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**Coordinating an Observation Network of Networks EnCompassing saTellite and IN-situ
to fill the Gaps in European Observations**

Deliverable D6.1 ***ConnectinGEO methodology***

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Executive summary

This report describes the ConnectinGEO methodology for the gap analysis, that will be developed and tested during the project. The deliverable “D3.2 ENEON methodology for management and coordination and first plenary Workshop minutes” deals with the methodology for management the ENEON.

The main aim of the ConnectinGEO methodology is to find gaps in EO networks and systems (mainly in-situ or non-space), determine remedies and recommend priorities to solve these gaps.

The gap analysis phase follows five different threads:

Top-Down thread 1: Identification of a collection of observation requirements

Top-Down thread 2: Research programs aims and targets

Bottom-up thread 1: Consultation process

Bottom-up thread 2: GEOSS Discovery and Access Broker analysis

Bottom-up thread 3: industry-driven challenges

This deliverable describes each thread and enumerates sub-steps for each one. It defines a common data model for gap description that all threads will need to follow and respect to communicate and concentrate gaps in a single list.

Then a review process will start and external and internal user feedback will be gathered. To end the review process the feedback will be examined and moderated and some gaps will be discarded but other will be confirmed and profiled.

Then, a period for reviewing the gaps and identifying remedies will start. The quantifications of the impact, the feasibility and the costs will permit the application of a semi automatic priority calculation.

Once the gap table is sorted by priorities, gaps will be classified and some recommendations will be formulated for the funding agencies.

1 Introduction

This report describes the ConnectinGEO methodology that will be developed and tested during the project and that will be promoted beyond the end of the project; in particular through the publication of a project book. It is important to differentiate this deliverable and “D3.2 ENEON methodology for management and coordination and first plenary Workshop minutes” that deals with the methodology for management the ENEON but do not covers the methodology to extract the ENEON know-how used in the gap analysis and prioritization process that the project users as a methodology and that is covered in this one.

The main aim of the ConnectinGEO methodology is to find gaps and recommend priorities and remedies in the EO data collection network. The project methodology is divided in two phases: Gap analysis elicitation and prioritization. The gap analysis phase follows five different threads:

1. *Top-Down thread 1:* Identification of a collection of observation requirements and specifications from generic goals for sustainability of the global civilization as expressed in the GEOSS Strategic Targets, the SDGs, and the adherence to the planetary boundaries.
2. *Top-Down thread 2:* Incorporation of material from international programs such as Future Earth, Belmont Forum, the Research Data Alliance and community assessments of socio-economic benefits of Earth observations
3. *Bottom-up thread 1:* A consultation process in the current EO networks, consisting of collaboration platforms, surveys and discussions at workshops and even involvement of citizen science.
4. *Bottom-up thread 2:* A careful analysis of the observations and measurements that are currently in GEOSS Discovery and Access Broker complemented by other means (e.g. scientific literature)
5. *Bottom-up thread 3:* The realization of a series of real industry-driven challenges to assess the problems and gaps emerging during the creation of business opportunities

Table 1 — ThreadCode values

Code	Name	Definition
1	Top-Down thread 1	Identification of a collection of observation requirements
2	Top-Down thread 2	Research programs aims and targets

Code	Name	Definition
3	Bottom-up thread 1	Consultation process
4	Bottom-up thread 2	GEOSS Discovery and Access Broker analysis
5	Bottom-up thread 3	industry-driven challenges

The prioritization and remedies consists sorting the gaps and in determining the most significant ones and eventually suggest possible solutions to them.

The aim of this deliverable is define a clear methodology that can be applied by ConnectinGEO once but can also be repeated in a systematic way in the future. Once applied and adjusted, this methodology will be published in a book by the end of the project.

ConnectinGEO also has the mission to create and manage the ENEON. The ENEON methodology is considered out of scope of this deliverable and will be considered in D3.2.

2 Methodology threads for the gap analysis

These sections describes the 5 threads involved in the gap analysis.

2.1 Top-Down thread 1: Identification of a collection of observation requirements

This is achieved by determining a set of targets that the Network of networks users has. The initial mission of GEOSS was to support the nations in quantitative assessing the evolution of the climate change by providing easy access to the Earth Observation data. Currently, GEOSS is adopting a more general set of goals defined by the UN for the sustainability of the global civilization that are expressed in the GEOSS Strategic Targets, the UN SDGs, and the compromise in not to exceed the planetary boundaries. It is important that goals targets clearly can be clearly quantified so that the evolution on achieve this goals can be measured and demonstrated.

It is important to increase the knowledge about this concepts so documentation need to be gathered and workshops with the participation of experts in this areas need to be organized, not just to understand the goals but also to define metrics to measure its. In our case, workshops to disseminate the SDGs concept and to clarify what is possible to monitor from EO need to be organized. The adoption of a set of well defined variables contributes to a better measure of the achievements. In this sense this project is adopting the Essential Variables concept. The Essential Variables have been successfully defined in Climate and

Biodiversity and other thematic areas are in the process of defining them. Metrics based in the EV needed to be defined for the different SDG.

Gaps in EO data depend on the aim and kind of study that is conducted in response to this aim. The URR is able to record user needs that are derived for this aim. In the URR, these user needs can be mapped to some EV and some requirements for its measurement. The later can then be mapped to Earth Observation data needs. This EO needs are then compared to what is currently available in the EO data repositories and in the DAB. The existing data should respond to the requirements to fit for the purpose initially stated; if no data fits for the purpose, then, a gap is detected. In this sense this thread is deeply related with the “bottom-up thread 2” described bellow.

Substeps:

- Define the gaps taxonomy (see section 3)
- Identifying the strategic goals we want to achieve. This can come from the SDG but also by scientific goals that we can identify in scientific literature.
- Express the goals as precise user requirements (as done in the URR)
- Identifying the essential variables that can be used to measure the achievement of the goals (see WP 2 deliverables about the EVs)
- Identifying the metrics and measurements used to achieve the goals
- Determine is the EO necessary fits the purpose of the user requirements. If not, a gap has been detected.

2.2 Top-Down thread 2: International research programs

International Research Programs such as the European Commission H2020, Future Earth, Belmont Forum, Research Data Alliance, etc have conducted their own gap analysis before and they already defined their priorities. This previous works are very important and need to be included in the gap analysis. Some of these programs have released documents (some times called roadmaps) where some gaps an priorities are identified. The calls for participation in research programs have implicit or explicit statements on what is considered missing and need to be promoted. Sometimes funding agencies organize workshops to discuss progress on scientific threads that can also be used to detect gaps Careful examination of the documentation released by research programs can hep in detecting gaps in Earth Observations and in determining the current priorities (that may o may not be the ones need for the next period). ERA-NETs are also a good instrument to examine due to it coordinates the research into a common European direction and structures priorities.

Substeps:

- Examine the documentation of EO related topics released by the funding agencies.



- Complement the documentation with research objectives roadmaps that some collectives already elaborate.
- Attend workshops organised by the funding agencies or the international instruments of collaboration and collecting minutes
- Identify the current directions of the funded research that uses or contributes to EO and produce a list
- Consult the funding agencies responsible in interviews and make them review the produced list of current priorities and explore possible continuation
- Later in the process, explain the results of the other threads to them and adjust them considering their expert opinion.
- Express them in a format that makes them compatible with the observation needs

2.3 Bottom-up thread 1: Consultation process

A consultation process in the experts in Earth observations need to be done to get direct impressions on what is missing. For convenience, it is useful to separate them in two collectives: producers and users. The mechanisms for doing the consultation process are of collaboration platforms, surveys and discussions at workshops and even involvement of citizen science. It is important the two collectives perceive the advantages of being part of the collective in a continuous way and also the need for participating in the consultation process.

Substeps:

- Elaborate a list of networks of Earth observation for all relevant topics considering satellite, airborne and in-situ segments.
 - Consider other possible data producers such as SME and private sectors and Citizens Observatories.
- Elaborate a list of EO stakeholders and consumers
- Structure the two lists into two networks to give it some stability
 - Communicate the needs and the benefits of the networks to them
 - Set up virtual environments where the networks can have their communication and debate mechanisms to keep the concept alive continuously.
- Consult both collectives using questionnaires and organize regular workshops
- Elaborate a list of requirements, gaps and priorities based on the results of the questionnaires and workshops
- Communicate to the results of the consultation process and make them review and validate it.

2.4 Bottom-up thread 2: Systematic analysis of the observations

Since SDIs introduced the use of geospatial data catalogues, metadata about the data is harvested and it is possible to use them to search for a geospatial data

product that fits for a purpose. GEOSS has recently adopted the Discovery and Access Broker (that was introduced for the first time by the EUROGEOSS FP7 project) as the unified single entry point to the GEOSS catalogues. The broker keeps a list of records for all EO products by harvesting or federating EO catalogues (it does not keep any record by himself). A systematic analysis of these records can reveal important information about gaps in current EO products. These gaps can be spatial, temporal or thematic. A further validation (expert review or scientific literature) of these results will be needed because some detections could be related to a bad documentation of the metadata, complete absence of metadata or noise in the registry that hides the relevant datasets

Substeps:

This research is conducted in two ways:

Method A: Giving a gap detected in other threads, it is still possible that data exists and the gap detected is wrong or not well formulated. It is important to validate does gaps in the DAB.

- Determine the query necessary to find data about the gap or user need
- Formulate the query in the DAB and retrieve the results
- Screen the results to see if some useful data is discovered.
- If some data is discovered, trace back the gap or user need and reformulate it or remove it.

Method B: Find new gaps in EO

- Formulate filtering rules that are able to cover the EV that are needed.
- Explore the results and look for missing data that was not reported in other threads.
- Populate the gaps inventory with the relevant entries.
- Validate analysis results with expert reviews and categorize the gaps using the gaps taxonomy.

2.5 Bottom-up thread 3: Hands on activities

It is well known that most of the time needed for an applied research in an Earth Observation issue is spent on finding and collecting data that will be used to analyze the problem. In principle, geospatial data catalogues were created to mitigate the amount of efforts in finding the right data. Sometimes the only way we have to know if their is the right data for solving a problem is just go out there and search for it. Determine a collection of well designed data intensive problems and generate and experiment for preparing this data in a way that is useful for a research activity can provide important insides on the gaps in EO data that still exist. Since these activities are conducted by experts in the field with contacts to the right people, the results will have a high degree of confidence. However, the scope of these activities is quite limited and only can be done partially in a project like ConnectinGEO. We call each of these individual activities a *challenge* and can be conducted either by scientists working on public research facilities or by research divisions of private companies.

Substeps:

- Define a set of data intensive challenges that are reasonable to be achieved but have not been tried before
 - Involve both remote sensing and in-situ.
- Complementarily, involve other parties by offering rewards (in the form of physical presents or in reputation and recognition) to participants that contribute their own challenges and their own evaluation.
- Use the geospatial catalogues to try to find the information
- When the information has not been found in catalogues, contact experts to continue looking for the data
 - If the data is found, determine if is it possible to register this data in the catalogues so other will be able to find it easily.
- Try to extrapolate the results to other topics or spatial or temporal extent.

3 Centralizing the detected gaps in an inventory

All threads will generate a list of gaps. The description of the gaps needs to be formalized in a way that can be easily reviewed and explored and compare internally in the project but also externally in the PAB and in ENEON.

To do this we will adopt a simple data structure for describing the gaps. This structure is based on initial ideas of the GAIA-CLIM project but adapt to this project needs. Whatever the thread that has detected the gap, it shall be described following the data structure of the CG_Gap class defined in Table 2 — CG_Gap class.

Table 2 — CG_Gap class

Name	Definition	Data type and values	Multiplicity and use
Gap Identifier	Unique identifier within the gap inventory	Character String type, not empty	One (mandatory)
Gap Type	Type of gap	GapTypeCode type (see Table 3)	One (mandatory)
ECV	Name of the EV	EVCCode type ⁴	One (mandatory)
Gap Short Description	Short Description of the gap	Character String type, not empty	One (mandatory)
Thread	Thread that generate this gap from the threads	ThreadCode type	One

Name	Definition	Data type and values	Multiplicity and use
	defined in this methodology	(see Table 1)	(mandatory)
Trace	Provenance information about the gap. Who formulated it and where was found.	Character String type, not empty	Zero or one (optional)
Date	Date where the gap was detected	DateTime data type	One (mandatory)
Purpose	Need (requirement) associated with this gap ² .	Character String type, not empty	Zero or one (optional)
Review	Comments done by reviewers	Character String type, not empty ³	Zero or more (optional) ⁵
Remedy	Possible remedy to fill de gap	Character String type, not empty	Zero or one (optional) ⁵
Feasibility	Difficulties in filling the gap	Character String type, not empty	Zero or one (optional) ⁵
Impact	Impact the we can achive id we fill the gap	Character String type, not empty	Zero or one (optional) ⁵
Cost	Quantitative estimation of the cost of filling the gap	Positive Integer	Zero or one (optional) ⁵
Priority	Priority degree	Positive Integer. Lower numbers means higher priority, being 1 the highest possible priority and 10 the lowest	Zero or one (optional) ⁵
Recommendation	Recomendation to a funding agency on how to finance and implement a remedy	Character String type, not empty	Zero or one (optional) ⁵
Filled	Date where the gap was filled and it is no longer a gap	DateTime data type	Zero or one (optional) ⁵
Status	Status of the entry in the ConnectinGEO process	StatusCode type (see Table 4)	One (mandatory)

Name	Definition	Data type and values	Multiplicity and use
<p>¹ Each thread in this methodology can potentially generate a Trace. For examples, in the DAB we can trace back the source of the gap to the “rule” or the “filter” applied to find the gap. In the consultation process, we can associate it to a scientific paper of a network name that provided this gap.</p> <p>² For example, the URR contains requirements that once analyzed and compared with the DAB, can provide gaps. The requirement in the URR is the <i>Purpose</i>.</p> <p>³ In practice the review and feedback will be stored in an independent user feedback database as described in Section 4 Synergy with the Users’ Feedback task and as described in the OGC draft standard document OGC 15-097 following the UserFeedbackItem data type. Here only the result of this user feedback revision by a moderator will be summarized as a text.</p> <p>⁴ This will be provided by the deliverables in WP 2</p> <p>⁵ These elements are introduced during the revision and prioritization phase. (See Section 4 for more details)</p> <p>NOTE: fields in grey are directly imported from the GAIA-CLIM methodology.</p>			

Adapting the GAIA-CLIM project methodology¹, gaps can be classified in the following taxonomy used by Table 2 — CG_Gap class:

¹ The original GAIA-CLIM methodology defines de following gaps (from the GAIA-CLIM Deliverable 6.2) that are reproduced here for convenience:

1. Coverage: gaps in geographical and/or temporal coverage, i.e. a lack of measurements
2. Vertical Resolution: either or not resolving the vertical column sufficiently
3. Uncertainty: uncertainty budget including calibration, i.e. uncertainties intrinsic to one measurement
4. Comparator Uncertainty: uncertainties relating to comparator measures, i.e. uncertainties related to comparisons between measurements which have different attributes
5. Technical: data dissemination, specific missing tools (specifically excluding governance)
6. Governance: data policy incl. (free) data access, unclear QA/QC methodologies, traceability/documentation/learning (specifically excluding pure technical gaps)
7. Parameter: missing parameter knowledge, missing auxiliary information for an ECV, etc.

Table 3 — GapTypeCode values

Code	Name	GAIA-CLIM class	Definition
1.1	Geographical extent	1	Incomplete geographical extent
1.2	Vertical extent	1	Incomplete coverage in vertical extent (applicable for atmosphere, geology, oceanography etc)
1.3	Temporal extent	1	Incomplete coverage in temporal extent
2.1	Spatial resolution	2	Not enough spatial resolution
2.2	Vertical resolution	2	Not resolving the vertical column sufficiently
2.3	Temporal resolution	2	Not enough temporal resolution
3.1	Uncertainty	3	Uncertainties are too high for the application. (uncertainty budget including calibration, i.e. uncertainties intrinsic to one measurement)
5.1	No catalogue	5	5.1 Lack of tools for discovery
5.2	Catalogue saturation	5	5.1 Difficult to discovery due to catalogues has many similar products that hide it
5.3	Can not be viewed	5	Lack of tools for visualization
5.4	No easy access	5	Lack of easy download
5.5	Known format	5	Format difficult to use, not well documented, proprietary format
5.6	No processable	5	Lack of tools to process

Code	Name	GAIA-CLIM class	Definition
			the data
5.7	Semantics	5	No clear semantics of the data
6.1	No access	6	Data is not available
6.2	No open access	6	Data policy incl. (free) data access
6.3	No quality	6	Unclear or undocumented QA/QC methodologies
6.4	No provenance	6	Traceability not documented
6.5	Bad metadata	6	Metadata is not complete or wrong
6.5	No metadata	6	Metadata cannot be found
6.6	No model or proxy	6	There is a lack of model to extract the variable from direct measurement or by a proxy
6.7	Long term data preservation	6	No long term data preservation strategy in place
6.8	No future	6	Insecure finance to continue the data acquisition activities.
7.1	No measured	7	The variable is not measured
7.2	No parameter	7	An aspect of the variable is missing

Each gap will have a status value that

Table 4 — StatusCode values

Code	Name	Definition
1	Detected	A possible gap has been detected but can not be prioritised due to a

Code	Name	Definition
		lack of review.
2	Has feedback	There is feedback linked to this gap in a feedback database. The gap needs to be accepted or discarded.
3	Accepted	The gap has been reviewed and accepted as valid. It ready for looking for remedies and assessing impacts
4	Discarded	The gap was never a gap. The gap has been reviewed and discarded as a misdetection and will not be longer considered valid.
5	Remedy found	A remedy has been found so feasibility and cost can be determined.
6	Prioritized	The gap has been associated with a numerical priority. A recommendation will be issued.
7	Filled	The gap is no longer a gap because it has been addressed and filled

A gap analysis table will be produced in ConnectinGEO and maintained by the project consortium and eventually shared to the advisory. The project is considering Google spreadsheet and a CGI to edit DBF tables online as two possible media to keep the table, but the exact format is still under discussion.

4 Synergy with the Users' Feedback task

The User Feedback can be provided during the review process in ConnectinGEO. This feedback will be stored in a user feedback system. A strong candidate to do so is the S&T corp. user feedback implementation that was developed during the GeoViQua project and that follows a standard candidate is being moved in the OGC (in the Geospatial User Feedback Standards Working Group; see <http://www.opengeospatial.org/projects/groups/gufswg>). In dead, the geospatial user feedback evolution and its possible interaction with the DAB were presented in a AIP deep dive that took place the Nov 3rt, 2015 (see the recorded video at: <http://www.ogcnetwork.net/node/1969>).

The only requirement that the user feedback system adds is that it has to be a code and a code space. In this case the user feedback entries will be related to the gap entries by means of the gap identifier and the namespace

<http://www.connectingeo.net/gaps>. This way the feedback will be stored separately. The gaps table will only contain a summary of the feedback and the results of the feedback review by a moderator.

5 Review of the methodology for the prioritization

A set of gaps will be elaborated coming from the different threads that were discussed in the previous section and centralized in the gap inventory. Each gap has its own impacts. The first step in this process is to suggest remedies to fill the gap. These remedies can be more or less technically feasible and have some costs. There is a need for setting priorities and try to address the different aspects in the more effective way. The final aim is sorted list of gaps is to inform the funding agencies and generate recommendations on how to remedy them.

There is high probability that some of the current gaps are remained unaddressed until now because they are not feasible to be covered due to technical barriers that make them unachievable, because the cost² for covering them is too high or because there is actually no interest in the data and acquiring it will generate any impact. The balance between these three main criteria will determine the priority that will be assigned in solving the gaps. Indeed, gaps that it is feasible to be covered, we foresee a high impact when filled and have a low cost of investment will have a very high priority (see Figure 1). As a second target, a more difficult (less feasible) and more costly issues can be filled. The gaps out of this two first target can be relegated to a third more generic target.

In that sense,

- Impact is related to
 - User needs in general. A gap that has been detected in more than one threat it is supposed to have higher impact. The URR will help in this direction.
 - A gap that has been detected by needs of current models could be important
 - A gap that has been reported from more than one domain, SBA or CoP (cross domain gap) will have more impact.
 - A gap that makes difficult to generate a value for an indicator of progress in one or more SDG has more impact. Gaps need to be combined with the requirements and needs derived for the strategic targets and EV for Task 2.1 and Task 2.2 with the ones in Task 5.1 and assess the relevance of the gaps.

² It has been argued that cost is a form of feasibility. We are considering here that feasibility is more related to intrinsic limitations of the measurement systems and technical obstacles. Some obstacles can be overcome if enough resources are invested; others can not.

- A gap that affects the in-situ and RS connection could have more impact
 - A gap reported by industry requirement, could have and indirect impacts in creating jobs and other strategic objectives of the EC that are not directly related to EO.
- Feasibility is related to
 - the ability of a remedy for a current gap and the technical and some governmental barriers to implement the remedy.
 - It is important to differentiate what can not be done because demonstrated intrinsic limitations of measurement systems or measured variables and what is technologically achievable in the near future if more research and innovation efforts are applied.
 - We can consider if VGI and Citizens Science can overcome feasibility issues. Citizens Observatories (CO) need a change in mentality in the final users (e.g. active COs tend to produce redundant data that eventually can compensate the individual quality of each observation).
 - Cost is related to
 - The money needed to implement the suggested remedies.
 - Cost of coordination efforts that in the end will reduce costs but could be time consuming to apply
 - We have to consider the money saving strategies such as sharing among networks data logger capture, data distribution networks, data dissemination infrastructures, etc.

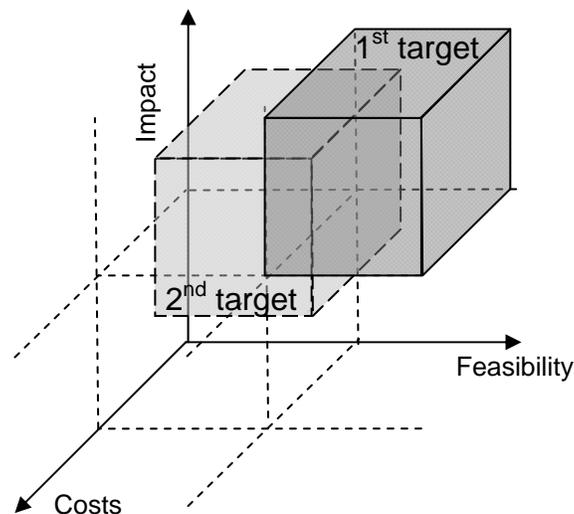


Figure 1: Gaps that need to be prioritized as first target (higher priority) should be situated on high feasibility, high impact and low cost (dark grey area). As a second target, a more difficult (less feasible) and more costly gaps can be filled (light grey area).

To be able to determine the feasibility and the cost we first need to know details about the possible remedies to fill the gaps. Then, feasibility and cost can be determined.

The gap analysis and prioritization done by the project could contain missing points or misunderstandings. For that reason, the project is structured in two loops with a consultation process in between to help in reviewing the gaps, formulate remedies, assessment of impacts, feasibility and cost. Later, the project will determine a priority number based on a set of rules and sort the gaps by the priority

This prioritization will be done in close collaboration with the research funding initiatives and will include the national funding agencies to improve the outtake of the EU funding in observation networks (e.g. in coordination with the ERA-Planet and future ERA-NET initiatives and future SC5 calls).

Substeps:

- Review the gap and determine if it is well known or can be accepted by the consulting experts.
- Determine the impact of the gap by detecting and quantifying the applications of the data. It is related with the requirement that generated the gap in the first place.
- Determine remedies to fill the gap
- Determine the feasibility to implement the remedy
- Determine the cost of apply the remedy
- Determine a priority degree base on the feasibility, the cost and the impact.
- Sort the gap table by priorities
- Classify priorities in the 3 described targets and present recommendations to funding agencies.
- Determine if the gap is been covered later on.

6 Relation with the GEOSS Work Plan, the GEOSS Community, and the other Gaps Analysis initiatives.

This project is one of the European Commission contributions to GEOSS. As part of the methodology, the relation with GEOSS has to be considered and emphasized.



Two ways are foreseen:

- Communities of practices needs in GEOSS will be considered by including the URR in the study as requirements for data. In addition, communities of practices will be able to participate in the different workshops that the project will conduct where their data needs will be recorded as input to the gap table. Communities of practices will be invited also to review the list of detected gaps and make comments and suggestion on the validity of the gaps and their possible remedies.
- ConnectinGEO will contribute tot the GEOSS work plan getting involved in the in-situ or non-space thematic groups both in the interim work plan and the 2017-2020 work plan. Draft results of the gap analysis, progress and conclusions of the project will be contributed to GEOSS. Its contributions will be input to the current IDIB and the equivalent boards that can emerge from the new workplans.