



Mapping of Training activities

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Executive Summary

Objectives: Europe is at the forefront of research on plant phenotyping. Some of the best infrastructures for plant phenotyping are based on laboratories and platforms led by European institutions. The development of a more structured and interconnected phenotyping community allowing the implementation of the infrastructures, enhancing the access is one of the major objective of EMPHASIS. However, to bridge the gap between crop phenotyping and the rich array of refined genomic already available, we need to train a new generation of researchers who can undertake, develop and exploit phenotyping technologies, interpreting multidimensional phenomic data required to address current and future challenges in agriculture and plant science, namely how to feed the world, sustainably use natural resources, and contribute to the bio economy.

Rationale: A number of education and training activities on phenotyping are currently already performed at European and International level. Nevertheless, these still remain stand-alone and one-off initiatives, which require a further degree of structuring and integration. Mapping of ongoing or foregone training activities in plant phenotyping is a mandatory exercise to fill the gaps. In 2017, some analysis were performed by WP3 in collaboration with other WPs to map the state-of-the art of plant phenotyping training activities through: i) regional mapping Conferences; ii) the 2017 survey addressed to the plant phenotyping community and iii) internet- based research.

Main Results: From the mapping of training activities, an increased need of training is emerging especially in data management. For this reason, a more coordinated action is necessary to offer all the interested stakeholder adequate training instruments to disseminate the plant phenotyping knowledge among the identified target groups.

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1. Background

Agriculture is asked to respond to the great challenge of feeding 9,5 billion people expected to populate the planet in 2050, with finite planetary resources (land, water, biodiversity), and under the unfavorable action of the ongoing climate change. Large progresses have recently been made in understanding the genomic bases of biodiversity, with the aim of selecting new varieties more adaptable to the environment changes helping to address this challenge. Plant phenotyping represents an efficient tool to support plant breeding that allows to rapidly identify and select climate-ready and highly productive genotypes, and will provide information on complex traits of plant/crop phenotypes increase agriculture sustainability and productivity.

Phenotyping involves large scale, non-invasive monitoring of relevant plant traits, from organelle-level metabolism to whole-body structure and function. Image based technologies play a key role in plant phenotyping. High resolution data acquisition using visible light (whole plant organs, biomass, yield traits), fluorescence (time series measurements of photosynthesis), infrared and near-IR spectral imaging (thermal and water status of seeds), canopy spectral reflectance (nitrogen- or water-use efficiency) hyperspectral imaging (field crop cycles, canopy water status and health assessment), magnetic resonance imaging and x-ray computed tomography assisted 3D reconstruction (water content and transport, plant development, shoot and root architecture), and a whole host of other state-of-the-art techniques have the potential to overcome the phenotyping bottleneck.

Plant phenotyping provides new insights on the plant growth, development and ~~defence~~ defense responses. Therefore, the fast identification and selection of desired traits and phenotypes leading characteristics of new plant varieties are mandatory to drive the “third green revolution”, addressing the growing needs of our planet, in terms of food quantity, security, safety, and quality.

Europe is at the forefront of research on plant phenotyping. Some of the best infrastructures for plant phenotyping are based on laboratories and platforms led by European institutions. The phenotyping community is shaped around large networks allowing implementation and a shared use of infrastructures is the major objective of EMPHASIS.

However, to bridge the gap between crop phenotyping and the rich array of refined genomic data in the coming decades, the need of training the new generation of researchers who can undertake and exploit phenotyping technologies and be competent in interpreting multidimensional individual-level phenomic data is strongly required.

A number of education and training activities are ongoing at European and International level; nevertheless, representing stand-alone and one-off initiatives, which require further structure and integration.

WP 3 has dealt with the mapping of existing education -and training activities to evaluate existing gaps and links to the other projects/initiative in order to coordinate training activities in plant phenotyping across Europe and establish training and education concept in plant phenotyping for early career and senior scientists including exchange of personnel.

2. Mapping current trends in plant phenotyping

Recent progresses in plant breeding rely on the genomic revolution coupled with technological advances for the acquisition of plant phenotyping data at various scales. As a complex organism, the plant plays a central object in modern breeding, therefore there is a strong need of new approaches for the characterization of the biological functions and developmental processes from the cells to the whole plant scale. An increase number of robotized plant phenotyping platforms

equipped with various sensors (3D laser scanner, different types of camera) have been developed in recent years (e.g., PHENOSPSIS in growth chamber, PHENOARCH in greenhouse and DiaPHEN in field).

These platforms typically produce spatio-temporal data of plant growth and development in high-throughput manner and enable to investigate the impact of environmental and genetic factors on these traits. The generation of Big Data request new methodologies for the analyses, an increased computing power and revealed the emergence of new mathematical paradigms at the crossroad between probabilistic modeling, statistical inference and pattern recognition.

The development of new computing infrastructures (e.g. large clusters) and software technologies for managing complex heterogeneous data and parallelizing scientific workflows, is therefore mandatory.

The training on plant phenotyping needs to cover all the emerging technologies and needs and also focus on the management of these infrastructure.

In order to identify the relevant education and training activities within the infrastructures for existing and potential users, WP3 has undertaken mapping activities as follows:

- Collecting inputs and information from participants in EMPHASIS regional events;
- Analysing results of the EMPHASIS 2017 survey;
- Pursuing internet research on existing education and training offers in plant phenotyping.

3. Identification of plant phenotyping training demands

3.1 Mapping activities

In 2017, EMPHASIS organized a series of regional events at European level, as listed below, to map stakeholder needs and expectations:

- EMPHASIS Satellite event, within 3rd General COST Meeting, 29 March 2017, Oreias, Lisbon (Portugal);
- EMPHASIS Satellite event, within 13th International Wheat Genetics Symposium; (23 -28 April 2017, Tulln (Austria);
- EMPHASIS Satellite event, SEB Annual Meeting, 7 July, Gotheburg (Sweden);
- Plant Phenotyping Forum: Integrating European plant phenotyping community, 22-24 November, Tartu (Estonia).

During the mentioned events WP3 has, inter alia, organized dedicated break-out sessions with interested stakeholders in order to collect information and stimulate a debate with the attending audience concerning education and training in plant phenotyping and –the related career opportunities.

After [analysing](#) the collected information and feedbacks, some training demands and expectations clearly emerged as follows:

- Plant phenotyping is a bottleneck in basic plant science and plant breeding and a transfer of knowledge and raise of awareness in this field should be promote;

- Plant phenotyping requires interdisciplinary approaches of plant scientists, bioinformatics, technology developers, modelers and environmental scientists;
- Plant phenotyping needs to integrate activities for establishing mechanistic, high-throughput and field-based platforms, data management.

Furthermore, following the feedbacks received from the community during the regional events, in ~~November~~ December 2017 a detailed survey was set up and launched with the collaboration of all EMPHASIS-PREP WPs to evaluate, inter alia, the availability of infrastructures, as well as user's demand and expectations towards training and education in plant phenotyping.

3.2 Results from the 2017 survey

The 2017 survey was circulated in each partner country by the national nodes of EMPHASIS-PREP and was planned to specifically reach the following recipient target groups:

- Leading institutions/companies involved in plant phenotyping
- Data managers at infrastructures
- Scientists, technologists and experts running the phenotyping facilities
- Experts involved in management of training, transfer of knowledge, and education
- Diverse users from academia and industry (Ph.D. students, technical staff, platform operators)
- Developer of phenotyping technology

The survey gained a participation of 136 participants and among those, 72 users, 35 operators of installations; 29 head of the local infrastructures; 17 managers of training and education; and 4 heads of the national infrastructures.

Training had a dedicated session within the survey, to gain information within the stakeholders to understand i) if training activities in plant phenotyping are attractive and timing, ii) how they can contribute in increasing the awareness in plant phenotyping.

The overall idea emerged from the survey is surely the importance of training activities for future development of plant phenotyping.

The respondents find training in plant phenotyping useful to i) expand the research network (76%), ii) access to data, tested for validation (60%), iii) support with raising funding (52%), iv) have access to installations (48%) and v) support innovation (44%).

Regarding training and education, the participants were also requested to respond on what key training and education field are important for current and future development of plant phenotyping. 76% identified the data management as a key training field to be improved, followed by imaging training and plant physiology (71% and 56% respectively). Training in field conditions was a keynote for 43% of the participants (Fig 1) .

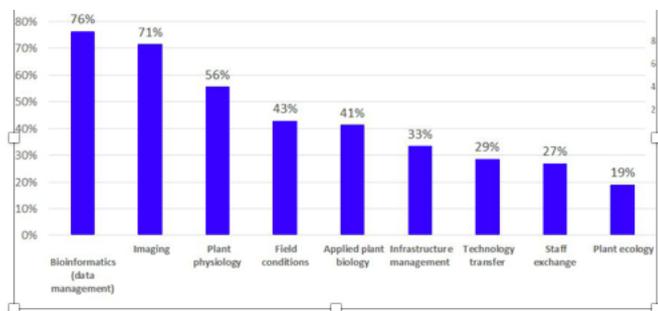


Fig 1 - Q: What key training and education disciplines do you regard as important for current plant phenotyping?

The education and training in plant phenotyping are perceived as directly linked to career prospects. In fact, many participants identified a lack of training programs for users of plant phenotyping research infrastructures in their own countries (Fig 2).

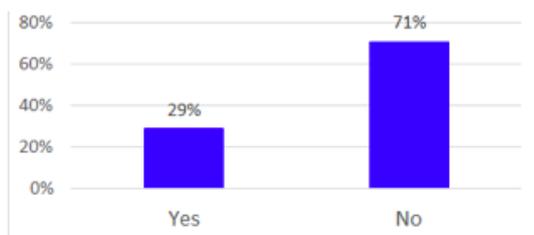


Fig 2 - Q: Do adequate training programs for users of research infrastructures exist in your country?

Most of the survey participants organize training for undergraduates/PhD students (96%) and only few do not offer training for them (4%). In particular, they offer the following activities (Fig 3)

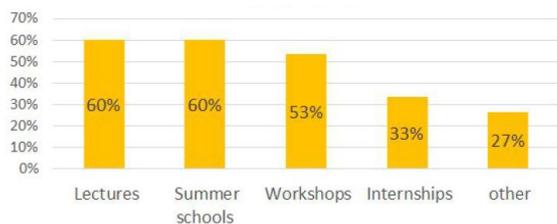


Fig. 3 - What kind of training for undergraduate/PhD students do you provide?

Furthermore, most of the survey participants do not offer training for senior scientists (63%), and less than an half (44%) organize some training activities for them. Staff exchange was identified as the most frequent training activities foreseen for senior scientists (Fig -4)-:



Fig 5 - What kind of training for senior scientists do you perform?

4. Identification of potential stakeholders for training

Plant phenotyping and its applications are very transversal to the various domains of science and industry sectors. Although the EMPHASIS community is a rather broad and varied, three main training gaps were identified:

- Access to high-quality training (courses, seminars, methodologies, hands-on training) to increase expertise and to open new research interests and career opportunities;
- Access to high-quality training (courses, seminars, methodologies, hands-on training) to face emerging developments in technology especially to manage big amount of data (data management);
- Coordination among different training offers at European level.

On the basis of the previous analysis, a set of stakeholder groups and training and education offers in plant phenotyping have been identified and listed in Table 1.

Table 1: Possible target groups and relative training activities

Target group	Training
Users / operators <ul style="list-style-type: none"> • researchers Researchers from Academia academia, • R Researchers from industries • Infrastructure Infrastructure operators 	<ul style="list-style-type: none"> • Training on specific infrastructures (staff-exchanges), management of infrastructures, new technologies, best-practices, methods of standardization; data management
Educators <ul style="list-style-type: none"> • Lecturers at universities, teachers, trainers 	<ul style="list-style-type: none"> • Training and teaching materials, best practice, provision of infrastructures
Students	<ul style="list-style-type: none"> • Basics knowledge of plant

<ul style="list-style-type: none"> • Undergraduates • Graduates • PhD student 	phenotyping, structured training programs <ul style="list-style-type: none"> • Structured training (e.g. ITN)
General Public	<ul style="list-style-type: none"> • General understanding of the impact of plant phenotyping; initiate a dialogue between researchers and public

Although, a number of education and training activities already exist at European level, still represent stand-alone and one-off initiatives, which require a further degree of structuring and integration. Universities plays a major role in training, therefore they were the primary stakeholder took into consideration to design the map of training. The picture emerged is that several training offers in plant phenotyping are already available and are listed below in Table 2.

Table 2: Universities offering training on plant phenotyping

UNIVERSITIES	ACTIVITIES	TARGET GROUPS
ABER - Aberystwyth University	Summer Schools, workshops, PhD programs, courses, lectures	mainly students on master level, graduates, researchers
AU - Aarhus Universitet - Department of Food Science		
SUA - Slovak University of Agriculture in Nitra		
UCL - Université Catholique De Louvain		
UCPH - University of Copenhagen		
UHEL - University of Helsinki		
UNOTT - The University Of Nottingham		
Campus of Triolet, University of Montpellier		
UNIBO- University of Bologna		
WU - Wageningen University		
DLO - Stichting Dienst Landbouwkundig Onderzoek		
Campuses of Baillarguet and Lavalette, Agropolis-Fondation/Montpellier		
Campus of LaGaillarde, Montpellier SupAgro		
Campus of Inra Montfavet		
AGAP joint research unit		
International Centre for Higher Education in Agricultural Sciences		

Kommentiert [PR1]:

Kommentiert [PR2]:
ou can combine WU and DLO as one organisation: WUR: Wageningen University and Research

The second step was to analyse whether other key actors in plant phenotyping performed other training activities as periodical courses and workshop. A sum-up of these findings is presented in the following in the following Tables.

Table 3 is focused on the research centres offering training activities on plant phenotyping. Summer schools, dedicated workshops especially to the early career researchers are mainly organized to build awareness among interested students.

Table 3: Research centres offering training on plant phenotyping

RESEARCH CENTRES	ACTIVITIES	TARGET GROUP
FZJ - Forschungszentrum Jülich	Summer Schools, workshops, PhD programs	Graduates, researchers students on master level, graduates, researchers
INRA - Institut National de la Recherche Agronomique France		
IPK - Leibniz - Institut Fuer Pflanzengenetik Und Kulturpflanzenforschung		
HMGU - Helmholtz Zentrum Muenchen Deutsches Forschungszentrum Fuer Gesundheit Und Umwelt GmbH		
MTA - Magyar Tudományos Akademia Szegedibiologiai Kutatokozpont		
VIB - Vlaams Instituut voor Biotechnologie		
The Graduate School 'Experimental Plant Sciences' (EPS)		
CNR - National Research Council of Italy		
ALSIA - Lucan Agency for Agricultural and Innovation in Agriculture		

The scientific community (international scientific societies, networks and initiatives) -have a wide range of interests and plant phenotyping is emerging within most of the subject covered by them. Table 4 describes the activities performed international and national networks which organize summer schools, courses, etc. on specific aspects of plant phenotyping. Their main role of the mentioned networks is promoting plant phenotyping among diverse communities.

Table 4: Projects/Networks/Cluster/Platforms with training on plant phenotyping

PROJECTS/NETWORKS/CLUSTER/PLATFORMS	ACTIVITIES	TARGET GROUP
IPPN - International Plant Phenotyping Network	Workshops, courses, summer schools, lectures, doctoral programs	Students on master level, graduates, researcher
EPPN2020 - European Plant Phenotyping Network		
DPPN - Deutschland Plant Phenotyping Network		
APPN - Austria Plant Phenotyping Network		
The Netherlands Plant Eco-phenotyping Centre (NPEC)		
PHENOME - France		
PHEN-ITALY		
BPPN - Belgium Plant Phenotyping Network		
RiTrain (Executive Masters In Management Of Research Infrastructures) - Eu Funded Project		
EPSO- European Plant Sciences Organisations		
Wheat Initiative		
MIAPPE - Minimum Information About a Plant Phenotyping Experiment		

Kommentiert [PR3]:
MIAPPE has no direct training

Very important is the training offered from by private sector representatives. Some of them dedicate some institutional activities to training in the field of plant phenotyping (Table 5). The training is mostly addressed to academics and professional at higher levels.

Table 5: Companies / Private sectors with training activities in plant phenotyping

COMPANIES/PRIVATE SECTOR (including non profit)	ACTIVITIES	TARGET GROUP
SIB -Swiss Institute of Bioinformatics	Workshops, courses	Mainly academics and professionals on different levels
Cultiva (fosters the exchange of information and capacities between researchers and students within established masters and phd curricula oriented towards plant breeding.) - multi-partner initiative		
PR Statistics (provides training courses and workshops in a broad range of statistical methods) (company)		
Lemantec Academy (company)		

5. Key Performance Indicators for education and training activities

To effectively evaluate the impact of training activities, the following key performance Indicators (KPI) have been identified and lies on the:

Impact of training activities	KPI
Increase the numbers of graduates of high quality	Employment trends of graduates, tests, employer evaluation of graduates
Strengthen the teaching-research linkage	Percentage of courses and activities with linkage, publications, number of International outreach events by organizing workshops, seminars and conferences
Deliver interdisciplinary learning offers	Number of trained educators / participants of education and training activities
Deliver of high quality educational offers for research postgraduate students	Tracking of careers of participants, publications of postgraduates
High quality teaching and learning processes	Evaluation by students according to defined criteria

A periodical assessment of training needs and of the resources available to address these requests is the first step in developing and delivering effective training initiatives.

Two approaches can be used to achieve this goal:

Bottom-up approach:

- Interviews with SME and breeders;
- Periodically re-performed a web based research on existing education and training activities

Top-down approach:

- Interviews with experts in plant phenotyping
- Interviews with key players in plant phenotyping
- Interview with training experts for the identification of the most effective training approach for the diverse category of stakeholders

6. Conclusion and perspectives

Training in plant phenotyping is of paramount importance for the development of research and services in this expanding sector.

The EMPHASIS training strategy should focus on the development and dissemination of the plant phenotyping concept, technological development, modelling and applications. The training and education events should be oriented at different career level and with different scopes:

- at the Masters, PhD and postdoctoral level. EMPHASIS is in a unique position to develop and maintain access to sustainable, high quality and state of the art training in plant phenotyping and to raise consciousness of the potentiality of plant phenotyping in the future scientific activities
- Higher professional degrees (senior researchers, researchers, head of institution) to increase awareness of the importance of plant phenotyping as innovative approach, as instrument to raised funds and to increase the research network potential.

Therefore main pillars of the **EMPHASIS training strategy** are:

- Coordinate and support the user training activities
- Disseminate advertisement of EMPHASIS training courses to oriented the European scientists to deal with the “jungle of courses”
- Develop and maintain an online platform with courses catalogue and quality indicators
- Perform as a guidance about what competencies are required in plant phenotyping field
- Coordinate design and execution of RI facility staff training courses

This strategy is favoured by the presence of Europe's outstanding plant phenotyping experts within national Nodes, the EMPHASIS community can help to coordinate high quality training activities.

The training strategy developed, is focused on current and future users (Master and PhD students, post-graduates, senior scientists, technicians) as well as on staff of the imaging facilities across Europe and is divided into three pillars:

- a) a user training program incorporated in the EMPHASIS open access procedure (hands-on-training for use of instruments designed to bring each user to the level required to use the technology, successfully perform experiments at the Node and analyses results).
- b) training of the plant phenotyping facilities' staff (“train the trainer”) e.g. in facility management, or advanced scientific courses, which will help to educate a new generation of experts, a group which is becoming under-represented in Europe);
- c) general training for a broad scientific audience covering all training aspects related to imaging (e.g. regular courses on specific imaging modalities, online training courses, and online repository of training material, summer schools etc.).

Some of the training activities are described in **Annex 1**. The idea is to clearly: i) identify the target and point out the benefits and the strengthen of the activity.

Annex 1: EMPHASIS individuated training activities

1. STAFF EXCHANGE PROGRAMS

Knowledge/staff exchanges to develop expertise in different areas relevant to run plant phenotyping infrastructure.

Detailed description of the service

EMPHASIS will develop a flagship training programme:

- managerial expertise: enabling RIs across all domains to gain expertise on governance, organisation, financial and staff management, funding, IP, service provision and outreach in an international context.
- operational expertise: phenotyping pipelines, data management, image acquisition and analysis, automation and engineering, etc.

Customers

- Professional workers in RIs (or organisations representing them) can dip into the content, focusing on areas where there is most need.
- Management teams can take the course as an organisation, dividing modules between them to gain a certificate for the RI. This will flag the RI as an organisation that values staff development, improving its attractiveness as an employer.
- Recent graduates and others wishing to enhance their employability

Benefits

Exchanges provide benefits for both participants and hosts. Participants can gain new skills, motivation, new perspectives and an expanded network; plus, it might be a reward for outstanding achievement. Host properties gain a temporary staff person with different skills and new perspectives; staff at the host property gain additional motivation as they participate in the exchange.

2. WEBINARS

Detailed description of the service

EMPHASIS will develop a series of webinars featuring leading personnel from research infrastructures. The webinars will take the form of a short talk (20-30 min) focusing on a specific challenge that was faced by the speaker and her or his RI, and how it was successfully overcome. In addition, a number of information-rich topics will be available as a talk with supporting slides.

Customers

- Professionals working in RIs (or organisations representing them)
- Scientists working in the field Plant Phenotyping
- Recent graduates and others wishing to enhance their knowledge

Benefits

Direct contact with a target group (global/European-wide). Interaction and networking with Scientists/Experts from all over the world. The participants have the opportunity to ask questions or discuss with each other. Webinars are very cost and time effective, since travelling is not necessary. It is possible to address specific topics in a short time frame.

3. INNOVATIVE TRAINING NETWORKS (ITN)

Detailed description of the service

Innovative training networks, funded by participating in EU Marie Skłodowska-Curie calls, bring together universities, research centres and companies from different countries worldwide to train a new generation of researchers. The funding boosts scientific excellence and business innovation, and enhances researchers' career prospects through developing their skills in entrepreneurship, creativity and innovation.

European Training Networks

Joint research training, implemented by at least three partners from in and outside academia. The aim is for the researcher to experience different sectors and develop their transferable skills by working on joint research projects. The organisations should be established in at least three different EU or associated countries. Additional participants from any organisation anywhere in the world can also join a network.

Customers

- PhD students who would like to deepen knowledge in plant phenotyping

Benefits

4. [Direct contact](#) with a target group (global/European-wide). Interaction and networking with Scientists/Experts from all over the world. **MOOCs** (Massive Open Online Course)

Detailed description of the service

A massive open online course (MOOC) is an online course aimed at unlimited participation and open access via the web. In addition to traditional course materials such as filmed lectures, readings, and problem sets, many MOOCs provide interactive user forums to support community interactions among students, professors, and teaching assistants. MOOCs are a recent and widely researched development in distance education. Most MOOCs use closed licenses for their course materials while maintaining free access for students.

Customers

- Open for everybody interested. Possibility to open the course only for selected participants.

Benefits

Improving access to Higher Education: MOOCs are regarded by many as an important tool to widen access to Higher Education for millions of people, including those in the developing world, and ultimately enhance their quality of life. MOOCs can help democratise content and make knowledge reachable for everyone. Students are able to access complete courses offered by universities all over the world. Providing an affordable alternative to formal education: MOOCs are for large numbers of participants, can be accessed by anyone anywhere as long as they have an Internet connection, are open to everyone without entry qualifications and offer a full/complete course experience online for free.

Annex 1: Check list

Deliverable Check list (to be checked by the “Deliverable leader”)

	Check list	Comments
BEFORE	I have checked the due date and have planned completion in due time	<i>Please inform Management Team of any foreseen delays</i>
	The title corresponds to the title in the DOW	<i>If not please inform the Management Team with justification</i>
	The dissemination level corresponds to that indicated in the DOW	
	The contributors (authors) correspond to those indicated in the DOW	
	The Table of Contents has been validated with the Activity Leader	<i>Please validate the Table of Content with your Activity Leader before drafting the deliverable</i>
	I am using the EPPN ²⁰²⁰ deliverable template (title page, styles etc)	<i>Available in “Useful Documents” on the collaborative workspace</i>
The draft is ready		
AFTER	I have written a good summary at the beginning of the Deliverable	<i>A 1-2 pages maximum summary is mandatory (not formal but really informative on the content of the Deliverable)</i>
	The deliverable has been reviewed by all contributors (authors)	<i>Make sure all contributors have reviewed and approved the final version of the deliverable. You should leave sufficient time for this validation.</i>
	I have done a spell check and had the English verified	
	I have sent the final version to the WP Leader and to the Project coordinator (cc to the project manager) for approval	<i>Send the final draft to your WPLLeader and the coordinator with cc to the project manager on the 1st day of the due month and leave 2 weeks for feedback. Inform the reviewer of the changes (if any) you have made to address their comments. Once validated by the 2 reviewers and the coordinator, send the final version to the Project Manager who will then submit it to the EC.</i>