Project no. 248992

Project acronym: NEUNEU

Project title: Artificial Wet Neuronal Networks from Compartmentalised Excitable Chemical Media

Small or medium-scale focused research project (STREP)

Deliverable 5.1 - Periodic Management report - identical to the Project Periodic Report

Period covered: from 1.2.2010 to 31.1.2011	Date of preparation: 18.9.2009
Start date of project: 1.2.2010	Duration: 36 months
Project coordinator name:	Dr. Peter Dittrich
Project coordinator organisation name:	Friedrich Schiller University Jena

Periodic Management report

The Deliverable D5.1: Periodic Managenent Report is identical to the Project Periodic Report, which was submitted in independent documents.

This report consists of a project summary on page 3, the progress report on page 7, an overview over the management actions and the ressources that were spent so far by the project on page 16 and finally a table of the deliverables that were due in the first project period on page 22.

Please note that we kept the numbering scheme of the report sections very close to the "Guidance Notes on Project Reporting". Unfortunately, the NEF expected a different ordering of the Sections, so that the management sections 3.2.3 and 3.4 now precede the Deliverables and Milestones Tables 3.3.

3.1 Publishable Summary

Context and Objectives

Information processing is ubiquitous in nature and functions very different from our present computing technology. Based on molecular components and phenomena it demonstrates that an alternate route to information processing exists. The NEUNEU project decided to explore this path with a minimal system that exhibits the properties (signal transmission, signal gain, self-repair) desirable for a molecular information processing architecture that harbors the potential to scale to applications. To explore the concept of performing computations with excitable media we use the Belousov-Zhabotinsky (BZ) medium. The BZ reaction is an oscillating reaction, existing far from the thermodynamic equilibrium. Though there are variations, the BZ-mixture can be prepared from potassium bromide, malonic acid, sodium bromate, sulfuric acid and ferroin as redox indicator.

When the system is oscillating, the indicator is continuously switching between its oxidized and reduced form, changing its color between blue and red or between red and white, as seen in Figure 1. Stirring the system leads the whole mixture to show about the same behavior in all parts of the test tube. On the contrary, leaving the mixture relatively undisturbed in a flat Petri dish, the BZ medium generates two dimensional wave patterns.

To control the signals that are transmitted through the chemical medium, continuous excitations are not desirable in this project instead, the BZ medium is mixed in proportions that does not allow a spontaneous start of an oscillation. Instead, the excitation needs to be triggered from the outside (e.g., by a silver wire) or by an already existing excitation wave. Hence we call the state of the medium "excitable" or "sub-excitatory". When the medium is excitable, a wave propagates equally in every direction. So the state of a droplet can be simplified by assuming a well-stirred reactor for each droplet.

Using the "sub-excitatory" condition alternatively, we can also include logic elements inside single large drops. In this case, waves do not spread in every direction, but preserve their shape and direction as illustrated in Figure 3A.

When we drop water containing BZ medium into oil, the phases do not merge and droplets form automatically. We are going to use microfluidics to produce droplets of smaller volumes, with higher precision, and in large quantities (Figure 1). Wrapping up the BZ reaction into these small droplets has the advantage of discretizing the otherwise continuously propagating excitations into precise units.

Lipid molecules contained in the oil phase self-assemble at the surface of the droplets and stabilize the droplets against merging. Living cells are also covered with lipids, but in this case lipids assemble between two aqueous compartments and therefore form the double layer typical for biomembranes. The amphiphilic lipid molecules assembling at the border between the oil and and the "water with BZ" phase, produce a lipid monolayer in our system.

When two of the droplets come into contact, the lipid monolayers coating each droplet can form a double layer similar to a biological membrane. As a consequence it is possible to insert membrane channel proteins at the interface between two droplets to facilitate the exchange of chemical compounds and consequently the propagation of the BZ medium excitation from

droplet to droplet.
By varying the coupling between droplets, the droplet radii, and BZ medium compositions, we will generate droplets with a wide variety of properties, such as excitability, oscillation phase length or refractory times. Controlling these properties should allow us to engineer droplet networks with computational capabilities as for example shown in Figure 2.

Work Performed and Main results

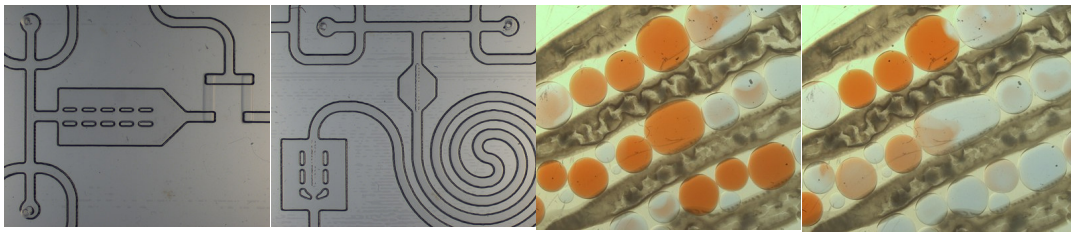

Figure 1: *Examples of microfluidic structures for generation and handling of droplets (left). Manually aligned droplets of BZ-reaction medium (right).*

The NeuNeu project approaches its objectives with a hierarchy studies encompassing laboratory experiments to produce functional droplets, biophysical modeling of the chemical dynamics in the droplets, theoretical studies of droplet interactions, and computer simulation studies of complex droplet architectures.

To produce droplets that can serve as elementary components in a computing architecture three problems need to be solved. First, a suitable chemical composition of the reaction medium in the droplets needs to be determined. Second, a suitable composition of the lipid layer enclosing the droplet needs to be found. And third, microfluidic droplet generator that can deliver fresh active droplets of a desired size is required. Work has been undertaken to tackle all three challenges. Initial experiments with large drops (3-10mm diameter) of BZ medium in oil showed that the BZ medium can function in lipid coated droplets. Observations of the temporal excitation patterns indicated that the excitation may travel directly from droplet to droplet without any pores and even without direct contact of the droplets. This result was encouraging, because the transmission of excitation from droplet to droplet is essential for a droplet-based architecture. However, it also leads to the problem of isolating droplets to prevent undesirable interactions. To determine the conditions under which transmission of of excitation can take place we made specialised reaction vessels by making a mold on a 3D-printer. We developed also a method of using a rapid prototyping printer to fabricate molds for the micro fluidic chips . After some initial problems with this technique had been resolved it turned out to be a fast and flexible method to produce high-aspect ratio channels. Through this approach it was possible to develop chips that integrate complex features in a short time.

On the theoretical side, three simulation models have been derived for different levels of abstraction: First, a family of kinetic ODE models describe the chemistry of single droplets and two connected droplets. These models are quantitative in the sense that they are fitted to experimental data.

Second, a CA based simulation model simulates wave propagation within a single droplet and a collection of (so far) statically arranged droplets (Figure 2). With this model, we have been exploring the computation possibilities of BZ vesicles by creating key computational components, such as logic gates and arithmetic circuits. BZ excitation waves are used to represent discrete quanta of discrete information. Validation of some of these simulations in-vitro has supported this approach to computing in BZ discs as 2D analogues of BZ vesicles.
The third simulation model abstracts the internal spatial dynamics of a droplet and uses a state-base model for a single droplet instead (Figure 3). Additionally, it can simulate 3-dimensional dynamical droplet structures (up to about 500 droplets) and self-assembly processes that can be specified by simple rules.

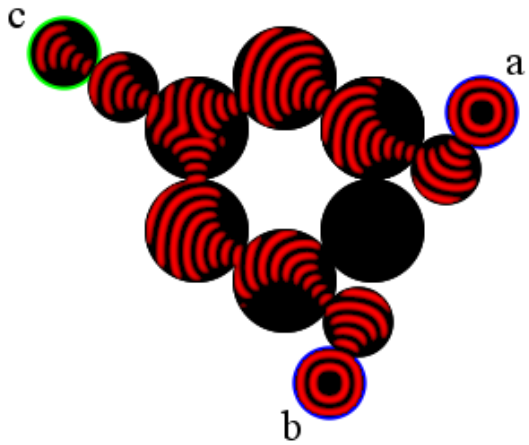

Figure 2: *Simulation of directed waves in sub-excitable medium within a network of droplets with two different inputs a,b and output c. For animation see: http://uncomp.uwe.ac.uk/holley/sim/sim.html).*

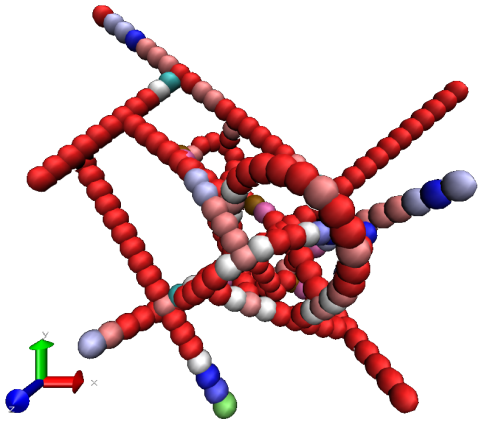

Figure 3: *Stochastic 3-D simulation of a droplet network counting the number of activated inputs. Source code available at:* http://www.biosys.uni-jena.de/Members/Gerd+Gruenert/SRSim.html

Potential Impact and Applications

Over the past three decades information technology found application in organisation, communication and increasingly in appliances. Wherever information processing could be applied, it typically revolutionised the field within two decades. The very narrow choice of available technologies for information processing, however, has so far prevented the application of information processing in many areas. The NeuNeu project expects to broaden the range of techniques and substrates available for computation. For the immediate future the concepts, methods and devices developed within the NeuNeu project will be most relevant as research tools.

The availability of chemical computing media will in the future allow for information technology that can be tightly interwoven with chemical and biochemical systems. Such wet computing architectures are complementary to conventional information technology and are expected to find applications which are not feasible with conventional technology. The control of chemical states within living cells through a information processing drug would be an example. The fine grained control of chemical reactions to enable biomolecule-like complexity in synthetic macromolecules and consequently a large range of new functional materials, would be another example.

Further Information

Up-to-date information about computing with mass-producible chemical information processing components is available at the NeuNeu web site:

http://www.neu-n.eu

For high resolution images visit: http://users.ecs.soton.ac.uk/kpz/tmp/neuneu/
Please do not hesitate to contact us for any enquiries:

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3.2 Core of the report for the period: Project objectives, work progress and achievements (without project management)

3.2.1 Project objectives for the period

Overview of project objectives for this reporting period (Year 1)

In the first project period, the technical foundations for working with the excitable chemical BZ medium need to be elaborated. That is, a full characterization of the chemical reaction properties (D2.1) and the peculiarities of the BZ reaction, when enclosed in lipid droplets (D1.1). This work includes the construction of first models describing a single droplet (D2.1) and interacting droplets (D2.2, in part D3.1); and clarify the process of passing an excitation on from one droplet to the next. For the more theoretical considerations, a simulation software for small to medium sized droplet networks should be developed (D3.1).
The milestone MS 1 should check whether a-hemolysin facilitated BZ droplet excitation can be achieved and a computational model for the chemical level is available.

Recommendation from the previous reviews

- not applicable --

3.2.2 Work progress and achievements during the period (Year 1)

Concise overview of the progress of the work (for each work package):

WP1: BZ oscillation and signal propagation

	WP1: BZ oscillation and signal propagation
Progress towards Objectives	At SOTON, we made significant progress in the evaluation and description of the Belousov Zhabotinsky medium in combination with elaborating suitable droplet production techniques. Since Deliverable D1.1 is not yet completed, due to delayed recruitment, the scientific progress for this work package is described in more detail in the attached document “Status of Deliverable D1.1”. We expect to orderly submit deliverable D1.1 in month 18. T1.1 At ICFPAN, we have performed a large number of experiments screening BZ mixtures in droplets covered by hydrocarbons. We considered

	different types of hydrocarbons: decane, octane, heptane and isooctane as well as different types of lipids. The preliminary screening was oriented on finding long lasting chemical oscillations in mechanically stable droplets. We have identified a few systems with the most promising properties for future experiments. T1.2 At the ICFPAN we performed more detailed studies on oscillations for droplets covered by mixtures of soy bean phosphoro-lipids immersed in decane. The period of oscillations within a single droplet was measured for different concentrations of BZ reagents . The results for more than 60 different systems were considered as the experimental basis for developing the numerical models. T1.3 At ICFPAN we studied excitability in BZ droplets using external triggers. An excitation with a silver wire typically used in BZ reaction does not work with the considered system probably due to the fact that metal covers with hydrocarbons and does not interact directly with BZ solution. We are currently working on alternative methods of excitation and control for a droplet system. T2.1 At the ICFPAN we performed experiments on a few interconnected droplets. We demonstrated that droplets can interact through migration of reagents from one droplet to another.
Highlight Significant Results	The experiments have shown that a BZ reaction proceeding withing droplets does not destroy the lipid layers. The droplets retain their mechanical stability for more than one hour. Having in mind that a typical period of oscillation is around one minute, single droplets appear stable long enough to observe information processing phenomena. The experiments on single droplets were a step towards building numerical models. Details can be found in Deliverable 2.1 [new version.] The experiments on multiple droplets have demonstrated that interaction between droplets through migration of reagents via lipid layers is possible, even without interconnecting droplets with alpha-hemolysin molecules. This observation seems important because it significantly simplifies the construction of chemical computers based on interacting droplets. However, it also leads to the problem of isolating droplets to prevent undesirable interactions. A simple model of interaction between droplets has been used to demonstrate unidirectional propagation of excitations between droplets of different diameters. (See Deliverable D2.2) The present study is focused on identification of BZ reagents that can migrate through lipid layers and hydrocarbons and provide communication

	between droplets. This information is crucial for constructing a numerical model of droplet to droplet interaction.
Reasons for Deviations from Plan, Ressources and Planning	Recruitment of suitable post-docs took longer than expected. While we were expecting to find the problem of controlling droplet interactions to be in facilitating an exchange between droplets at all, experiments from the Gorecki Lab showed at the start of the project that it might rather be problematic to prevent unwanted interactions. Hence we will not try inserting a-hemolysin membrane channels for now but we will try different lipid and oil combinations. While it was planned to force droplets to form bilayer-membranes using electric fields a new publication showed that this can also be done with purely microfluidic techniques [1]. As a result, we started setting up the fabrication processes for microfluidic chips and started experimenting with appropriate materials that can be used here. While experimenting, we realised that the chemistry of the BZ droplets cannot be developed independently from the microfluidics for the following reasons: ● The chemistry strongly affects the physical properties of the droplets (stability) and the possibility of merging (intentionally for mixing or unintentionally when lined up). ● The materials used in microfluidics suffer under the conditions we would like to use them (exposed to oil and acid), some swell for example. ● The materials used in microfluidics may absorb components needed for the reaction or leach compounds into the reaction medium that affect the BZ droplets. (BZ medium behaves differently in a microfluidic chip than on a glass Petri dish.)
Anything critical? Impact on other Objectives	
Use of Ressources / Deviations	We have spent 23.5 PM (SOTON: 11.2, ICFPAN: 10, UWE: 2.3)
Corrective Actions	Our overall goal to develop the chemistry for a single droplet is still what we are working on under D1.1, however the requirements now include: ● the chemistry of the surface layer enclosing the droplet (lipid/surfactants):

	● droplet stability ● droplet-to-droplet isolation ● droplet-to-droplet communication ● compatibility with the microfluidics ● minimise or avoid gas production ● find a combination of BZ-medium and materials for microfluidics which are compatible ● We contemplate to investigate reactions under milder conditions to allow for some flexibility with the materials for the droplets and the fluidics.

WP2: Modelling and computation at chemical level

- Build a kinetic model describing the chemistry of single droplet and two connected droplets.

	WP 2: Modelling and computation at chemical level

Progress towards Objectives	T4.1: At ICFPAN we considered Rovinsky-Zhabotynski model of Bielousov-Zhabotynski reaction and fitted its parameters such that it correctly describes the period of oscillations as a function of acidity of reagent solution. Such simple model was used to predict the diode action at contact of two droplets with different sizes (Deliverable 2.2). T4.1 and T4.3 and T4.4: We considered a three equations model of the Bielousov-Zhabotynski reaction obtained from the Field-Koros-Noyes reaction scheme and fitted its parameters on the basis of a large number of experimental results for oscillation period within droplets obtained within WP1 T1.2. For the fitted values of parameters the model correctly describes oscillations in a wide range of compositions of reagents. Moreover it uses the real concentrations of reagents as input parameters and returns period in the real time (seconds). In this respect the new model is superior to the Rovinsky-Zhabotynski model mentioned above which uses scaled, composition dependent, units of concentration and time. Next the model was reduced to two variable model. We discussed the validity of such approximation and verified the usefulness of it. (Deliverable 2.1). T4.2: We introduced a simple model of interaction between droplets assuming that the activator of the BZ reaction can migrate into the lipid layer but not into hydrocarbons. Within such assumptions, the interaction between droplets depends on the deformed boundary between them. We tested pulse propagation between droplets as a function of boundary size and found the conditions at which diode type behavior occurs. (Deliverable D2.2) At UWE, we developed a simulation framework and mathematical model of virtual prototyping of BZ-vesicle-based circuits See http://uncomp.uwe.ac.uk/holley/sim/sim.html for several examples and videos. We started to explore of the basic methods of modulating wave behavior in networks of discs. At UWE we performed experimental validation of simulated gates and circuits in lab chemistry using a light sensitive BZ gel. This work includes in-vitro experimentation to validate logical circuits on a photosensitive BZ silica gel, including, not, and, xor and our single reactor 1 bit ha circuit.

Highlight Significant Results	Two and three reaction model of the BZ reaction that uses real concentration and time units (D2.1). Paper pre-print describing a model for the interaction of two BZ vesicles and its application for the estimation of the parameter range for unidirectional signal propagation (D2.2). Simulation software from ICFPAN for detailed kinetics of droplet-enclosed BZ-media (D2.1 and D2.2). Simulation software for wave propagation within droplet networks developed at UWE http://uncomp.uwe.ac.uk/holley/sim/sim.html
Reasons for Deviations from Plan, Ressources and Planning	
Anything critical? Impact on other Objectives	
Use of Ressources / Deviations	We have spent 19.9 PM (ICFPAN: 9 (but not payed by NEUNEU), UWE: 10.9 PM)
Corrective Actions	

WP3: Modelling and computation at architectural leve

	WP 3: Modelling and computation at architectural level

Progress towards Objectives	At FSUJ, we developed an abstract computational model of stochastic, excitable droplets that can be connected and used to represent a computing droplet network (cf. Deliverable 3.1). The excitations are modeled as a discrete set of states for each droplet, representing a full oscillation cycle of the Belousov Zhabotinsky medium. Single transitions between excitation states are exponentially distributed, leading to a Poisson distributed number of passed droplets per unit time. To work with this model, we extended our spatial and rule-based simulator *SRSim* to simulate the propagation of excitations along droplet circuits. The dynamics of small to medium sized droplet circuits (up to about 500 droplets) can be explored with this software. Droplets are represented in continuous 3d space and can dynamically assemble into networks during the simulation. Alternatively, droplet circuit diagrams can easily be introduced into the simulation in the form of ASCII graphs to rapidly test and evaluate droplet network designs for their computational properties. Using the droplet model and simulator, we have identified first properties and possible pitfalls of excitable droplet based signal transmission. Details about the model and the simulation software can be found in Deliverable D3.1.
Highlight Significant Results	Simulation Software developed, which is available at http://www.biosys.uni-jena.de/Members/Gerd+Gruenert/SRSim.html It can simulate self-assembling or predefined droplet networks. Input/output patterns to the network can be tested and evaluated against an optimal output. Paper draft describing the abstract model and the simulation software with exemplary network designs (Deliverable D3.1)
Reasons for Deviations from Plan, Ressources and Planning	-
Anything critical? Impact on other Objectives	-

Use of Ressources / Deviations	We have spent 6.7 PMs (FSUJ:6, UWE:0.7) JENA has not employed a Postdoc yet, but is currently in negotiations. As planned, the postdoc will begin in the second project period exploring the architectural level, when basal information about BZ droplet characteristics is gathered in the first period from WP1 and WP2.
Corrective Actions	-

WP4: Topical circuits and self-organization as a method of network generation

	WP4 : Topical circuits and self-organization as a method of network generation
Progress towards Objectives	Although there are no deliverables due in the first period for WP4, we are already working to lay the foundations for an automatic network generating systems. This includes generating models and simulation software for the WPs 1, 2 and 3.
Highlight Significant Results	- not applicable yet --
Reasons for Deviations from Plan, Ressources and Planning	-
Anything critical? Impact on other Objectives	-
Use of Ressources / Deviations	We have spent 0.4 PM (UWE)
Corrective Actions	-

WP5 and WP6 (Dissemination, Collaboration, and Exploitation) are management tasks, which are reported in Document “Management and Resources” (Section 3.2.3).

[1] Stanley, C.E. et al, 2010. A microfluidic approach for high-thoughput droplet interface bilayer (DIB) formation. Chemical Communications, 46(10), pp. 1565-1776.

3.2.3 Project Management and 3.4 Explanation of the use of the Resources

3.2.3 Project Management during the period

In the following, we summarize management of the consortium activities during the period.

Consortium management tasks and achievements;

- Consortium Agreement negotiated and signed by all beneficiaries.
- Financial coordination as planed
- Internal communication infrastructure installed:
    - Wiki for internal communication, especially reporting
    - internal file repository SVN
    - public Website neu-n.eu (See Deliverable D6.1) with CM that allows each beneficiary to edit the website's contents
    - one login/passwd for all web services
- Coordination of reporting
- Communication with EC, forward collated reports

Publications in the popular science media:

- BBC News, "Chemical computer that mimics neurons to be created" by J. Palmer, 11 January 2010, http://news.bbc.co.uk/2/hi/8452196.stm
- Computing Now, March, 2010,, "Researchers Take Promising Approach to Chemical Computing" by G. Lawton, http://www.computer.org/portal/web/computingnow/archive/news055
- Article in "Naturwissenschaftliche Rundschau" Nr 7, 2010 - a german-language popular science magazine
- Heise News Ticker "Reseach on Chemical Computer", Forscher arbeiten am chemischen Computer" (in German) http://www.heise.de/newsticker/meldung/Forscher-arbeiten-am-chemischen-Computer-902434.html
- ERCIM News http://ercim-news.ercim.eu/ article submitted, reporting on NEUNEU activities, submitted for special theme "Unconventional Computing Paradigms"
- Poster at the Gordon Conference Oscillations and Dynamic Instabilities in Chemical Systems. Barga, Italy, July 04-09, 2010 "BELOUSOV - ZHABOTINSKY REACTION IN LIPID COVERED DROPLETS" - Jan Szymański, Yasuhiro Igarashi, Jerzy Górecki, Joanna Natalia Górecka, Klaus-Peter Zauner, Maurits de Planque
- Seminar at the Non-Standard Computation Group in York, England. November 28th, 2010 "Information processing with chemical reactions" - Jerzy Górecki

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

- Late employment of SOTON researchers led to a delay in producing Deliverable D1.1, see Section 3.2 “Objectives and Work Progress for Details”.
- Late employment of JENA researcher has not led to a delay in producing Deliverables in the first project year, but might lead to a delay in the second project year.
  Envisage solution: We will spend more PMs in the second and third year than originally planned in order to catch up.

List of project meetings, dates and venues;

- 28th of April 2010: Kickoff Meeting in Jena
- 28th - 30th of September 2010: Project Meeting in Southampton
- 25th of November 2010: local scientific exchange between UWE and SOTON in Southampton
- 26th of January 2011: local scientific exchange between UWE and SOTON in Bristol
- 12th - 18th March 2011: local scientific exchange between ICFPAN and JENA in Warsaw

Project planning and status;

- Status: With respect to the PMs spent, the project progresses as planed.
- Due to a delay in employment, D1.1 is delayed and rescheduled for the second year. Nevertheless we made good progress in D1.1 as document in the attached report for D1.1.

Impact of possible deviations from the planned milestones and deliverables, if any;

- The Description of Milestone MS1 was slightly altered to incorporate the new findings of period 1. This seems not to influence the plan of the future actions for the project.

Other Co-ordination activities

- We are participating in the coordination support action COBRA www.cobra-project.eu
- Within the context of COBRA, a workshop is planed at ECAL2011 www.ecal11.org
- Invited satellite workshop on “On-silico ChemIT meets Wet ChemIT” planed for CMC12, Paris, cmc12.lacl.fr

No changes to the legal status of the beneficiaries occurred.

Development of the Project website, if applicable;
We regularly updated the public website, adding current events, project media, software and news about the project. (See Deliverable 6.1)

3.4 Explanation of the use of the resources

Table 3.1 Personnel, subcontracting and other major cost items for Beneficiary 1: JENA

Work Package	Item Description	Amount in € with 2 decimals	Explanations
3,5,6	Personnel direct costs	37,636.01€	9 person months for 2 PhD students, half positions
1 - 6	Computer Hardware	2,064.00 €	4 Workstations, 1 Laptop, 2 Displays
5	Organization, kick off meeting	705.00 €	
1 - 6	Travel	3,596.00 €	Meetings (Warsaw, Southampton) Workshops (San Sebastian) & Summer School (Barcelona)
	Remaining direct costs		
	Indirect costs	26,400.00 €	
TOTAL		70,401.00 €	

Table 3.2 Personnel, subcontracting and other major cost items for Beneficiary 2: SOTON

Work Package	Item Description	Amount in € with 2 decimals	Explanations
1,2,4,6	Personnel costs	49925.16 €	1 Postdoc (Fabrication) 7 months, 1 Postdoc (Chemistry) 1.53 months, 4 senior staff (3.67months)
1	Stereozoom Microscope Zeiss Discovery V8	11012.18 €	Imaging of droplet generation, droplet interfacing, and droplet excitation
1	Prosilica GX3300C Camera	5835.78 €	Imaging of droplet generation, droplet interfacing, and droplet excitation

1	2 x Harvard Pump 11 Plus Advanced	4075.84 €	Supply oil phase and aqueous phase to microfluidic chips
1	Consumables	2804.06 €	Chemical supplies, components for fluidics (e.g. valves), rapid prototype resin, mask printing
	Travel	546.98 €	Travel to NEUNEU Meetings in Jena, New Forest, and Bristol
	Indirect costs	44361.89 €	
TOTAL		118561.88 €	At 0.8536 £ = 1 € (Rate of Feb 1st 2011)

Table 3.3 Personnel, subcontracting and other major cost items for Beneficiary 3: ICFPAN

Work Package	Item Description	Amount in € with 2 decimals	Explanations
1 - 6	Computer Hardware	11,418.57 €	Nvidia TESLA S2050 numeric accelerator and controlling workstation
1	Personnel direct costs	5,406.25 €	10 person months for 2 PhD students

1 - 6	Conferences & Travel	5,607.94 €	The Gordon Conference Oscillations and Dynamic Instabilities in Chemical Systems. Barga, Italy, July 04-09, 2010 , two participants (Jerzy Gorecki and Jan Szymanski), participation in NEUNEU Meetings (Jena - Jerzy Gorecki and Jan Szymanski, Southampton - Jerzy Gorecki, Yasuhiro Igarashi and Jan Szymanski), UC 2010 Tokyo, Jerzy Gorecki (part of participation costs)
1 - 6	Consumables	1,385.28 €	Chemicals, laboratory glass and small parts, computer disks, toners
1	Remaining direct costs	26.37 €	poster printing
	Indirect costs	14,312.65 €	
TOTAL		38,167.06 €	The actual costs are in polish Zlotys, the rate of Feb, 1st 2011 was used: 1 EUR = 3.9138 PLN

Table 3.4 Personnel, subcontracting and other major cost items for Beneficiary 4: UWE

Work Package	Item Description	Amount in € with 2 decimals	Explanations
1,2,3,4	Personnel direct costs	82,609.95	17.8 person months for 1 full-time RA and 3 researchers part-time on project
	Computer Hardware	1,329.64	PC for simulation

	Travel	1,182.95	Meetings and Workshops: Jena Kickoff Meeting, Project Meeting Southampton, Collaboration Meeting Southampton
	Indirect costs	51,072.93	
	TOTAL:	136,194.47	

3.3 Deliverables and Milestones Tables

Table 1: Deliverables

Del. no.	Deliverable Name	Version	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery Date (proj month)	Actual/ Forecast delivery date	Status	Contractual	Comments
D6.1	Public Website	1	6	1	R	PU	2	2	submitted	yes	www.neu-n.eu
D2.1	Developed Model and Preliminary Simulation Program	2	2	3	R	PP	8	12 (*)	submitted	yes	tech report + program (same as D2.2)
D1.1	Report about full characterization of BZ reaction in lipid-enclosed droplets	1	1	2	R	PU	10	18	not submitted		delayed due to late employment, for progress see attached documen t “Status of Deliverable D1.1”
D2.2	Report on the model of interacting droplets and a simulation program (software)	1	2	3	R	PU	12	12 (*)	submitted	yes	accepted paper on diodes + program (same as D2.1)
D3.1	Report on computational model for architectures composed of a moderate number of	1	3	1	R	PU	12	12 (*)	submitted	yes	tech report + program/ software

	units										
D5.1	Periodic management report	1	5	1	R	PU	12	12 (*)	submitted	yes	equivalent to the Project Periodic Report (PPR)

(*) actually submitted together with the Project Periodic Report in M14.

Table 2: Milestones

Miles tone no.	**Milestone name**	**Work package no**	**Lead beneficiary**	**Delivery date**	**Achieved**	**Actual / Forecast achieveme nt date**	**Comments**
MS1	a-hemolysin facilitated BZ droplet excitation achieved and computational model for the chemical level	WP1	2	12	12	-	We have obtained BZ droplet excitation, but without a-hemolysin. That is, a-hemolysin seems not to be necessary to transmit an activation from one droplet to the next. See our revised strategy, attached document: “Status of Deliverables D1.1” for details. A computational model for the chemical level is available, see Deliverables D2.1 and D2.2.