

		Requirements	Description	Principal Actor				Conceptual proposal
				Specialist	Auxiliar	Patient	Machine	
1	Security	Have a work volume inside the functional range of motion.	If there are positions outside the FROM, there is a chance that device might injuty the patient.			1	2	Software and hardware limitations
2		Stops the position of the device in case of a eventuality.	The specialist decides if the therapy procedure should be stopped in case of any eventuality.	1			2	Emergency button, actuators decoupling system, programming
3		Return to rest position after a eventuality takes place.	Understanding eventuality as external factors such as: patient uneasiness, low electric fluid, loss in connection or binding. Or internal factors such as: failure of the mechanical, electronic components.			1	2	Programming
4		Begin therapy in safe mode.	Understanding safe mode as the verification of the protocol send by the user to the device.			1	2	Programming: Progressive increment of the ROM at low speed.
5		End therapy in safe mode	Reach rest position.			1	2	Programming
6		Avoid singularity points for the mechanisms	The death position originate inestability in the mechanisms behaviour.			1	2	Kinematic analysis and control of movement to avoid singularity points.
7		Isolate the circuit from the patient	Protect the patient against nocive electric shocks.			1	2	The patient would be in contact only with non-conductive materials
8		Isolate the circuit from the power source.	Protect the electronic components from electric shocks.				1	Isolating/Operational amplifier (voltage buffer).
9		Communicate ON/OFF state	A hardware and software interfece is necessary for the user to be aware of the state of the device.		1		2	Button from conductual design, with LEDs. Audible alarm. Red and green LED.
10		Communicate the begining or the end of a stage of the therapy.			1		2	Audible alarm. LED with scale of colours.
11		Communicate if a procedure is executing			1		2	Audible alarm. LED with scale of colours.
12		Communicate if there is any eventuality			2	1		3
13		Move the DOF necessary to execute DLA using the hands	Appendix C			1	2	MECHANISMS: Pulleys and torsional springs, rack and pinion, spur gear, four-bars. ELECTRONICS: Servo amplifiers, corrent source with amplifiers.
14		Move the range of movements necessary to execute the ADL using the hands	Table 5.7			1	2	
15		Move to a established speed between the defined RoM	Low speed. Aproximately 1 to 10 ° per second			1	2	
16		Move the articulations without exerting force perpendicular to the articulations	Equilibrium could be achieved between the mechanical advantage and undesirable forces in the jonts.			1	2	
17		Positiona the wrist to an established angle.	20° in flexion and 30° in extension			1	2	
18		Adaptability to different DoF, RoM and number of repetitions.	Move the articulations in the defined ROM in repetitive series. These parameters are defined by the Specialist in the Rehabilitation Protocol.		2	1	3	Microcontrolers: Atmega, Ardunios, PIC.

19	Funcional	Enable isotonic active rehabilitation and register force data	Active therapy includes isotonic and isometric exercises		2	1	3	DC Motors, Stepper motors, servos, pneumatic actuators.
20		Enable isometric active rehabilitation and register force data	Understanding isometric rehabilitation as a static position of the hand with incremented force of the patient		2	1	3	
21		Possibility to integrate the design to teleoperated technologies.	The communication between the actors is defined as local and disperse communication. The specialist is located in disperse location (from the patient point of view) and the Auxiliar, Patient and Machine are located locally, where the rehabilitation takes place.			1	2	Teleoperation via Internet
22		Communicate the system with a local server	The system must communicate with the local server, which sends and receives rehabilitation protocols and data registered during the therapy.	1			2	Wireless protocol (PAN,IP, Xbee), Serial Protocol
23		Measure the instanteneous position of each joint and the range of motion.	The device must be "aware" of its aoun position with repect to the patient position, in order to control the passive movements.				1	Potiontometers, encoders, hall effect sensorns, accelerometers and Flex-potentiometers
24		Measure the initial position of the patient	The "zero" posture is defined by the patient' s individual condition and the specialist criteria.	1		2	3	Software strategy, where the sensors measure the values of the initial position of the patient and store them in the memory.
25		Send the Patient ROM to the specialist.	Using the convention described in Section 5.1.	1			2	Programming code + communication protocol: Wireless protocol (PAN,IP, Xbee)
26		Measure indirectly the patient force during active therapy.	The biomechanical model selected is used extensively to translate the measured force by the sensor to the equivalent effect in the biological articulation				1	Piezoelectric transducer, compressive load cells, OEM, hall effect sensors, piezoresistive sensors, pressure sensors(FSR)
27		Send the torque or force exerte by the patient to the specialist, in order to have an historic register of force values and patient progress.	It is neccesary for the specialist to kwon the exerted for by the patient	1			2	Programming code + communication protocol
28		Register the repetitions by the patient according to the rehabilitation protocol.	The specialist should be able to recall the historic data of the patient	1			2	Programming code + communication protocol
29		Establish a hardware interface that is appealing and intuitive for the user.	The device must communicate each state of the therapy to the user and allow special visual stimulus for the patient		1	2	3	Integrative concept
30		Establish a software interface that is appealing and intuitive for the user.	The assistant and specialist must have an inteface that allows them to communicate with each other and send and receive information to and from the device.	1	2		3	Programmation environments that allow the creation of the interface.

31	Ergonomics and Perception	Describe graphically the stages of the rehabilitation procedure while using the device.	Previous to the beginning of the rehabilitation using the device, a familiarization process with the patient is necessary. The graphical description would be then a key tool for that purpose.			1		Descriptive infography, multimedia or publicitary video
32		Establish an interface focused on goals accomplishments.	It it necessary to motivate the patient to use the device.			1	2	An interface that makes evident visceral oriented design.
33		Generate a possitive visual impact				1	2	Design concepts: tweezers, retractable claws, dinamism, adaptability, modularity.
34		Generarte a security sensation				1	2	Simplicity as a concept for the machine.
35		Generarte an aseptic sensation sensación de limpieza	It is necessary to promote the continuity of the use of the device.			1	2	Use "clean" colours, textures and forms
36		Generarte a feeling of accompaniment		3	2	1		An assistant must receive and accompany the patient during all the procedure.
37		Promote the continuity of the procedure with rehabilitation at home				1	2	Design concept from a visceral level for the continuous use
38		Provide an adequate temperature at the elements in contact with patient skin.	The elements in contact with the patient's skin must be at room temperature, for the patients comfort.			1	2	The material for the surfaces in contact with the skin must be poor termo conductants. The heat-source -components must be as far as possible from the patient.
39		Have an adequate weight to assure portability.	The user assistant must adecuate the space and manipulate the device.		1	3	2	Use of light materials and use forms that allow easier manipulation of objects.
40		Adapt the device parameters to different hand dimensions.	Tables 5.3 and 5.4			1	2	Modularity concept
41		Adapt the surface of the device, in contat with the user, in order to interfere the hand particulaties.	The hand has several particularities as listed on Table A.1, and the device must no exert any kind of pressure on them, since this would cause discomfort and injuries for the patient.			1	2	Pressure points along the hand surface that do not interfere with the hand particularities.
42		Establish an effective mode of use sequence.	The effectivity of the mode of use sequence can be measured on the amount of sequences in comparison to commercial alternatives.		1	2	3	Descriptive infography, multimedia or publicitary video
43	Maintenance	Guarantee the access to internal components of the device.	Technical service in regular periods is important to assure the most optimal performance of the device.				1	Modularity concept
44		Guarantee the affordability of replacement parts					1	Use of materials and manufacture processes that can be affordable in the national context.
45		Enable easy cleaning and lubrication of the elements of the device					1	Modularity concept