INTUITIVE

INnovative Network for Training in ToUch InteracTIVE Interfaces

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Report on the progress for the first three years

Deliverable text:

Third Year Progress Report – INTUITIVE-ITN

General progress of the action

The Covid-19 pandemic had a major impact on the INTUITIVE project during the first year, and it continued to affect the project during the next two years as well. At first the restrictions that were set around Europe during the start-up of the project delayed the recruitment of the Early-Stage Researchers (ESRs). When all the ESRs had been recruited, the project continued to suffer from travel restrictions, delayed deliveries and limited availability of administration. In the aftermath of the Covid-19 pandemic, the consequences can be summarized with delayed deliverables and postponed secondments. This will however be solved with a no cost extension of the project and a new secondment plan that will take the delays in the recruitment and deliverables, into account.

The focus for the ESRs during the first year were to plan their technical work of the individual research packages (IRP). Due to the delay in recruitment, the planning continued during the second year of the project, before the ESRs could start working on their deliverables in the second half of 2021. The INTUITIVE project has been able to submit 12 scientific deliverables until M36. 6 scientific deliverables should have been submitted but have been postponed to a later point in the project.

The project is built on the interactions between the ESRs and the different IRPs. The contact between the different supervisors and ESRs is important and will be kept through the whole project. Another significant component is the unique training opportunities provided through network and the ESRs participation in every step. Several ESRs have been able to go on secondments and participate in conferences. The project has also arranged two Research Schools. The first was forced to be online due to the pandemic, but the second Research School took place in Genova, Italy in September 2022.

A number of deliverables were set up to be completed during the first 36 months of the project. The following table is an account of them as well as their status.

Del. Nr.	WP	Title	Status
D1.1	1	Project Website; Welcome kit	Approved
D1.2	1	Advertising Vacancies	Approved
D1.3	1	Consortium Agreement	Approved
D1.4	1	Supervisory Board	Approved
D1.5	1	First round of Selection/Appointment	Approved
D1.6	1	Data Management Plan	Approved
D1.7	1	First year progress report	Approved

D2.1	2	First representation of haptic input features across a population of cortical neurons	Submitted M30
D2.3	2	First prototype of tactile transducer for use in rodents developed	Approved
D2.4	2	Report on molecular scale mechanism of mechanoreceptors in skin	Submitted M31
D2.6	2	Multi-scale model of synthetic materials mimicking tactile sensing in skin	Submitted M37
D3.1	3	Learning classifier system for high-dimensional sensorimotor data	Submitted M36
D4.1	4	E-skin with microactuator for tactile feedback in robotics and prosthetics	Submitted M31
D4.4	4	Sensors with memory	Submitted M31
D4.6	4	Low-power sensory readout and electronic interface	Approved
D4.8	4	Integration on flexible substrates – survey and limitation of existing methods	Submitted M32
D5.1	5	Taxonomy of image processing algorithms in the context of categorizing tactile graphics	Submitted M32
D5.5	5	Classification of 2D refreshable tactile user interfaces	Approved
D5.6	5	Design principles and basic version of the intuitive tactile user interface	Submitted M32
D6.2	6	First year research schools, workshops, & tutorials	Approved
D6.3	6	Second year research schools, workshops, & tutorials	Submitted M37
D7.1	7	H - Requirement No. 1	Submitted M27, Reopened M36
D7.2	7	POPD - Requirement No. 2	Submitted M27, Reopened M36
D7.3	7	A – Requirement No. 3	Submitted M27, Reopened M36
D7.4	7	EPQ – Requirement No. 4	Submitted M27, Reopened M36
D7.5	7	GEN – Requirement No. 5	Approved

Table 1: Completed deliverables and their status

The deliverables in table 2 should have been submitted before M36 but have been postponed. The justifications for the delay are included in the table.

Del. Nr.	WP	Title	New sub. date	Justification
D2.5	2	In-silico model of tactile sensing in skin	M42	Since the hiring process for ESR4 suffered from huge delays due to the Covid-19 pandemic, the experiments are running late. The ESR would like to postpone the deliverable with 12 months in order to have the original time given to finish the report as well as be able to submit a more interesting and valuable report.

D3.2	3	Next generation sensory augmentation device	M38	Postponing the deadline would provide enough time to include the work towards a next generation sensory augmentation device carried out at Actronika and thereby to extend the report beyond the research carried out at UOS and related projects. Moreover, this would provide the opportunity to make a comparison between the novel solutions developed at UOS and Actronika (potentially also the Tactonom) with other (mostly commercial) products/solutions on the market by analyzing their practicality and effectiveness. During the research school the aim is to discuss some final technical product features with the researchers from Actronika as the ESR currently do not have access to their products. A detailed understanding of the technology is crucial for the report.
D4.2	4	Graphene based touch sensor and benchmarking	M42	Since the hiring process for ESR9 suffered from huge delays due to the Covid-19 pandemic, the experiments a running late. The ESR would like to postpone the deliverable with 12 months in order to have the original time given to finish the report as well as be able to submit a more interesting and valuable report.
D4.3	4	Graphene based touch sensor integrated with memristive device	M38	The Cluster tools which should be used for the nanofabrication in the James watt nanofabrication are down and under maintenance. The stability of the fabricated devices is very poor with instable behavior and needs some optimizations with the thickness of the active layer for memristors. The ESR was working on the couple of batches of the devices using multiple active layers of the memristor device and developing a new system for the sensor measurements which took some additional time.
D4.5	4	softMEMS based stress and slip sensor	M45	The work has been significantly delayed in the first year due to the sanitary situation in Italy, along with the ESR's training in Glasgow (the secondment was spent in quarantine due to Covid-19). Therefore, the agreement was that an ESR from Glasgow would come to visit at FBK. That help was also delayed because of administrative arrangements reasons. Finally, the contract was supposed to start 6 months earlier than in the original project schedule.
D4.7	4	Ultra-thin chips based sensory interface	M43	Due to an unforeseen delay in the taping out and fabrication of the chip, which was out of the ESR's hand, the readout chips only arrived in mid-October. Therefore, thinning of the chip is also

				delayed. We are now preparing for functional testing of the chip, followed by sensor deposition, then thinning of the chip lastly. Note that it is necessary to do the prior steps before doing the chip thinning. We foresee the functional testing and the deposition to take around 4 months. Chip thinning could take 2 months.

Table 2: Postponed deliverables and their justification

Recruitment strategy

The recruitment process for the INTUITIVE project, that was disrupted by the Covid-19 pandemic, has been explained in Deliverable D1.5. But since it wasn't completed at the end of M12, table 3 list all the ESRs and their employment month as well as the delay in their recruitment.

ESR Nr	Name	Host Institution	Employment Start	Employment Delayed
1	Kaan Kesgin	ULUND	M13	10 months
2	Sofie Skårup Kristensen	ULUND	M6	3 months
3	Yerkebulan Massalim	ACA	M12	8 months
4	Shashank Mishra	UoG	M18	15 months
5	Aruna Ramasamy	ACA	M16	9 months
6	Vincent Schmidt	UOS	M9	2 months
7	Alexis Devillard	ICL	M17	10 months
8	Mahdieh Shojaei Baghini	UoG	M19	16 months
9	Bhavani Yalagala	UoG	M18	15 months
10	Inci Rüya Temel	FBK	M12	9 months
11	Mark Daniel Alea	KUL	M10	4 months
12	Rudra Mukherjee	UoG	M14	4 months
13	Omar Moured	KIT	M25	15 months
14	Anirvan Dutta	BMW	M19	9 months
15	Gaspar Ramoa	IVO	M14	4 months

Table 3: The recruited ESRs

Management of the action

Management primarily relies on a joint effort of the project coordinator (CO) and the Network Steering Committee (NSC). The NSC consists of PIs from all participants and was selected at the Kick-Off meeting. The members of the NSC have been in continuous contact via electronic communication to ensure a quick decision-making during the progress of the INTUITIVE project.

Project meeting: M2
The first INTUITIVE project meeting was held in October 2019, prior to the Kick-Off meeting. At this on-line meeting the requirements and regulations for the hiring process were discussed as well as eligible costs under H2020 ITN:s

PPM1/Kick-Off meeting: M2
The Kick-Off meeting took place during two days at Lund in November 2019. The Pis of all the beneficiaries as well as a few partner organizations were present and got to introduce themselves and their research. They gave presentations relevant for the planned secondments and for further exchanges that could take place. The first detailed plans for secondments were made as well as how the collaboration between all of the ESRs should be organized.

PPM2: M6
In March 2020 there was another on-line meeting including the Pis of all partners. A main topic was the planning of the first Research School. Also, our Ethics Advisor, prof. em. Ulf Görman, was introduced.

NSC meeting: M13
During an on-line meeting in October 2020, the Covid-19 situation was discussed and that the hiring of ESRs had suffered from huge delays. It was also decided that the first Research School should be in a digital form.

NSC meeting: M21
Prior to the Mid-Term Review there was a NSC-meeting in June 2021. The topics that were discussed during this meeting were the upcoming deliverables, the secondment plan and the arrangement of a journal club to give the ESRs a better insight to each other's different topics.

PPM3/Mid-Term Review: M21
The MTR took place in June 2021, delayed by 11 months.

PPM4: M30
PPM4 was held in March 2022. All the ESRs gave an update regarding their project and upcoming secondments. A few ESRs had already been out on their secondments and shared their experiences. During the included NSC meeting there was a discussion regarding the second Research School and the secondments.

Amendment

The termination of Shadow Robotics as a beneficiary and the amendment procedure in which BMW became a new beneficiary was completed September 2020. The consequence of this process was that the CA had to be updated based on BMW's comment and all beneficiaries had to again analyse its content and initiate a new approval procedure. Fortunately, the amendment didn't have any consequences to the implementation of the Workplan. BMW was able to take over the role of Shadow Robotics without any changes.

Communication Activities

The INTUITIVE webpage has been set up with a public-accessible area, which describes the project and the Individual Research Projects, introduce the partners and indicate interesting, related articles and workshops. The website includes one restricted area for Pis and ESRs.

The INTUITIVE project is also present on social media with a Linked-In account, a Twitter account and a YouTube channel. These channels are administrated by the ESRs.

Communication measures for strengthening the scientific careers of ESRs included an annual report on their work that was be presented at the INTUITIVE Research Schools. These schools will include a public engagement event where ESR will present their work to a public audience.

Research School 1, M20
Research School 1 were a digital meeting in May 2021, and it was a way for the ESRs to get to know each other even though it were online. Many points in the agenda were designed to foster active participation, contributions, and interaction from the ESRs. One important thing for this Research School was that the ESRs should learn how the different Beneficiaries and their different projects interact with each other and how they will cooperate during their time in the INTUITIVE project. The ESR contribution included:

- Poster Session: The ESRs prepared a poster about a project, ongoing or old, that in some ways were connected to the work they will do in the INTUITIVE project. These posters were presented and discussed in small groups.
- Journal Club: Four ESRs volunteered to present an article that they considered important to the INTUITIVE project.
- Speed Dating about secondments: The ESRs were divided into small groups where they discussed their upcoming secondments and how they will contribute to each other's projects.
- Individual Presentations: The ESRs presented themselves, their background, and their individual project within INTUITIVE.
- Student Presentations: Two ESRs were selected to give a full-length presentation instead of the shorter poster presentation.

Research School 2, M36
The second Research School took place in Genova in September 2022 and was arranged together with another ITN-project, NeuTouch. There were points in the agenda that were designed to foster active participation, contributions, and interaction from the ESRs.
Poster session: The ESRs were encouraged to present an interesting experiment and/or result in a poster. This was a chance for the ESRs to showcase their work to their peers and the invited lecturers, since the poster would be displayed throughout the Research School.
Panel discussion: An ESR from INTUITIVE was, together with an ESR from NeuTouch, in charge of organising and chairing the panel session (one per day).

Presentations at leading national/international conferences will provide an excellent forum for promoting the project and communicating the progress of INTUITIVE to the international research community. The ESRs will be encouraged to submit abstracts to external conferences. The ESR contribution to different conferences is presented in table 4.

ESR Nr	Name	Conference	Title of Paper
4	Shashank Mishra	IEEE FLEPS 2022	*Sensitivity Analysis of ZnO NWs Based Soft Capacitive Pressure Sensors using Finite Element Modeling*
5	Aruna Ramasamy	Eurohaptics Conference 2022	*Human Self-Touch vs Other-Touch Resolved by Machine Learning*
6	Vincent Schmidt		
8	Mahdieh Shojaei Baghini	IEEE FLEPS 2022	*Sensitivity Analysis of ZnO NWs Based Soft Capacitive Pressure Sensors using Finite Element Modeling*
9	Bhavani Yalagala	IEEE FLEPS 2021	*Flexible and ultra-fast bioresorbable nanofibers of silk fibroin-PVA composite*
10	Inci Rüya Temel	Micro and Nanoengineering 2021	presentation
12	Rudra Mukherjee	IEEE FLEPS 2021	*Life Cycle Assessment of Energy Generating Flexible Electronic Skin*
15	Gaspar Ramoa	ICCHP-AAATE 2022	*Classification of 2d refreshable tactile user interfaces*

Table 4: ESR contribution to conferences

Besides the above-mentioned conference papers, the ESRs have authors or co-authors to a number of journal papers during the first three years of the INTUITIVE project.

Safa, A., Van Assche, J., **Alea, M.D.**, Catthoor, F., Gielen, G.
Neuromorphic Near-Sensor Computing: From Event-Based Sensing to Edge Learning
IEEE Micro, 2022

Mukherjee, R., Ganguly, P., Dahiya, R.
Bioinspired Distributed Energy in Robotics and Enabling Technologies
Advanced Intelligent Systems, 2021

Baghini, M.S., Vilouras, A., Douthwaite, M., Georgiou, P., Dahiya, R.
Ultra-thin ISFET based Sensing Systems
Electrochemical Science Advances, 2021.

Murali, P.K., **Dutta, A**., Gentner, M., Burdet, E., Dahiya, R., Kaboli, M.
Active Visuo-Tactile Interactive Robotic Perception for Accurate Object Pose Estimation in Dense Clutter
IEEE Robotics and Automation Letters, 2022

Impact of the Action

The scientific outcome of the project will be a soft biomimetic tactile skin integrating sensors, memory and electronics embedded in soft materials, and capable of encoding the haptics data as in the human central nervous system. The network will push forward the research frontiers in:

1. Neuroscience through valuable knowledge on tactile information processing by population of tactile afferents and skin biomechanics
2. Flexible electronics through novel tactile skin with sensors embedded in soft materials and their 3D integration on flexible substrates
3. Robotics and rehabilitation through novel computational models and critical need met by the biomimetic tactile skin and through ground-breaking applications.

During the first 36M, the project manages to submit 12 scientific deliverables.

WP2 – Tactile perception in biological systems

The ESRs will learn the underlying principles of translation from shear forces in the skin to activation of populations of tactile sensors and will record from neocortical neurons to understand how the brain processes such activation. The influence of internal neocortical state on that processing will be explored to clarify perceptual principles. The design of a haptic display to achieve stimulation along selected tactile primitives is organized as follows: (a) engineering requirements from biological data for multi-resolution multi-species tactile stimulation; (b) multi-physics (em/mech/ therm) simulation for design and miniaturisation of high-density device.

The deliverables related to various studies on tactile perception in biological systems and haptic inputs features, which all together present critical inputs for research on Biomimetic tactile skin.

D2.1: First representation of haptic input features across a population of cortical neurons
Lead Institution: ULUND
ESR number 1 – Kaan Kesgin
Learning the multiple, parallel in vivo whole cell patch clamp recording technique in the neocortex of the rat. Exploring the representation of haptic input features in neocortical neurons. Tuning properties of neocortical neurons with respect to the haptic input features representation of haptic input features across a population of cortical neurons.

D2.3: First prototype of tactile transducer for use in rodents developed
Lead Institution: ACA
ESR number 3 – Yerkebulan Massalim
Analyze closed-form electro/thermal scaling laws for miniaturization. Realize computer aided design based on the analysis and perform multi-physics simulation. Implement physical miniaturized system

D2.4: Report on molecular scale mechanism of mechanoreceptors in skin
Lead Institution: UoG
ESR number 4 – Shashank Mishra

Develop molecular scale model of mechanoreceptors of the skin. Incorporate biomimetic mechanoreceptor models in synthetic material to be used for artificial skin.

D2.6: Multi-scale model of synthetic materials mimicking tactile sensing in skin
Lead Institution: UoG
ESR number 4 – Shashank Mishra
Validate in-silico model with experimental data. Use the in-silico model for design and development of realistic tactile sensing skin

WP3 – Neural mechanisms of haptic and perceptual functions
The ESRs will learn haptics and perceptual processing by studying tactile interaction invariants and the role of multisensory cues. They will apply the knowledge in the development of sensory augmentation devices. The principles will be transferred to algorithms for implementation and proof-of-principle in robotic systems.

D3.1: Learning classifier system for high-dimensional sensorimotor data
Lead Institution: ACA
ESR number 5 – Aruna Ramasamy
Characterization of neuromimetic sensorimotor processing. Identification of tactile interaction invariants. Implement learning classifier system for high-dimensional data

WP4 – Biomimetic tactile skin
The objectives are to develop biomimetic tactile skin based on the knowledge gained from biological systems in terms of morphology and functionality. The sensors, electronics and memory element will be embedded in soft polymers to develop next generation of soft skin and demonstrate its capabilities for haptic exploration.
The deliverables are related development of technology, sensors/electronic components and their integration on flexible substrates to obtain biomimetic tactile skin.

D4.1: E-skin with micro actuator for tactile feedback in robotics and prosthetics
Lead Institution: UoG
ESR number 8 – Mahdieh Shojaei Baghini
Design and layout of micro actuator array. Fabrication of 2x2 array of micro actuators on flexible substrates (e.g., polyimide) and validation.

D4.4: Sensors with memory
Lead Institution: UoG
ESR number 9 – Bhavani Yalagala
Demonstrator of the properties of the sensors based on memristive device

D4.6: Low-power sensory readout and electronic interface
Lead Institution: KUL
ESR number 11 – Mark Daniel Alea

Architectural study of time-based sensor readout in CMOS. Circuit design and layout of a low-power time-based sensor interface in CMOS.

D4.8: Integration on flexible substrates – survey and limitation of existing methods
Lead Institution: UoG
ESR number 12 – Rudra Mukherjee
Literature survey analyzing the suitability of some of planar electronics integration methods for soft electronics. Stretchable interconnections and stiff sensor/electronics integration configuration.

WP5 – Robotics and assistive haptic technology
The objectives for this work package are testing of biomimetic strategies for haptic sensing; Development of efficient robot control for haptic exploration; Determination of sensory information (thus sensor) needed for robust haptic sensing.
The deliverables are related to applications enabled by biomimetic skin and biomimetic strategies for haptic sensing.

D5.1: Taxonomy of image processing algorithms in the context of categorizing tactile graphics
Lead Institution: KIT
ESR number 13 – Omar Moured
Systematic analysis of 'translating and simplifying visual to tactile graphics by a literature review

D5.5: Classification of 2D refreshable tactile user interfaces
Lead Institution: IVO
ESR number 15 – Gaspar Ramoa
Literature review of the user interfaces and interaction

D5.6: Design principles and basic version of the intuitive tactile user interface
Lead Institution: IVO
ESR number 15 – Gaspar Ramoa
Software prototype for the new user interface allowing interaction between the Tactonom and computer

A good synergy between participants is critical to attaining of the intertwined objectives of INTUITIVE, and the ESRs from the INTUITIVE network will be exposed to an array of different specialists through close collaboration among participants and high-tech industry.

To achieve this the ESRs will spend at least two secondments of 2-8 weeks working at other participants of INTUITIVE. Due to the Covid-19 pandemic and the thereby delayed recruitment process and travel restrictions, the original secondment plan are continuously updated, and some dates are yet to be decided. The tentative secondment plan, and by the end of M36, are shown in picture 1.

	Secondment 1						Secondment 2						Secondment 3					
	According to GA			New			According to GA			New			According to GA			New		
ESRs	Where	When	Time	Where	When	Time	Where	When	Time	Where	When	Time	Where	When	Time	Where	When	Time
Kaan Kesgin	ACA	M12	4w	ACA	M34	4w	UoG	M26	4w	ICL	M45	4w						
Sofie Skårup Kristensen	ICL	M13	4w	ICL	M31	4w	UOS	M28	4w	UOS	M40	4w						
Yerkebulan Massalim	UoG	M10	6w	ULUND	M29	4w	ULUND	M20	4w	BMW	M41	4w	BMW	M30	3w	UOS	M43	4w
Shashank Mishra	TCS	M12	8w	TCS	M27	5w	ULUND	M20	2w	ULUND	M41	2w	TCS	M30	4w	TCS	M45	5w
Aruna Ramasamy	ICL	M12	4w	ICL	M33	4w	ULUND	M28	4w	ULUND	M42	4w						
Vincent Schmidt	ULUND	M14	2w	ULUND	M32	2w	ACA	M22	2w	ACA	M41	2w	IVO	M35	2w			
Alexis Devillard	ACA	M14	4w	ACA	M36	6w	UOS	M25	2w				ULUND	M35	4w			
Mahdieh Shojaei Baghini	OSS	M10	2w	FBK	M39	2w	BMW	M22	4w	BMW	M45	4w	OSS	M32	4w	FBK	M51	4w
Bhavani Yalagala	ACA	M12	2w	FBK	M36	3w	FBK	M22	4w	ACA	M44	1w	KUL	M33	4w			
Inci Rüya Temel	UoG	M10	12w	UoG	M26	10w	UoG	M22	12w	UoG	M41	12w	KUL	M37	4w			
Mark Daniel Alea	FBK	M16	4w	FBK	M32+37	4w	IMEC	M24	4w	UoG	M32+45	4w	UoG	M39	4w	FBK	M40	4w
Rudra Mukherjee	BMW	M19	4w	FBK	M35	13w	IMEC	M24	4w				KIT	M36	3w			
Omar Moured	ICL	M19	4w	ACA			ULUND	M27	2w	ICL			SRC	M34	3w	UOS		
Anirvan Dutta	ICL	M18	4w	ULUND	M31	2w	IVO	M26	4w	ICL		4w	OSS	M34	4w	SRC/OSS		
Gaspar Ramoa	UOS	M19	4w	UOS	M26+29	4w	ICL	M26	4w	ICL	M33	4w	ACA	M33	4w	ACA	M41	4w

Picture 1: Tentative secondment plan by the end of M36

The overall reasons for these changes in the secondment plan are the delayed recruitment and the traveling restrictions due to the Covid-19 pandemic. But also, as a consequence from the pandemic, the project suffered from delay of component deliveries and therefore delay in the ESRs IRPs and deliverables. The original secondment plan is built on the interaction between the ESRs and their host institutions, and when their timeline changes, the co-operation between the ESRs also must change. This explains the postponed timeline for the secondments, the changed order among the secondments, but also the many changes of receiving institutions. Table 5 list the justifications for the changes of receiving institution in the updated secondment plan.

Name	Change	Justification
Kaan Kesgin	ICL instead of UoG	
Yerkebulan Massalim	UOS instead of UoG	After discussions during RS1 it was realised that the research at UOS is more related to the work for ESR3 than the research at UoG.
Vincent Schmidt	No third secondment	The ESR's last secondment would be to visit IVO. But in a previous secondment (IVO at UOS) a study with human participants was conducted, where ESR15's device was tested. After the secondment, both ESRs have additionally invested significant time and efforts (i,e, 3-4 weeks each) in collaborating remotely on a manuscript to publish the results of that study. The manuscript is currently being reviewed by a journal, but it might still require a significant amount of labor before it could be published. While both ESRs profited from the extensive first

		secondment together, the process of publishing this manuscript has led to significant delays in their individual projects and tasks. Given the fact that they already exceeded the time investments required for the secondments according to the Grant Agreement, the suggestion is that they invest more time in getting the results from their first secondment published, rather than organizing another physical secondment in Nürnberg that would only make sense if they were planning to start (another) new project.
Mahdieh Shojaei Baghini	FBK instead of OSS	The ESR will go to FBK to define specifications for skin patch and testing feedback in micro-coils integrated with flexible sensors developed by ESR9 and ESR10, and for a second time to validate the skin patch. In collaboration with ESR9 and ESR10, they will test the suitability of the coil fields to produce motion in ferromagnetic nanoparticles as well as for magnetic stimulation.
Bhavani Yalagala	No third secondment	
Mark Daniel Alea	FBK instead of IMEC	The original goal of attending microelectronics classes has been fulfilled at KUL, not IMEC. Also, the wafer post-processing to be performed at FBK is of crucial importance in both delivering a working electronic skin prototype and finishing the ESR's PhD. Finally, the said post-processing procedures to be done at FBK are expected to take a significant amount of time, which the originally agreed 4-week secondment at FBK would not suffice.
Rudra Mukherjee	Only one secondment FBK instead of BMW	The work related to the use of solar skin, planned with BMW, has not progressed at a pace we initially thought. It will be helpful if ESR12 can pay more attention to the development of prototype (which need to overcome several integration related challenges). In a longer secondment at FBK the ESR will learn about the fabrication/integration strategies that will be useful in the project.

Omar Moured	ACA instead of ULUND	
Omar Moured	UOS instead of SRC	
Anirvan Dutta	ULUND instead of IVO	In this secondment, the ESR will learn to understand the multi-modal sensory integration in the brain which is the research theme of ESR2. This will help ESR14 to refine his proposed human-inspired visuo-haptic integration framework in robotics.

Table 5: Justification for changes in the secondment plan