3rd PROJECT PERIODIC REPORT

Grant Agreement number:	**216100**
Theme:	**ICT-2007.8.3 - FET proactive 3 “Bio-ICT convergence”**
Project acronym:	**LAMPETRA**
Project title:	**Life-like Artefacts for Motor-Postural Experiments and Development of new Control Technologies inspired by Rapid Animal locomotion**
Funding Scheme:	**CP (STREP)**

Date of latest version of Annex I against which the assessment will be made: 17/12/2010

Periodic report:	**1st ☐ 2nd ☐ 3rd X**
Period covered:	**from month 24 to month 42 (01/02/2010 - 31/07/2011)**

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Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate):
  - ☑ has fully achieved its objectives and technical goals for the period;
  - ☐ has achieved most of its objectives and technical goals for the period with relatively minor deviations;
  - ☐ has failed to achieve critical objectives and/or is not at all on schedule;
- The public website is up to date;
- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 6) and if applicable with the certificate on financial statement;
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 5 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Prof. Paolo DARIO

Date: __________

Signature of scientific representative of the Coordinator: ______________________________

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1. Publishable summary

During its course the LAMPETRA project aimed at developing lamprey and salamander-like bioinspired artefacts, with a twofold goal: to achieve new knowledge in neuroscience and to find new engineering solutions for high-performance artificial locomotion in terms of fast response, adaptability, reliability, energy efficiency and control. The main technological goal has been to develop autonomous artefacts that replicate living animal characteristics, from the neuronal level up to control and behavioural responses. Bioinspired robots have been successfully developed, capable of controlling their locomotion in goal-directed task, moving like real animals in their natural environments. These systems have been used for conducting neuroscientific studies and for performing experiments on vertebrate mechanisms involved in the neural control of goal-directed locomotion.

The choice of the lamprey and the salamander as animal models is motivated by their agile locomotion skills, their great importance from an evolutionary point of view, and by the fact that their neural centres controlling locomotion have been studied in detail.

During more than three years of collaborative activity LAMPETRA allowed to achieve advances both in neuroscience (better understanding of information processing and sensorimotor coordination in biological systems), and in robotic technologies. Bioinspired artefacts have been developed by adopting original design solutions, consisting of a high number of active segments, of compliant body structures, muscle-like actuators, legs-like appendages, artificial stretch receptors, vestibular and vision (stereoscopic) sensors, electronic hardware combining digital and analogue circuitry. The control architecture takes inspiration from neurobiological studies and it is based on the concept of central pattern generators and sensorimotor loops for robust and adaptive goal directed locomotion.

The lamprey robot moves in a real adaptive way and it optimize power consumption (more than five hours of autonomous goal-directed swimming) by storing elastic energy in its notochord and in its muscle-like actuators, as in real swimming fishes.

The salamander artefact also goes beyond most of the existing developments in the field of robotic locomotion and stretches farther the limits of finer motion and body complexity. The salamander was an excellent animal through which to explore and base these innovations. Salamanders are able to walk on ground and swim in water (with a swimming gait that is almost identical to that of the lamprey). One of the aims of this project was to understand how they do so; and how the walking abilities were added to those of swimming during evolution. These questions have been tackled not only by studying the animal itself but also by developing simulated and physical models of it.

Neuroscientific models of neural mechanisms of decision making and selection of behaviour have been successfully investigated and a detailed simulation tool has been developed as for both refining neuroscientific models as well as for implementing bioinspired control strategies into the developed artefacts.

For more information and project material published (articles, multimedia, etc...) visit the project website: www.lampetra.org).

2. Project objectives for the period

The Lampetra project aims at developing and exploiting lamprey/salamander bioinspired artefacts with a twofold aim:

1) to conduct **neuroscientific studies** on vertebrate mechanisms involved in the neural control of goal-directed locomotion, including:
    - mechanisms addressing striatum/basal ganglia in the selection between different patterns of behaviours based on visual input, other senses and previous experience;
    - motivational control as in the case of hunger, aggression, sexual partner selection, day/night cycle;
2) to find new solutions for **high-performance artificial locomotion** in terms of fast-response, adaptability, reliability, energy efficiency, control. In particular the aim is to go beyond steady state locomotion and investigate locomotion that is continuously modulated for implementing a rich variety of behaviours.

Artefacts evolve during the Project:

- a **first artefact** (delivered during the second year) is based on the identification and exploitation of commercial components;
- a **second artefact**, embedding dedicated and novel sensors, actuators and low level control circuits, for a very advanced biomimetism and allowing for the biohybrid interfacing of the lamprey/salamander nervous systems with acquisition and control hardware.

<u>Several objectives are pursued during the third year of the project:</u>

Neuroscientific activities and studies conducted on the activity of specific neuronal structures and addressed to improve knowledge on neural mechanisms of decision making and selection of behaviour have allowed to develop simulation models representing the basal ganglia and various relevant brain stem nuclei. These models have been connected to our lamprey and salamander models to control steering in a virtual world based on decisions on what to approach and what to avoid.

The final artefact has been designed and fabricated according to the biomechanical and neuroscientific knowledge on the lamprey. The identification of novel commercial components (structural components, electronics, actuators, vision system, etc …) enabled to develop a truly bioinspired artefact, with a flexible body, a binocular vision system, force-driven backdrivable actuators, and proprioceptive sensors to detect body deformation. The integration of behaviour level has been implemented, focusing the attention on the improvement of bio-mimicking actuators and on the development of a suitable control software, in order to achieve the right movement behaviour.

Finally, the **dissemination** of the project objectives, activities and results was also addressed, together with relevant **cooperation** initiatives within the FET area.

3. Work progress and achievements during the period

An overview of the work progress carried out in the reporting period for each WP is reported hereafter, (except project management, which is discussed further below).

WP2 (Neuroscientific mechanisms)

WP Leader: **KI**

WP Member: SSSA, KTH, U862

During this period we have reported on the neural mechanism underlying selection of behaviour in the basal ganglia. These have clarified that the organization of the control system for selection of behaviour in great detail is conserved from throughout the vertebrate phylum and thus that the same control circuits are used in lamprey and primates. The difference being that the lamprey has a limited behavioural repertoire (locomotion, turning, eye movement, foraging and spawning etc), while primates clearly have a much broader repertoire. The organization is considered to be subdivided in separate basal ganglia modules, each of which controls a specific aspect of behaviour (e.g. locomotion), the lamprey would have much fewer modules of this type than primates.
For visuomotor control the information about the surroundings comes from retina (the light sensitive part of the eye), which provides an image of the surrounding world. Different parts of retina project to the midbrain structure, tectum, in which the information from the eye is stored in a retinotopic map. The different parts of tectum in turn form an aligned motor map, from which eye movements in different directions and with different amplitude can be elicited as well as orienting movements of the head (trunk), which orients the body towards the point of interest. If these orienting movements occur during swimming they result in steering of the body. This aspect has been explored by a close interaction with the SSSA team, and together we have investigating the turning behaviour in the lamprey and implemented that into the lamprey robot. We have also utilized the neuromechanical simulations developed by the KTH team to simulate the turning behaviour.
Within this project we are therefore also reporting on the projections from the different parts of tectum to the brainstem neurons that initiate orienting movements. We have found that one group of efferents from the deeper layer of tectum projects to the contralateral side and is responsible for orienting movements. In addition a number of efferent neurons from tectum have ipisilateral axons projecting to brainstem command neurons that elicit evasive movements making the body turning away from a given point.

WP3 (Detailed mathematical modelling and simulation)

WP Leader: **KTH**

WP Member:KI, EPFL, U862

The work in WP3 has focused on investigating our novel model for decision making and integrating it with the models for rhythm generation and descending control. We base our models on the hypothesis that decision making is primarily taking place in the basal ganglia and that this system operates in a hierarchical fashion. The lower parts of the basal ganglia, i.e. globus pallidus and the subthalamic nucleus, have the responsibility to prevent simultaneous execution of incompatible actions. The higher parts, i.e. the striatum, can override these rules and provide alternative, learnt, actions.

Within WP3 we have constructed a simulation model comprised of interconnected neurons with physiologically realistic properties, representing the basal ganglia and various relevant brain stem nuclei. The neural networks in the model are interconnected based on anatomical data from WP2 and the literature. Finally, this model has been connected to our lamprey and salamander models to control steering in a virtual world based on decisions on what to approach and what to avoid.

In parallel with the investigation of the decision making circuits, we have improved our understanding of the rhythm generating abilities of the spinal cord by coupling it to our musculo-mechanical models of the lamprey and salamander, respectively. In particular, we have investigated what is required to achieve different gait patterns in the salamander, as observed in the video recordings from WP7.

Work carried at EPFL included the implementation of proprioceptive sensory feedback on top of the CPG and muscle model described in the WP5 section. This was done in simulation and on the EPFL lamprey and salamander artefacts. This development allowed us to investigate the interaction between descending control, the CPG, the muscle/body dynamics and sensory feedback. In particular, we used numerical simulations to investigate how the intersegmental phase lag in the CPG, as determined by descending controls and the spinal networks, is affected by the muscle dynamics and sensory feedback during land stepping and underwater stepping (for the salamander) and during swimming (for the lamprey). Some initial work was published in a book chapter in *Motor Control: Theories, Experiments, and Applications* by F. Danion and M. Latash (editors). The latest results were published in abstract form in the proceedings of the Twentieth Annual Computational Neuroscience Meeting.

<u>WP4 (Bio-inspired artefacts components development)</u>

WP Leader: **SSSA**

WP Member:KI, EPFL, KTH, U862

The work reported in this section addresses the development of the hardware components of the final bio-inspired lamprey artefact. Many progresses and upgrades have been made with respect to the previous prototype, both in hardware and software components, in order to have a robot with better performances and highly bioinspired. This robotic platform, that represents a step forward for achieving the project goals, has a high number of segments (21 of which 10 are active) and a new kind of muscle like actuation system based on the use of direct magnet interaction for producing actuation forces with small energy losses. Thanks to this ad-hoc technology it is possible to overcome, in fact, limitations due to high inertias, low adaptability and low efficiency. These two aspects (higher number of segments and improvements of the actuation system) combining with an intra-vertebral distribution of the batteries along the whole body of the robot allowed to dispose of an artifact not only with excellent swimming performances but also able to swim, continuatively, for at least five hours (two hours more than the previous version). The control system is based on CPG locomotion in order to optimize reactive behaviour and to produce travelling waves for forward locomotion with variable speed and waveform. A binocular vision system is used for autonomous swimming behaviours of the artifact. In fact, it drives the distributed segment boards in case of object tracking or obstacle avoidance. The artificial skin is waterproof and compliant and its mechanical properties make sure that it does not hamper the undulatory movements of the artefact. Its multi-layer configuration provides not only a greater impermeability but also a greater resistance to rupture phenomena: in fact, each layer is separated from the other thanks to a release agent. An intra-vertebral distance sensors system provides information about the angular position of each segment with respect to nearest ones. Finally, the multi-layer fiberglass tail ensures an optimal fluid dynamic behaviour and propulsion at the robotic platform. Locomotion results from the coupling of many parallel "tasks", distributed, as in living animals, between morphology, materials, control, and connected to the artefact's sensory-motor apparatus.

WP5 (Bio-inspired artefacts control)

WP Leader: **EPFL**

WP Member: SSSA, KTH

Task 5.3: Control hardware for the second prototype.
The control architecture is based on two main structure: the main control is embedded in the head (i.e. head board) and the distributed control is embedded in the body (i.e. segment board). The aim of the main control is to define the high level control and perform the communication, by means of wireless control, with the external PC. The wireless control gives the capability to supervise the robotic platform status, the motor encoder information, the angle sensors and the battery voltage.
Two cameras are embedded into the head and by wireless communication give the capability to acquire stereovision. The external PC processes the stereo images and improves the object tracking by colour detection. Along the body are present distributed board able to recharge the battery. The robot has so far been used in a tethered mode where the joint angles extracted from the X-ray kinematic data is replayed on the robot.

Task 5.4: Control software for the second prototype.
For the lamprey artefact both, firmware and software control are new. In particular, the distributed board for control (segment board) have been redesigned because the new artefact has new analogue position sensors and because the space available is smaller. Therefore, the firmware has improved and the analogue signal are acquired and filtered on-board. The control system has been improved because the computational burden is shared with an external PC. In particular, the low level control is improved inside the Lampetra artefact but, the stereo vision is acquired by an external PC that improve a tracking colour detection. By an ad hoc wireless control, the communication has been optimized and just high-level commands are sending into the artefact (e.g. encoder position, segment angle frequency-amplitude-phase, etc.). The CPG control architecture has been implemented with EPFL and the biological structure is provided from neuroscientific partners.

For the salamander artefact, a new high level model of the spinal CPG was developed, taking into account the biological observations from our partners from Bordeaux. In particular, the new model is more flexible, allowing for the generation of traveling waves of activity in the trunk while the limb oscillatory centres are active (the previous model only allowed for standing waves in the trunk during limb activity). This allows us to reproduce a larger set of behaviours as observed in the animals including underwater stepping and backward stepping. The parameter space for the muscle model was explored systematically in swimming and walking simulations. This allowed us to identify good values for the muscle gain, active stiffness, passive stiffness and damping. The resulting model was tested successfully on the EPFL lamprey (Amphibot III) artefact. Some results were published in abstract form in the proceedings of the Twentieth Annual Computational Neuroscience Meeting. The latest results, in collaboration with our partners from Bordeaux, are about to be submitted for journal publication. A biologically more accurate muscle model was then developed at EPFL for the salamander artefact. The new model (a non-linear Hill-type model) includes the muscle activation dynamics. This more accurate model will be useful for future studies (e.g. on energy consumption, and on sensory feedback, where the activation dynamics affect timings in the feedback loop). The parameters of the new muscle model were optimized based on kinematic data. High resolution kinematic data were obtained by analyzing X-ray recordings of animals during swimming, land stepping and underwater stepping. The swimming data were used to optimize the muscle parameters in simulations, and the resulting model was implemented on the artefact. The communication protocol (upper layer of the CAN protocol) was modified to allow for a faster control loop, as required by the new muscle model. The model was then successfully tested on the artefact for the swimming gait.

WP6 (Bio-inspired artefacts integration)

WP Leader: **SSSA**

WP Member: EPFL

The final prototype of the Lampetra robot has been fabricated by the integration in the body structure of commercial and in-house developed components.
The robot is about 910 mm long, with a diameter of 54.4 mm and the capability of a radius of curvature of the body down to 75 mm (higher than the 50 mm of the previous one).
The robot consists of:

- 21 vertebras connected by means of a “notochord-like” flexible thin elastic metal structure
- 10 DC motors with encoders for orienting the magnets in order to guarantee and drive the locomotion
- 5 electronic boards to distribute CPG control and one electronic board for communication and high level control
- A binocular vision system with 2 PAL cameras to obtain visual information from the environment and to detect objects or targets for obstacle avoidance or object tracking
- An artificial, compliant, waterproof and multilayered skin that ensures impermeability, resistance and suitable operation during swimming
- A neutral trim tail made in fiber glass
- Stretch sensors distributed along the whole body that provide information about the angular position of each vertebra as regard to the others nearest vertebras

As shown in D6.3 the final prototype of the Lampetra robot is swimming effectively and in a very natural way.
As illustrated by videos and images provided with deliverables and downloadable on the project website, test and demos were done in different contexts and events in order to share the project results with an heterogeneous audience (experts and not).
A novel lamprey-like robotic platform is under development in order to ensure the 3D swimming (with a cam system) overcoming and solving limits introduced by the underwater wireless communication both during data acquisition (sensors, cameras, etc ...) and when commands are sent at the artefact when it is tele-operated.

A novel salamander-like prototype was developed using off the shelf servo-motors motivated by the results obtained from the collaboration of EPFL and INSERM concerning the detailed 3D kinematics study of the skeletal movements of real salamanders (soon to be submitted for publication).

WP7 (Experimental analyses of motor coordination)

WP Leader: **U862**

WP Member: KI, KTH

The primary WP goal addressed during this period was to elucidate the descending command signals to the spinal locomotor networks during different locomotor behaviours exhibited by freely moving salamanders.
The second WP objective was to compare the data obtained in salamanders with those previously reported in the lamprey by KI, because this may shed light on the motor control processes related to the evolution of the locomotor modes in vertebrates.

Identification of the descending pathways.

Using electrical microstimulation in a semi-intact preparation, we have shown that simple signals from the brainstem can elicit either locomotion (swimming or stepping, depending on the level of activation), or rhythmic movements of a single hindlimb. Furthermore, rhythmic movements restricted to the tail can be induced by electrical stimulation of the first spinal cord segment. These results support the view that some descending pathways can selectively activate subparts of the locomotor network.

Recording from tectal activity, head and eye movements during locomotion in freely behaving salamanders.

We have developed tripolar electrodes suitable to record/stimulate from motor supraspinal structures in freely moving salamanders.
We have focused our recordings on the optic tectum because this structure plays a critical role for visuomotor coordination, and this further allowed a comparison with the data reported in the lamprey by KI. Moreover, we took advantage that both the retina projections to the optic tectum and

the tectal efferents to the lower brainstem structures (e.g. the reticular formation) that control spinal motor centres have previously been described in detail in salamanders.

In a first step, using electrical microstimulation we have obtained an oculomotor map of the optic tectum which overlapped its retinotopic innervation.

Thereafter, our kinematics and EMG recordings evidenced rhythmic yaw and pitch of the head and rhythmic retractions of the two eyes during land stepping along a straight track. Retractions of each eye occurred during protraction of the ipsilateral forelimb and yawing of the head towards the ipsilateral side. Interestingly, the coordination pattern between the two eyes depended on the environment: the left and right eyes alternatively retracted during stepping on ground, while they synchronously retracted during underwater stepping.

Finally, multiunit recording from the optic tectum evidenced: i) a double-bursting pattern of activation of the optic tectum during stepping; ii) a correspondence of the activation pattern of the lateral/medial parts of the optic tectum to the oculomotor map.

Altogether our results increase the current knowledge on the descending motor systems that control the spinal locomotor networks in salamanders, in line with the pursued WP first objective. They further emphasize the environment dependence of both the eye movement pattern and the tectal activation pattern during locomotion.

Comparison with the lamprey

Our results bridge over the two vertebrate models, in line with the second WP objective. Indeed, a comparison with the data previously reported in the lamprey by KI suggests strong similarities in the brainstem mechanisms that control the initiation and speed of locomotion.

In salamanders, each of the four limb CPGs and the body CPG can be activated independently of each other (e.g. just the CPG for one limb) by specific descending pathways. This is a potential mechanism which may explain the richer locomotor skills which appeared during evolution from limbless aquatic vertebrates to the first tetrapods which venture out onto land.

Comparison further reveals a more varied visuomotor control during locomotion in salamanders. This is related to the appearance of a more sophisticated extraocular musculature and a richer locomotor repertoire during evolution.

Achieved results and lessons learned:

The aforementioned results, which are crucial for the improvement of the salamander artefact, support the view that the new neuronal systems devoted to stepping in tetrapods were built on top of a primitive (i.e. lamprey-like) swimming circuit.

WP8 (Bio-hybrid experiments)

WP Leader: **KI**

WP Member: SSSA, EPFL, U862

As indicated in the second periodic project report the original plan to use recording of the reticulospinal signals mediating the steering command from the brain turned out to be technically

difficult, since the signal was too noisy. During the last period we have looked in some detail on the biological steering signal as recorded from muscle segments along the body in interaction with SSSA group. These signals can be used for controlling the lamprey artefact after adaptation to the robot control system.
We have also conducted experiments on the lamprey robot, which swims with biological principles with a phase lag along the body. The artefact can also be steered and turn in an efficient way in a mode similar to the biological model and perform targeting task driven by light stimuli.

WP9 (Dissemination, Collaboration and Exploitation,)

WP Leader: **EPFL**

WP Member: SSSA, KI, KTH, U862

As described in the deliverable D9.4, the whole consortium has been very active in dissemination activities. LAMPETRA has been involved in the organization of symposiums, workshops, and summer schools. In particular, it has co-organized with the ANGELs project an International Workshop on Bio-Inspired Robots from April 6 to 8, 2011 in Nantes, see http://www.emn.fr/z-dre/bionic-robots-workshop/

Furthermore, LAMPETRA partners have published over 15 papers in journals and conference proceedings, and guess edited two special issues (one in *Autonomous Robots* and one in *Bioinspiration & Biomimetics*).

The results of LAMPETRA have been featured extensively in national and international media, with both TV (BBC, France 3, Swiss German TV, Swiss Italian TV) and newspaper (The Economist, Sole 24 Ore, Le Figaro, Ouest-France, L’Expess, Sud-Ouest) coverage.

All these items are described in more details in Deliverable D9.4.

4. Deliverables and milestones tables

Deliverables - The deliverables (excluding the periodic report) due in the reporting period, as indicated in Annex I of the Grant Agreement, are reported in the following table.

Del. no.	Deliverable name	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (from Annex I)	Delivered (Yes/No)	Actual / Forecast delivery date	Comments
D 9.1	Project website	9	EPFL	O	PU	2	YES	2	
D 4.1	Report on artefact components choice for first prototype	4	SSSA	R	PU	6	YES	6	
D 1.1	Periodic activity, assessment and lessons learned report	1	SSSA	R	PU	12	YES	12	
D 2.1	Report on the analyses of mechanisms of visuo-motor control	2	KI	R	PU	12	YES	12	
D 3.1	Simulation Platform	3	KTH	P	PU	12	YES	12	
D 3.2	Draft report on models for descending control and decision making	3	KTH	R	PU	12	YES	12	
D 4.2	Progress report on the development of components for second artefact prototype	4	SSSA	R	PU	12	YES	12	
D 5.1	Control HW and SW for the first prototype	5	EPFL	O	PU	12	YES	12	

Del. no.	Deliverable name	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (from Annex I)	Delivered (Yes/No)	Actual / Forecast delivery date	Comments
D 6.1	Parts of the first prototype to be integrated and report on specifications	6	SSSA	O	PU	12	YES	12	
D 7.1	Draft report on motor coordination and on discharge patterns	7	U862	R	PU	12	YES	12	
D 8.1	Draft report on signal recording from lamprey command neurons	8	KI	R	PU	12	YES	12	
D 9.2	Report on dissemination, collaboration and exploitation, first year	9	EPFL	R	PU	12	YES	12	
D 6.2	First prototype integrated	6	SSSA	O	PU	18	YES	18	
D 7.2	Report on motor coordination	7	U862	R	PU	18	YES	18	
D 1.2	Periodic activity, assessment and lessons learned report	1	SSSA	R	PU	24	Yes	24	
D 2.2	Draft report on neural mechanisms underlying decision making and selection of behaviours	2	KI	R	PU	24	Yes	24	
D 3.3	Models for descending control	3	KTH	O	PU	24	Yes	24	
D 3.4	Draft report on models for decision making	3	KTH	R	PU	24	Yes	24	

Del. no.	Deliverable name	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (from Annex I)	Delivered (Yes/No)	Actual / Forecast delivery date	Comments
D 4.3	Progress report on the development of components for second artefact prototype	4	SSSA	R	PU	24	Yes	24	
D 5.2	Progress report on control HW and SW for the second prototype	5	EPFL	R	PU	24	Yes	24	
D 7.3	Draft report on discharge patterns and on data comparison/analysis	7	U862	R	PU	24	Yes	24	
D 8.2	Report on command signals for initiation of locomotion, speed control, steering and body orientation	8	KI	R	PU	24	Yes	24	
D 9.3	Report on dissemination, collaboration and exploitation, second year	9	EPFL	R	PU	24	Yes	24	
D 4.4	Components for second artefact prototype ready for integration	4	SSSA	P	PU	34	Yes	34	
D 5.3	Control HW and SW for the second prototype	5	EPFL	O	PU	34	Yes	34	
D 6.3	Second prototype integrated	6	SSSA	O	PU	35	Yes	35	
D 1.3	Periodic activity, assessment and lessons learned report	1	SSSA	R	PU	42	Yes	42	

Del. no.	Deliverable name	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (from Annex I)	Delivered (Yes/No)	Actual / Forecast delivery date	Comments
D 2.3	Report on neural mechanisms underlying decision making and selection of behaviours	2	KI	R	PU	42	Yes	42	
D 3.5	Models for decision making	3	KTH	O	PU	42	Yes	42	
D 7.4	Report on discharge patterns and on data comparison/analysis	7	U862	R	PU	42	Yes	42	
D 8.3	Report on artefact control via lamprey signals and on influencing the lamprey behaviour via artefact signals	8	KI	R	PU	42	Yes	42	
D 9.4	Report on dissemination, collaboration and exploitation, third year	9	EPFL	R	PU	42	Yes	42	
D 9.5	Book collecting project results and relevant scientific knowledge achieved during the project	9	EPFL	R	PU	42	Yes	42	

Milestones - Milestones in the reporting period are reported in the following table, together with corresponding means of verification, as specified in Annex I of the Grant Agreement.

Milestone no.	Milestone name	Work package no	Lead beneficiary	Expected date (from Annex I)	Achieved (Yes/No)	Actual / Forecast achievement date	Means of verification
Mil.1	Simulator and control hardware and software for the first prototype	WP 3; WP 5	KTH, EPFL	12	YES	12	Deliverables D3.1 and D5.1
Mil.2	Artefact First Prototype	WP6	SSSA	18	Yes	18	Deliverables 6.2 and 9.3
Mil.3	Bio-inspired components ready to be integrated	WP4; WP5	SSSA; EPFL	34	Yes	34	Deliverable D4.4 released
Mil.4	Artefact Second Prototype	WP6	SSSA	35	Yes	35	Robotic artefact enhanced prototypes completed and working flawlessly; (Deliverable D6.3).

5. Project management

This section summarises management of the consortium activities during the period.

Consortium management tasks and achievements

5.1 *Problems which have occurred and how they were solved or envisaged solutions*

Changes in the consortium

Changes of legal details are mentioned in the following table:

Beneficiary Number	Short name	Changes occurred	Status (31. 07. 2011)
1	SSSA	**OLD LEGAL REPRESENTATIVE** Prof. Enrico Bonari Vice Director - Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna **Old Person in charge of Administrative legal and Financial aspects** Prof. Pietro Tonutti Director of Research Division Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna	**NEW LEGAL REPRESENTATIVE:** Prof. Pierdomenico Perata Vice Director - Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna: Effective date: 19/11/2010 **New Person in charge of Administrative legal and Financial aspects** Prof. Paolo Dario The BioRobotics Institute Director
2	KI	NONE	NONE
3	EPFL	NONE	NONE
4	KTH	NONE	NONE
5	INSERM	NONE	NONE

Changes to the legal status of any of the beneficiaries

Beneficiary Number	Short name	Legal Status (31/01/2010)	Legal Status changes (31 07. 2011)
1	SSSA	5. non profit public body 5. higher education establishments 5. research organisation	NONE

2	KI	5. non profit public body 5. higher education establishments 5. research organisation	NONE
3	EPFL	5. non profit public body 5. higher education establishments 5. research organisation	NONE
4	KTH	5. non profit public body 5. higher education establishments 5. research organisation	NONE
5	INSERM	5. non profit public body 5. research organisation	NONE

List of project meetings, dates and venues

During the period, the following **project meetings** have been held:

Meeting no.	Participants	Date	Venue
1	ALL	9-12/02/2011	Stockholm, Sweden
	INSERM	26 feb. 2010	Brussels , **Review meeting**
2	SSSA, KI, EPFL, INSERM	6-9/04/2011	Nantes, France
3	SSSA, EPFL, INSERM	3-7/05/2011	Budapest, Hungary
4	EPFL, KTH	April 2010	Lausanne
	INSERM	**3-7 july 2010**	**Amsterdam - FENS meeting**
	SSSA, EPFL	October 25.2010	Lausanne
5	EPFL, INSERM	November 2010	Lausanne
6	EPFL, SSSA	November 2010	Lausanne
7	SSSA, KI, KTH; INSERM	2010/2011*	Stockholm
8	KI, KTH	Multiple times 2010/2011	Stockholm

* Lorenza Capantini PhD student from SSSA spent one year in KI laboratories creating, in effect, a “bridge of knowledge” between the two partners.

Project planning and status

In consideration of the objectives and of the achievements in the period and taking into account the six months extension of the project, the activities are on track with respect to the original planning.

Impact of possible deviations from the planned milestones and deliverables

There are no deviations from the planned milestones and deliverables.

Development of the Project website

The LAMPETRA project website (www.lampetra.org) has been improved and constantly updated with photos and videos. Events in which the consortium was involved for showing the scientific results of the project or have demos with the robot (e.g FET11) have been widely advertised. Compared with the first two years of the project in which visits at the website pages were around 8000 accesses have more than doubled: actually they are roughly 17500. This result is an objective fact of how the consortium has done a good job in dissemination activities and of how the project and its results have been effectively advertised at the general public. In web search engines (e.g.: Google), our Project website is the first link if the words

- "Lampetra"
- "Lamprey artefact"
- "Swimming artefact"
- "Bio-inspired lamprey"

are typed.

Use of foreground and dissemination activities during this period

The high number of publications or accepted papers in 2010 and 2011 is very rich. Furthermore LAMPETRA partners guess edited two special issues (one in *Autonomous Robots* and one in *Bioinspiration & Biomimetics*). This is an indication of how the scientific results achieved by the consortium within the project provided a good scientific progress. Each partner has at least one ISI journal publication on Lampetra, also proving individual productivity. The consortium has been involved in the organization of symposiums, international workshops, and summer schools. Finally, thanks to the appealing concept of the Lampetra platform, our robotic system has been have been featured extensively in national and international media, with both TV and newspaper coverage.

ARTICLES

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- Stephenson-Jones M, E. Samuelsson, J. Ericsson, B. Robertson and S. Grillner, Evolutionary conservation of the basal ganglia as a common vertebrate mechanism for action selection. Curr. Biol., 21;1081-1091, 2011.
- C Stefanini, S Orofino, L Manfredi, S Mintchev, S Marrazza, T Assaf, L Capantini, E Sinibaldi, S Grillner, P Wallén and P Dario, A novel autonomous, bioinspired swimming robot developed by neuroscientists and bioengineers. Bioinspiration and Biomimetics, [IN PRESS]
- Crespi A., Karakasiliotis K., Ijspeert A.J. Salamandra robotica II: an amphibious salamander robot controlled by a central pattern generator. IEEE Transations in Robotics. [UNDER REVIEW]
- Harishandra N, Knüsel J., Kozlov A., Bicanski A., Cabelguen J-M, Ijspeert A., Ekeberg O.: Sensory feedback plays a significant role in generating walking gait and in gait transition in salamanders: a simulation study. Frontiers in Neurorobotics [UNDER REVIEW]
- Bicanski A., Ryczko D., Cabelguen J.-M., Ijspeert A.J. Modeling salamander axial spinal segments [TO BE SUBMITTED]
- Ryczko D., Knüsel J., Lamarque S., Mathou A., Ijspeert A. J., Cabelguen J.M.: Locomotion underwater and on land with multifunctional circuits. [TO BE SUBMITTED]

PAPERS:

- Bicanski A., Ryczko D., Cabelguen J.-M., Ijspeert A.J., Modeling axial spinal segments of the salamander central pattern generator for locomotion, Abstract presented at the Twentieth Annual Computational Neuroscience Meeting, CNS 2011, BMC Neuroscience, Volume 12, Supplement 1, P157, 2011.
- Knuesel J., Ijspeert A.J., Effects of muscle dynamics and proprioceptive feedback on the kinematics and CPG activity of salamander stepping, Abstract presented at the Twentieth Annual Computational Neuroscience Meeting, CNS 2011, BMC Neuroscience, Volume 12, Supplement 1, P157, 2011.
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- C.Stefanini, L.Manfredi, S.Orofino, S.Mintchev, S.Marrazza, T.Assaf, L.Capantini, U.Scarfogliero, E.Sinibaldi, and P.Dario, Development of a compliant, high-efficiency and bio-inspired snake-like swimming robot. Abstract for the International Workshop on Bioinspired Robots, Nantes, 2011
- S.Mintchev and C.Stefanini ,A novel muscle-like, high efficiency actuator for biorobotics. Abstract for the Workshop on Biologically Inspired Actuation – ICRA 2011

Dissemination activities (also described through the project deliverable D9.4) have been carried out by a variety of means.

The **main outcomes** of this WP are:

- The finalizing of a **special issue** collecting project results and relevant scientific knowledge achieved during the project. Following the organization of the International Workshop on Bio-Inspired Robots -Nantes, France, 6-8 April 2011, a special issue of Bioinspiration & Biomimetics was organized with Cesare Stefanini as one of the guest editors. See: http://iopscience.iop.org/1748-3190/page/Bio-Inspired%20Robots%20special%20issue

- Invited presentations at international conferences. Partners have presented LAMPETRA results to large audiences to various international scientific events. International Workshop on Bioinspired Robots, FET11, ICRA 2011, Biomimetics 2011, CNS 2011, EUSFLAT-2011 and the Embodied Intelligence Summer School are just some examples of events in which LAMPETRA scientific results have been presented. For more details please read D9.4.

- **Demonstrations.** The SSSA and EFPL lamprey and salamander robots have been shown multiple times to visitors. They have also been demonstrated at various scientific events such as the FET conference in Budapest and the International Workshop on Bioinspired Robots (Nantes, France April 6th- 8th 2011).

- **Summer-school co-sponsorization**. As recommended by the reviewers, LAMPETRA has contributed to the organization of the Second Summer School on Embodied Intelligence and Lampetra, June 27 – July 1 2011, Zurich, Switzerland with the EMBODy project.

- **International Workshop**. Lampetra Partners have been actively involved in organizing and co-sponsoring, with ANGELs partners, the International Workshop on Bioinspired Robots that took place on April 6-8 2011, in Nantes France was a great success with over 200 international participants.

- **Media**. The results of LAMPETRA have been featured extensively in national and international media, with both TV (BBC, France 3, Swiss German TV, Swiss Italian TV) and newspaper (The Economist, Sole 24 Ore, Le Figaro, Ouest-France, L'Expess, Sud-Ouest) coverage.

Co-ordination activities

During the last year of the project several collaboration with other projects active with the FET area have been pursued; the aforementioned FET 11 event (where we have proposed an exhibition stand) and International Workshop on Bioinspired Robots (co-organize with the ANGELS project) represent an effort on regard, aimed at disseminating the main objectives and outcomes of the Lampetra project.
In addition several interactions between LAMPETRA and other FET-Proactive projects have taken place. These include:

- The participation of Auke Ijspeert as invited speaker to Embodied Intelligence Summer School, Livorno, September 21, 2010.
- The organization of the Second Summer School on Embodied Intelligence and Lampetra, June 27 – July 1 2011, Zurich, Switzerland with the EMBODy project.
- The participation of Orjan Ekeberg as invited speaker to that summer school

- The participation of Kostas Karakasiliotis (EPFL) to a study of lizard locomotion with partners from the LOCOMORPH project

It is worth to mention that on January 2011, SSSA has also **coordinated the collection of project information** in order to fill the questionnaire designed by the RTD DG for assessing the **progress in 2010 towards the achievement of the IST-RTD implementation** objectives.

6. Explanation of the use of the resources

EFFORTS table:

3rd PERIOD (01/02/2010 - 31/07/2011)

The following tables provide an explanation of personnel costs, subcontracting and any major direct costs incurred by each beneficiary, such as the purchase of important equipment, travel costs, large consumable items, etc. linking them to WP of the project.

WP	Activity Type		SSSA	KI	EPFL	KTH	U862	TOT
RTD/ Innovation Activities								
WP2	Neuroscientific mechanisms	Planned	2,00	18,00	0,00	9,00	15,00	44,00
		Actual	0,96	20,20	0,00	2,33	5,00	28,49
WP3	Detailed mathematical modelling and simulatio	Planned	0,00	5,00	10,00	24,00	2,00	41,00
		Actual	0,00	0,00	8,00	13,34	1,00	22,34
WP4	Bio-inspired artefact(s) components developme	Planned	51,00	4,00	9,00	1,00	1,00	66,00
		Actual	13,35	0,00	6,00	1,03		20,38
WP5	Bio-inspired artefact(s) control	Planned	4,00	0,00	33,00	5,00	0,00	42,00
		Actual	0,51	0,00	16,00	9,31		25,82
WP6	Bio-inspired artefact(s) integration	Planned	12,00	0,00	9,00	0,00	0,00	21,00
		Actual	1,32	0,00	3,00	0,00		4,32
WP7	Experimental analyses of motor coordination	Planned	0,00	6,00	0,00	6,00	24,00	36,00
		Actual	0,00	0,00	0,00	7,04	8,50	15,54
WP8	Bio-hybrid experiments	Planned	6,00	10,00	6,00	0,00	3,00	25,00
		Actual	5,42	10,00	0,00	0,00		15,42
Total RTD/ Innovation Activities		**Planned**	**75,00**	**43,00**	**67,00**	**45,00**	**45,00**	**275,00**
		Actual	**21,57**	**30,20**	**33,00**	**33,05**	**14,50**	**132,32**
Consortium/Management Activities								
WP1	Management	Planned	18,00	0,00	0,00	0,00	0,00	18,00
		Actual	8,33	0,00	0,00	0,00	0,00	8,33
Total Consortium/Management Activities		Planned	18,00	0,00	0,00	0,00	0,00	18,00
		Actual	8,33	0,00	0,00	0,00	0,00	8,33
Other Activities								
WP9	Dissemination	Planned	5,00	5,00	5,00	3,00	3,00	21,00
		Actual	2,19	3,60	3,00	2,09	0,00	10,88
Total Other Activities		Planned	5,00	5,00	5,00	3,00	3,00	21,00
		Actual	2,19	3,60	3,00	2,09	0,00	10,88
TOTAL PLANNED			**98,00**	**48,00**	**72,00**	**48,00**	**48,00**	**314,00**
TOTAL ACTUAL			**32,09**	**33,80**	**36,00**	**35,14**	**14,50**	**151,53**

ALL	
PMS Male	116,90
PMs FEMALE	34,64

CUMULATED EFFORTS table:
1st , 2nd and 3rd PERIOD (01/02/2008 – 31/07/2011

WP	Activity Type		SSSA	KI	EPFL	KTH	U862	TOT
RTD/ Innovation Activities								
WP2	Neuroscientific mechanisms	Planned	2,00	18,00	0,00	9,00	15,00	44,00
		Actual	2,63	30,20	0,00	10,13	16,00	58,96
WP3	Detailed mathematical modelling and simulatio	Planned	0,00	5,00	10,00	24,00	2,00	41,00
		Actual	0,00	3,50	17,00	34,84	2,50	57,84
WP4	Bio-inspired artefact(s) components developme	Planned	51,00	4,00	9,00	1,00	1,00	66,00
		Actual	48,71	1,20	12,00	1,03	0,00	62,94
WP5	Bio-inspired artefact(s) control	Planned	4,00	0,00	33,00	5,00	0,00	42,00
		Actual	5,03	0,00	43,00	9,31	0,00	57,34
WP6	Bio-inspired artefact(s) integration	Planned	12,00	0,00	9,00	0,00	0,00	21,00
		Actual	10,04	0,00	5,00	0,00	0,00	15,04
WP7	Experimental analyses of motor coordination	Planned	0,00	6,00	0,00	6,00	24,00	36,00
		Actual	0,00	1,00	0,00	8,04	32,50	41,54
WP8	Bio-hybrid experiments	Planned	6,00	10,00	6,00	0,00	3,00	25,00
		Actual	6,91	18,30	0,00	0,00	0,00	25,21
Total RTD/ Innovation Activities		**Planned**	**75,00**	**43,00**	**67,00**	**45,00**	**45,00**	**275,00**
		Actual	**73,32**	**54,20**	**77,00**	**63,35**	**51,00**	**318,87**
Consortium/Management Activities								
WP1	Management	Planned	18,00	0,00	0,00	0,00	0,00	18,00
		Actual	13,08	0,00	0,00	0,00	0,00	13,08
Total Consortium/Management Activities		**Planned**	**18,00**	**0,00**	**0,00**	**0,00**	**0,00**	13,08
		Actual	**13,08**	**0,00**	**0,00**	**0,00**	**0,00**	2,09
Other Activities								
WP9	Dissemination	Planned	5,00	5,00	5,00	3,00	3,00	21,00
		Actual	3,57	3,60	5,00	3,38	2,00	17,55
Total Other Activities		**Planned**	**5,00**	**5,00**	**5,00**	**3,00**	**3,00**	21,00
		Actual	**3,57**	**3,60**	**5,00**	**3,38**	**2,00**	17,55
TOTAL PLANNED			**98,00**	**48,00**	**72,00**	**48,00**	**48,00**	**314,00**
TOTAL ACTUAL			**89,97**	**57,80**	**82,00**	**66,73**	**53,00**	**349,50**

6.2 Personnel, subcontracting and other major direct cost items

TABLE 3.1 PERSONNEL, SUBCONTRACTING AND OTHER MAJOR DIRECT COST ITEMS **BENEFICIARY NO. 1 : SSSA** **PERIOD: 01/02/2010 – 31/07/2011**			
WORK PACKAGE	**ITEM DESCRIPTION**	**EXPLANATIONS**	**AMOUNT**
1-2-4-5-6-8-9	Personnel costs	• Salaries for research activities for total PMs 21,57; • Salary management activities PMs 8,33; • Salary for other activities PMs 2,19	€89.257,00
1-2-5-4-6-9	Travel	Travel costs are related to the participation in: • Reimbursement for participation at Lampetra Review Meeting, February 26,2010 Brussel Belgium; • participation at Lampetra technical Meeting, December 4,2009 Lausanne Swiss; • Participation at technical meeting, September 21,2010 Genova Italy • Participation at Lampetra Review Meeting, February 26,2010 Brussel Belgium; • Reimbursement for participation at FET 2011Conference, May 4-6,2011 Budapest Hungary; • Reimbursement for participation at Lampetra General Meeting, February 10-11,2011 Stoccolma Sweden; • Biorobotics workshop in Nantes • Reimbursement for participation at Lampetra Final reviewl Meeting, September 2011 ; • Participation at ROMECUP 2011, March 14-16, 2011 Rome Italy; • Participation at 2011 IEEE International Conference on Robotics and Automation, May 9-13, 2011 Shangai Cina.	€23.292,00

	Subcontracting	• External services for the realization of printed circuits, WP4for the Lampetra • Realization of electronic circuits; • Courier mail costs; • realization of project brochure • Conference room for Lampetra Final-review meeting; • Audit certificate.	€ 7.374,00
2-4	Equipment	• Pc and laboratory equipment. The amount is related to the depreciation and use in this period	€2.144,00
4-6-8	Consumables	Acquisition of consumable materials used for research activity performed in WPs 2-4, 6, 8: • Optical module and mechanical components for prototype realization; • components for assembly automation for the interface robot platform; • electronic components, electrical, electronic materials; • consumables products; • channel USB Frame Grabber; • kit dragon skin, glue, snap-hooks, screws, hooks; • transmitters and receiver for wireless display signal transmission	€12.204,00
9	Other costs	• Patent for Permanent magnet actuator for adaptive actuation.	€1.992,00
		TOTAL DIRECT COSTS	**€ 136.263**

TABLE 3.2 PERSONNEL, SUBCONTRACTING AND OTHER MAJOR DIRECT COST ITEMS BENEFICIARY NO. 1 : SSSA ADJUSTMENT TO THE PREVIOUS PERIOD: 01/02/2009 – 31/01/2010			
WORK PACKAGE	**ITEM DESCRIPTION**	**EXPLANATIONS**	**AMOUNT**
2-3-8	Personnel costs	Adjustment to the cost claimed in the 2nd year research activities taking into account the actual annual gross salary (not yet available at the end of the previous reporting period).	**€ 347,00**
1	Other costs	Minor adjustment to the consumables costs claimed in the previous reporting period (electronic components)	**€ 8,58**
		TOTAL DIRECT COSTS	**€- 338.42**

TABLE 3.2 PERSONNEL, SUBCONTRACTING AND OTHER MAJOR DIRECT COST ITEMS **BENEFICIARY NO. 2 : KI** **PERIOD: 01/02/2010 – 31/07/2011**			
WORK PACKAGE	**ITEM DESCRIPTION**	**EXPLANATIONS**	**AMOUNT**
2-8	Personnel costs	• Post docs have been involved 16 months, lab engineer 7,2 months, senior researcher 7 months (under WPs 2-8); • Training activities 3.6 PMs	**€ 129.417,00**
1	Travel	Travel costs are related to the participation in: • Lampey conf., Bordeaux 2010, Society fo Neuroscience ann. Meet. 2010, poster presentation Meet. D. Poulain, INSERM, Bordeaux , November 2009; • LAMPETRA project meetings in Pisa 2010 and Stockholm 2011; • Biorobotics workshop in Nantes	**€ 8.647,00**
	Subcontracting		**0,00**
	Equipment		
2-3-8	Consumables	Chemicals, metals, aquarium/pool costs	**€ 16.413,26**
8	Other costs	Microscopi/imaging equipment service costs/replacements in the experimental neurobiology part of the project; Publication costs	**€ 22.716,00**
		TOTAL DIRECT COSTS	**€177.193,26**

TABLE 3.3 PERSONNEL, SUBCONTRACTING AND OTHER MAJOR DIRECT COST ITEMS BENEFICIARY NO. 3 : EPFL PERIOD: 01/02/2010 – 31/07/2011			
WORK PACKAGE	**ITEM DESCRIPTION**	**EXPLANATIONS**	**AMOUNT**
WPs3-7-4-5-	Personnel costs	RTD Personnel costs: • Salary of PhD student Jeremie Knuesel, 18PMs; • Salary of PhD student Konstantinos Karakasiliotis, 18 PMs	**€ 163.326,00**
3-4-5-9	Travel	• Travel of K. Karakasiliotis to collect Xray kinematic data, Jena, January 2010; • Review meeting held in Brussels, February 2010; • Travel of K. Karakasiliotis to collect Xray kinematic data, Jena, February/March 2010; • Meeting held in Lausanne, October 2010; • Workshop held in Bordeaux, April 2010; • Meeting held in Lausanne, N. I. Harischandra, April 2010; • Meeting held in Lausanne, November 2010; • Workshop held in Stockholm, February 2011; • Workshop held in Nantes, April 2011; • FET Conference, Budapest, May 2011	**€ 13779,00**
	Subcontracting		**0,00**
	Equipment		**0,00**
4-5	Consumables	Electronic components, electrical, electronic materials, motors for the salamander robot prototype	**€ 10.345,00**
3-4-5-6	Other costs	Costs for the organization of Lampetra meeting: 04.12.09, Lausanne, Switzerland, EPFL - SSSA - INSERM	
	Remaining direct costs		**0,00**
		TOTAL DIRECT COSTS	**€187.450,00**

TABLE 3.4 PERSONNEL, SUBCONTRACTING AND OTHER MAJOR DIRECT COST ITEMS BENEFICIARY NO. 4 : KTH PERIOD: 01/02/2010 – 31/07/2011			
WORK PACKAGE	**ITEM DESCRIPTION**	**EXPLANATIONS**	**AMOUNT**
2-3-5-7-9	Personnel costs	• Salary of researchers and project leader mainly for RTD activities	**€ 126.409,00**
5-9	Travel	Travel costs are related to the participation in: • Project review meeting - Brussels Feb 2010 projekt leader; • CNS 2011 - Stockholm July 2011 projekt leader, PhD student; • Embodied Intelligence Summer School - Zurich June 2011 projekt leader; • Cooperation with EPFL - Lausanne - March 2010 - PhD student; • SNC 2009 Chicago October	**€ 4.275,00**
	Subcontracting		
9	Equipment	Depreciation of PC	**€ 2.716,00**
2-3	Consumables	n.2 Dator componenter/accessories	**€ 3.418,00**
	Other costs	Publications costs, representation, delivery/freight costs	**3.189,00**
		TOTAL DIRECT COSTS	**€140.007,00**

TABLE 3.5 PERSONNEL, SUBCONTRACTING AND OTHER MAJOR DIRECT COST ITEMS BENEFICIARY NO. 5 : INSERM U862 PERIOD: 01/02/2010 – 31/07/2011			
WORK PACKAGE	**ITEM DESCRIPTION**	**EXPLANATIONS**	**AMOUNT**
WPs 2-3-7	Personnel costs	Salary of Vanessa CHARRIER (11,5 PMs) Salary of engineer Stéphanie LAMARQUE (3 PMs) -	**€ 42.762,00**
2-3-7	Travel	• Travel costs are related to the participation in: • Review meeting in Brussels (26 feb. 2010); • FENS meeting in Amsterdam (3-7 july 2010); • Project meeting in Lausanne (22-23 nov. 2010); • Project meeting in Stokholm (10-11 feb. 2011); • Project meeting in Nantes (6-8 april 2011); • FET meeting in Budapest (may 2011)	**€ 10.251,00**
	Subcontracting		
	Equipment		
2-3-7	Consumables	Electronic and electrical components Stimulating and recording electrodes Neurobiological markers and chemical products Surgical tools Supplies for animal housing	**€ 26.007,00**
	Other costs		
		TOTAL DIRECT COSTS	**€ 79.020,00**

7. Financial statements – Form C and Summary financial report

The Financial Statement from each beneficiary will be submitted on the NEF system and the Summary Financial report which consolidates the claimed Community contribution of all the beneficiaries in an aggregate form will be automatically generated.

8. Certificates

List of Certificates that are due for this period, in accordance with Article II.4.4 of the Grant Agreement:

Beneficiary Number	Short name	Certificate on the financial statements provided? yes / no	Any useful comment, in particular if a certificate is not provided
1	SSSA	YES	YES
2	KI		
3	EPFL		
4	KTH	NO	Total costs less than 375.000€
5	INSERM	NO	NO

Beneficiary Number	Short name	Certificate on the methodology on both personnel and indirect costs	Certificate on the methodology on average personnel costs
1	SSSA	NO	None
2	KI		
3	EPFL		
4	KTH	NO	Not applicable
5	INSERM	None	None