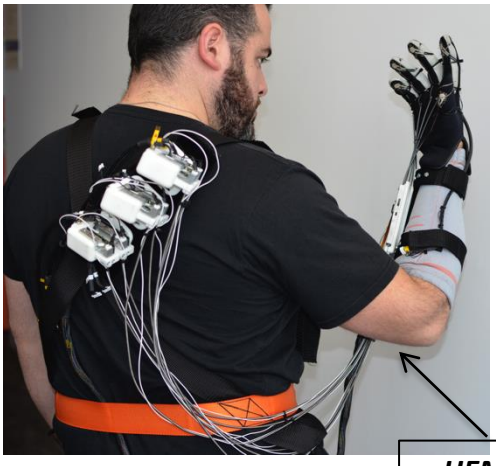






CCU

FS



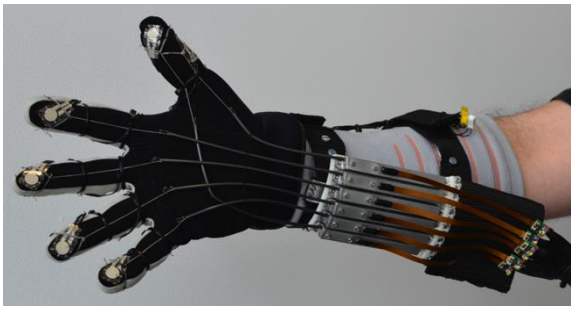
HEMS

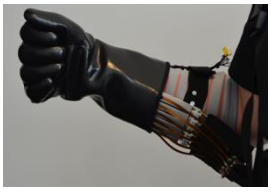
General description:

- The FS register force information to detect the movement intention of the user. This information is sent to the CCU through the SM FS to monitor the user movement intention to decide the adequate actions (sending control signals to the actuating system) when using the device.
- The sensors of the HEMS measure information about position and force. All this information should be transmitted to the CCU to check the status of the actuating system and to send the required control actions.
- The SMs are responsible of coordinating the data acquisition and transferring sensor signals to the upper control layers.
- The CCU sends command signals to the actuating system via the Microcontroller and Driver block. The required control actions are also sent to the actuating system module (HEMS) using the SMs.
- The Platform is formed by the Power Unit and the Suit Structure. A Power Unit is required to feed each module of the device in a direct or indirect way. The suit structure gives mechanical support to the demonstrator, providing a suit demonstrator for the hand. It contains fixations for the different subsystems and blocks and connections for the transmission of forces to the user.

Hand Exo-Muscular Systtem

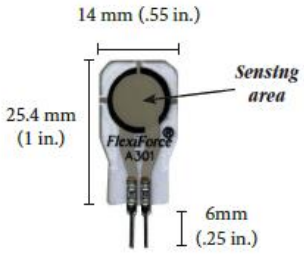
- Shape memory effect to perform the required actuation. When heated, the SMA wires contract, thus causing the flexion of the fingers. Upon cooling, the wires gradually return to their initial length thanks to the opposition force produced by the stiffness of the EVA glove, which also cause the extension of the user's fingers.
- Force applied on the fingers, allowing a more comfortable flexion while wearing a stiff glove. The amount of force is controlled by the user by changing the pressure applied in the fingertips.
- Mechanical structure – glove with a series of tendons attached to the fingertips and tendons routed through the underside of the fingers and the palm of the hand.
- The index, middle, ring and little fingers have only one tendon each, while the thumb has two tendons.
- Tendon system attached to the output of the HEMS actuators through an interface consisting of a series of pulleys to multiply the linear displacement of the actuators.
- Rigid tendons allows to flex the wrist without affecting the actuators performance.
- HEMS actuating system fixed end in the shoulder, where it is linked to Bending Beams force sensors.
- Sensors: fingertip sensors (FlexiForce #A201), force sensors (Bending Beam), and position sensors (Rolin linear).





HEMS Specifications		
Linear stroke		25 mm
Maximum force		35 N
Technology		SMA actuator
Max. Frequency of complete cycle		0.125 Hz
Lifetime		50,000 actuating cycles
Aggregated mass		< 1500 g
Power consumption		300 W
HEMS Controller	Performances	Control of fingers
	Resolution	> 0.025 Nm
	Freq.	1 kHz
Position Sensor	Range	0-40 mm
	min. res.	1 µm to 250 µm
	Freq.	> 100 Hz
Force Sensor	Range	> 50 N
	min. res.	> 0.5 N
	Freq.	1 kHz

Finger Sensors



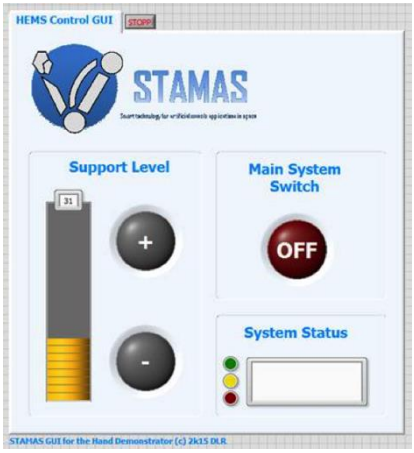
- The FS are formed by six force sensors located on the fingertips.
- One sensor is placed on each finger except in the thumb, which has two of them because two degrees of freedom will be analysed/controlled.
- Each sensor is a force sensing resistor (FlexiForce #A201 capacity sensor) that obtains analogic signals.
- These sensors are connected to the SM FS.

FS Specifications	
Range	Sensitivity towards 20N able to withstand 110 N
Power Consumption	0.1-0.5 V
	2.5 mA max
Resolution	12 bit
Output signal	Digital over Sensor Module

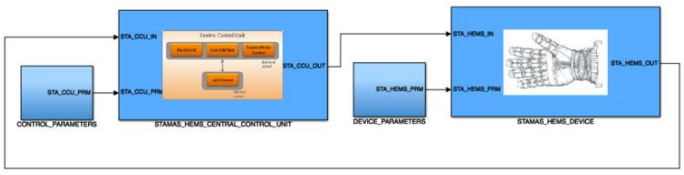
Central Control Unit – GUIs

- Overall control of hand demonstrator: upper control hierarchies, and two GUIs, one for the astronaut, and the other one for an expert or engineer.
- Monitors user parameters measured by the FS and information from actuating system.
- In case of an error, safety strategy that deactivates the device.
- Checks with regard to: timeout (delay between device and controller), status (actuating system), plausibility (sensor data), and range (control commands).
- Setting the required force to support the astronaut in manipulation tasks.
- Expert GUI: visualization of commanded and measured data, input and control of control parameter values, and data logging.
- Astronaut GUI: intuitive and easy-to-use interface that offers the astronaut access to the selected parameters and that displays information on the device state.

Astronaut GUI



Expert GUI

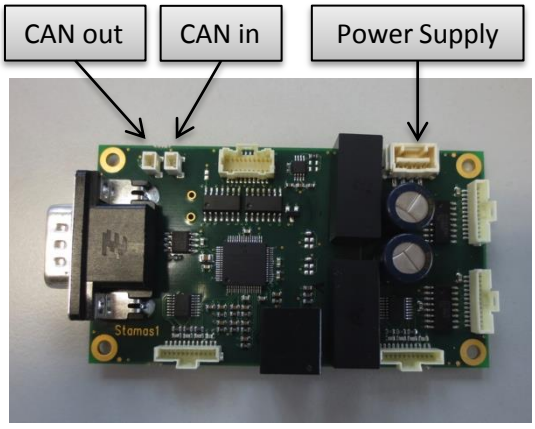


Platform

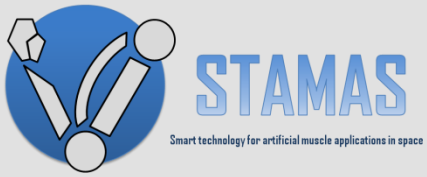
- The Power Unit and the Suit Structure are included in the Platform.
- The Power Unit feeds each module of the device in a direct or indirect way. It feeds directly the CCU, the Microcontroller and Driver and the SMs.
- The Suit Structure gives mechanical support to the demonstrator, providing a suit demonstrator for the hand. It contains fixations for the different subsystems and blocks and connections for the transmission of forces to the user. It also provides protection to the user.
- The Bending Beam is attached to a mechanical interface that is used as its structure. This interface provides an easy system for attaching and detaching the HEMS actuators to the shoulder structures when putting on and off the suit.

Platform – Power Supply Specifications of each module	
CCU	European electrical standard, 230 V, 50 Hz
Microcontroller	Micro-USB to USB A
Drivers	0-40 V, 0-20 A (banana connectors)
SM	12 V, 0-0.5 A (banana connectors)
HEMS actuators	Molex 22-27-2021 with two pins
FS	0.1-0.5 V, 2.5 mA

Sensor Modules



- There are different types of sensors in the actuating systems of the hand demonstrator. The SMs have been designed to coordinate the data acquisition and to transfer signals to the upper layers.
- The SM board is able to read all the sensors and is connectible with the SMA Controller.
- A CAN Bus system is used to coordinate the information provided by the set of SMs because of the quantity of sensors and the spatial distribution.


STAMAS
Smart technology for artificial muscle applications in space


ARQUIMEA


DLR


ETH


SENSODRIVE


UNIVERSITÀ DI PISA


SEVENTH FRAMEWORK
PROGRAMME