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BioMeld

Project:

BioMeld

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"A MODULAR FRAMEWORK FOR DESIGNING AND PRODUCING BIOHYBRID MACHINES"

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D2.2: BILL OF MATERIALS

DELIVERABLE FACTSHEET

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Abstract	The aim of this deliverable is to create a preliminary but comprehensive list of materials and actuators required to create a BHM. Each item in the BOM will be parameterized so that these values can be used in modeling and simulation tasks.

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EXECUTIVE SUMMARY

This document provides the structure in which all partners list the bill of materials. This activity is important within the WP2 (Modelling and simulation framework) to provide the list of the major components which

will be analyzed in simulation environments. The bill of materials (T1.2) will be updated throughout the project.

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LIST OF ABBREVIATIONS

Abbreviation	Description
WP	Work package
BHM	Biohybrid machine
BOM	Bill of materials
DMEM	Dulbecco's Modified Eagle Medium
FBS	Fetal bovine serum
HS	Horse Serum
IGF-1	Insulin-like Growth Factor-I human
PBS	Phosphate Buffered Saline
PDMS	Polydimethylsiloxane
BSA	Bovine Serum Albumin

1 DESCRIPTION OF TASK

Within the WP “Modelling and simulation framework”, the goal of this task is to create a comprehensive list of materials and actuators required to create a BHM. The items in the BOM will be parameterized so that these values can be used in modeling and simulation tasks throughout the project.

This document will help the establishment of the modeling and simulation framework.

2 DESCRIPTION OF WORK AND MAIN ACHIEVEMENTS

The creation of a BOM is one of the first steps for getting all components in manufacturing and supply chain management needed for the production of BHM. Here, partners listed a BOM according to the project’s commitments. BOM will be composed of the following information:

(1) BOM Level— Each element will be assigned a number to detail where it fits in the hierarchy of the BOM;

(2) Element Number—ID of each element to be used through the project;

(3) Element Name—The unique name of each part or assembly.

(4) Description—A detailed description and parametrization of each part;

(5) Quantity—Number of parts to be used in each assembly or subassembly to help guide purchasing and manufacturing decisions and activities;

(6) Unit of Measure—Classify the measurement in which a part will be used or purchased;

(7) Procurement Type—Document how each part is purchased or made (i.e. off-the-shelf or made-to-specification);

(8) BOM Notes—Other relevant notes to keep everyone who interacts with your BOM on the same page.

3 BILL OF MATERIALS

In the first six months of the project, partners arranged a preliminary list of BOM that will be necessary to complete the fabrication of the BHM in the form of a multilevel bill of materials.

The BOM corresponds to a centralized source of information containing a list of items used to manufacture the product. Within the BioMeld project, the final product will be the BHM. The BOM has been formulated in a hierarchical format, with the highest level displaying the finished product (e.g., BHM), and the lowest level showing individual components and materials. Every line of the BOM includes the level, element number, element name, description, quantity, unit of measure, procurement type and notes.

Through an exploded-view display, the manufacturing of the BHM has been split in different sub-assemblies up to the second level, as reported in Figure 1.

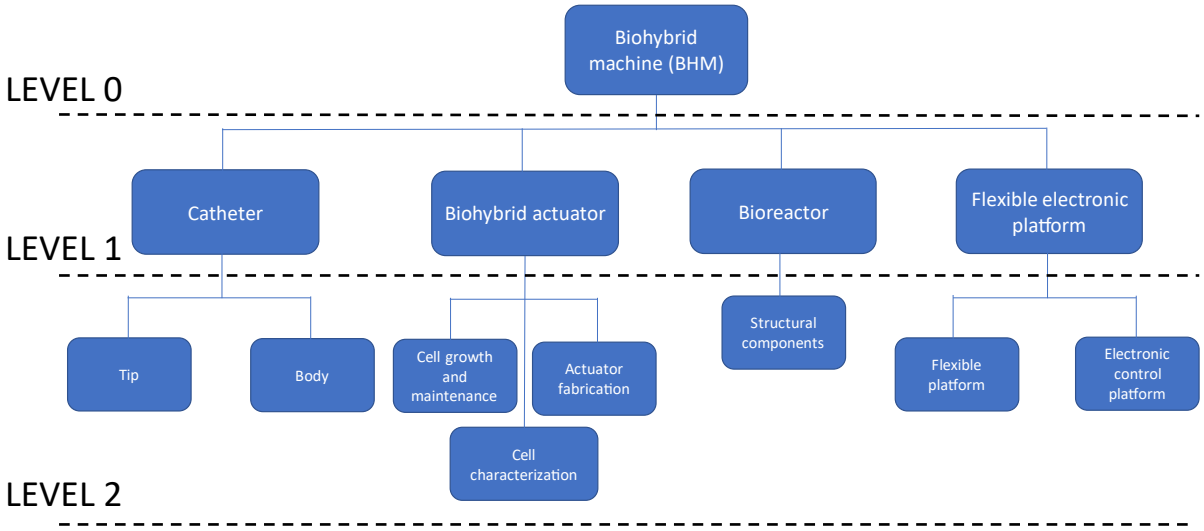

Figure 1: BOM exploded-view for the BHM fabrication.

In the first level, four components have been individuated as the main modules of the BHM, which will be manufactured throughout the project. Table 1 reports the elements present in the first level of the BOM with their description.

Table 1: Bill of materials inherent to the BHM at the first level.

BOM Level	Element Number	Element Name	Description	Quantity	Unit of Measure	Procurement type	BOM Notes
1	CAT	Catheter	Hollow structure composed by a tip and a body	1	unit	Manufactured	None
1	BAC	Biohybrid actuator	Actuator used to bend the catheter tip	1	unit	Manufactured	None

1	BIO	Bioreactor	System to keep the biohybrid actuator alive and functional	1	unit	Manufactured	None
1	FEP	Flexible electronic platform	Flexible sensor integrated within the catheter, and connected to a electronics control platform	1	unit	Manufactured	None

The first version of the BHM foresees the content of one unit for each component. In case of the agonistic/antagonistic movement of the catheter is implemented, the unit of the biohybrid actuator could be brought up to 2 and, consequently, the flexible platform for each element of the catheter hosting the biohybrid actuator.

The current list of the raw materials, sub-components and the estimated quantity of each needed component in the second level is reported in the sections below.

3.1 CATHETER

The soft and reconfigurable catheter is part of level 1 of the BOM, and can be split at the second level into two main sub-components: tip and body. The catheter tip (element number: CAT.TIP) will be the distal part of the catheter, fabricated with soft materials to be bent by the action of the biohybrid actuator. The catheter body (element number: CAT.BDY), which corresponds to the main structural component, will be fabricated to incorporate magnetic-responsive fillers for being controlled magnetically through an external magnetic field. These sub-systems comprise different materials and components, as reported in Table 2.

Table 2: Bill of materials inherent to the catheter at the second level.

BOM Level	Element Number	Element Name	Description	Quantity	Unit of Measure	Procurement type	BOM Notes
2	CAT.TIP.1	PDMS	Sylgard 184, biocompatible, gas permeable silicone	1	kit	Purchase (from Dow Corning)	None
2	CAT.TIP.2	Ecoflex 00-10	Silicone for fast prototyping	1	kit	Purchase (from Smooth on)	None
2	CAT.TIP.3	Mechanical plugs	Plugs used to set the internal diameter of the catheter	1	unit	Purchase	It can vary in size
2	CAT.BDY.1	Magnetic powder	Powder made of neodymium iron boron	1	5g/package	Purchase	none

			(NdFeB), or magnetic responsive materials				
2	CAT.BDY.2	PDMS	Sylgard 184, biocompatible, gas permeable silicone	1	kit	Purchase (from Dow Corning)	None
2	CAT.BDY.3	Pebax	Biocompatible thermoplastic material	100	g	Purchase	None
2	CAT.BDY.4	Mold	Mold made in photocurable resin	1	unit	Purchase or manufacture	It can vary in size

This list of components might change in case different requirements arise from the material chemistry, or the fabrication viewpoint.

3.2 BIOHYBRID MOTOR

The biohybrid actuator is part of level 2 of the BOM. It can be split at the second level into three main sub-activities: cell growth and maintenance (element number: BAC.CEL), actuator fabrication (element number: BAC.INK) and cell characterization (element number: BAC.STA). These activities are necessary to maintain cells alive in culture, build the biohybrid actuator and analyze in vitro the response of the engineered muscle tissue in terms of differentiation and contraction force. Here, different materials and fabrication components are defined, as reported in Table 3.

Table 3: Bill of materials inherent to the biohybrid motor at the second level.

BOM Level	Element Number	Element Name	Description	Quantity	Unit of Measure	Procurement type	BOM Notes
2	BAC.CEL.1	ATCC-CRL-17721C2C12	Cell line, muscle Myoblast (Mus musculus)	2	Vials	Purchase (from ATCC)	850 €/each
2	BAC.CEL.2	Cell Culture Medium (Growth)	DMEM, FBS, Penicillin/Streptomicin, Glutamin	15	Bottle (500 mL)	Purchase (all from Gibco)	40 €/each
2	BAC.CEL.3	Cell Culture Medium (Differentiation)	DMEM, HS, Penicillin/Streptomicin, Glutamin IGF-1	15	Bottle (500 mL)	Purchase (all from Gibco, IGF-1 from Merck)	140 €/each

2	BAC.CEL.4	Trypsin	Trypsin 0.25%, sterile-filtered, suitable for cell culture	3	Bottle (100 mL)	Purchase (from Gibco)	55 €/each
2	BAC.CEL.5	PBS	PBS 1x	10	Bottle (500 mL)	Purchase (from Gibco)	30 €/each
2	BAC.CEL.6	Cell culture plastics	Flasks, pipettes, tips, falcon, tubes etc.	variable	-	Purchase	500 total
2	BAC.INK.1	Bioink	Gelatin, Fibrinogen, and Thrombin (Merck)	1 unit (Gelatin), 10 Units (Fibrinogen) and 2 units (thrombin)	Gelatin (100g/bottle), fibrinogen (1 g/bottle), thrombin (40-300 NIH units/mg protein)	Purchase (from Merck)	2500 total
2	BAC.INK.2	PDMS	Dowsil SE 1700 Clear Base	1	kit	Purchase	70 €/each
2	BAC.INK.3	Bioprinting consumables	Tips, syringes, needles etc.	variable	-	Purchase	400 total
2	BAC.STA.1	Staining for cell characterization	Hoechst, Myosin 4 (53-6503-82), BSA (Merck)	2	Hoechst 1 ml/bottle, Myosin 4 100 µg/bottle, BSA 10 g/bottle	Purchase	1500 total

This list of components might change in case different requirements arise from the biological or the fabrication viewpoint.

3.3 BIOREACTOR

The bioreactor is part of level 2 of the BOM. The bioreactor (element number: BIO.MAT) plays a relevant role in maintaining the biohybrid motor alive during catheter exploitation, assuring the supply of nutrients and oxygen to the tissue, and favouring the removal of wastes. It comprises different elements, as reported in Table 4.

Table 4: Bill of materials inherent to the bioreactor at the second level.

BOM Level	Element Number	Element Name	Description	Quantity	Unit of Measure	Procurement type	BOM Notes
2	BIO.MAT.1	PDMS	Sylgard 184, elastomeric organosilicon that is bio-compatible, gas permeable and easy to cast.	1	kit	Purchased (Dow Corning)	
2	BIO.MAT.2	Silicone tubing	Mono-lumen tubing of medical grade	1	kit	Purchased (Freudenberg Medical)	
2	BIO.MAT.3	Bioreactor mold	3D printed mold	1	unit	Manufactured	
2	BIO.MAT.4	Pump	Peristaltic pump to supply continuous flow to the bioreactor.	1	unit	Purchased (Ismatec)	

This list of components might change in case different requirements arise from the biological viewpoint, material chemistry or fabrication viewpoint.

3.4 FLEXIBLE ELECTRONICS PLATFORM

The flexible electronic platform is part of level 2 of the BOM, and can be split at the second level into two main sub-systems: flexible platform and electronic control platform. A flexible element (element number: FEP.FLX) will host a strain sensor, having Parylene C as interface/supporting material on the catheter, and, according to the assembly of the platform, electrodes for biohybrid actuator stimulation. The sensor will consist of an organic field-effect transistor, thus including printed conductive elements (e.g. graphene, silver-based inks PEDOT:PSS), insulating and encapsulation layers (Parylene C) and organic semiconductor (e.g., TIPS pentacene). An electronic control platform (element number: FEP.ELE) will be designed with custom-made electronics and prototyped using off-the-shelf electron devices, hosting basic blocks for biohybrid actuator stimulation, sensor readout, and data transfer to elaboration units. Demonstrators will be produced through the involvement of professional PCB fabrication services. These sub-systems comprise different materials and fabrication approaches, as reported in Table 5.

Table 5: Bill of materials inherent to the flexible electronics platform at the second level.

BOM Level	Element Number	Element Name	Description	Quantity	Unit of Measure	Procurement type	BOM Notes
2	FEP.FLX.1	Parylene-C	Material used as insulating and encapsulation layer	1	kg	Purchased	None
2	FEP.FLX.2	Conductive ink	Graphene, silver-based inks or PEDOT:PSS to be used as electrodes	500	mL	Purchased	None
2	FEP.FLX.3	Organic semiconductor	TIPS pentacene	1	mg	Purchased	None
2	FEP.ELE.1	Electronic control platform – analog front-end	Amplifiers, capacitors resistances, regulators, connectors	variable	components	Manufactured	None
2	FEP.ELE.2	Electronic control platform – stimulation circuits	Amplifiers, capacitors, resistors, regulators, connectors	variable	components	Manufactured	None
2	FEP.ELE.3	Electronic control platform – digital control unit	microcontrollers, ADC/DAC, resistors, capacitors, oscillators	variable	components	Manufactured	None

This list of components might change in case different requirements arise from the material chemistry or fabrication viewpoint.

4 CONCLUSIONS

The current version of the document describes the preliminary hierarchical structure of the bill of materials for building a BHM. Here, we identified two levels in which the components and sub-elements of the BHM are reported. The fabrication of the BHM was split into four sub-components (catheter, biohybrid actuator, bioreactor and the flexible electronic platform), further subdivided in the second level to the raw components.

From further evaluation of the components, the BHM performance would be parametrized to optimise it in modeling and simulation tasks. The initial bill of materials (T2.2) will be updated throughout the project according to possible variations from the material chemistry, fabrication and biological viewpoints, or if there would be a change in the project requirements.

5 DEVIATIONS FROM THE WORKPLAN

None.