WikiCAP

Category:LPIS upkeep

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<u>SECOND DRAFT</u>

This UPKEEP category represents a 2013 (second) draft of guidance for upkeep processes. Since 2016, the UPDATE related elements have been formalized by the technical guidance update. This upkeep draft remains online for archiving reasons only The update category (https://marswiki.jrc.ec.europa.eu/wikicap/index.php/Category:TG_update) now holds the technical guidance for updating LPIS reference parcels.

You can make a pdf version of this draft (http://marswiki.jrc.ec.europa.eu/wikicap/index.php/Category:LPIS_upkeep?action=pdfbook). It is obsolete

The earlier 1st draft can still be downloaded for information purposes only. This first draft is obsolete.

--Wim (talk) 13:35, 26 April 2013 (CEST) --Wim (talk) 15:57, 8 January 2016 (CET)

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1 LPISupkeep

<u>SECOND DRAFT</u>

This LPIS UPKEEP article represents a 2013 (second) draft of guidance for upkeep processes. Since 2016, the UPDATE related elements have been formalized by the technical guidance update. This upkeep draft remains online for archiving reasons only The update category now holds the technical guidance for updating LPIS reference parcels.

This obsolete, draft guidance provides a comprehensive approach to the many concepts, activities and side aspects of the LPIS upkeep process. It results from further development of the 2009 LPIS dataflow article and describes how the reference parcels should be processed. The final objective is that reference parcel attribute values correctly and complete reflect the current situation on the ground regarding the contemporary set of IACS rules.

The articles hold data flow schemas derived from an Enterprise Architect model. That model provides the logic and business rules expressed in an IT-language. The main wikiCAP articles are textual simplifications of the schemas. Support articles provide in depth explanations and examples. The underlying UML model is obsolete and has been superseded by the draft LCM2 model.

The full model does NOT have to be copied without modification. Despite its detail, the model acts primarily as a conceptual one. LPIS custodians can adapt it to work inside their own IT architecture while respecting the underlying business logic.

You can make a pdf version of this draft guidance

2 Upkeep - Introduction

<u>SECOND DRAFT</u>

2.1 Purpose of the guidance

The purpose of this guidance is to provide a comprehensive view of the technical activities and interactions related to keeping an LPIS up to the specifications, which aims at removing the non-conformities.

Indeed, a reference parcel is not always an appropriate representation of the concepts that it is supposed to represent. A **non-conformity** can appear when

- the physical <u>land has changed</u>, which creates a need for <u>update</u>
- the <u>IACS rules have changed</u>, and consequently an <u>upgrade</u> is necessary
- poor or <u>erroneous processing has been performed</u>, an <u>error correction</u> is required
- <u>incomplete processing has occured</u>, a remediating <u>completion</u> action should be launched.

  If a non-conformity cannot be linked to any of the four above causes, further and deeper investigation in the design and procedures should take place.
  LPIS QA identifies a sixth cause of non-conformity due to the "Historic GAC". Since this latter is of a regulatory character, it is not addressed in this guidance. Please see detailed instruction 3 the LPIS QA methodology for more details.

The upkeep process is primarily documented by the activity model built in Enterprise Architect software. This model is a powerful tool for reinforcing integrity of the guidance. The wikiCAP articles are textual representations of the various components of the model.

This model is available in the download section and can provide a better insight inside the logic and business rules to IT staff and to anybody else who is familiar with UML.

The purpose of this upkeep guidance is to detail the **general upkeep processing and update/refresh activities**. Error correction, completion and upgrades are not detailed in this document and have to be tackled on a case by case basis by the custodian.

2.2 Scope

2.2.1 Essential use cases
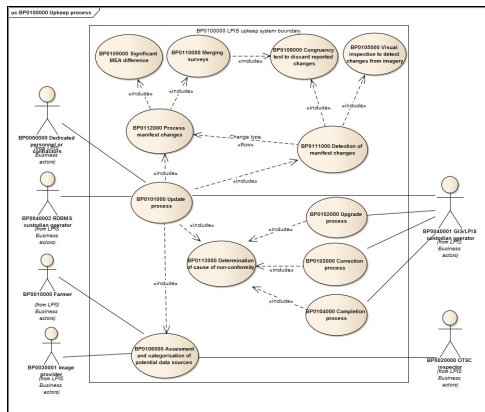
Figure 1.1: essential LPIS upkeep use cases
This guidance addresses the technical aspects and activities required to keep the LPIS reference parcels up to specification. Their upkeep is a continuous process that runs quite separate from the annual process of farmer aid declaration. Although the individual components of the aid declaration process (pre-established form, application, OTSC) are not within the scope of this guidance, the feedback threads that they generate are indicated.

The guidance is built around and affects two database features:

1. the **anomaly**, the vehicle to manage the information exchange on the state of a reference parcel
2. the **reference parcel**, defined in the Regulation, with its key attributes such as geographical perimeter and maximum eligible area.

The **anomaly** is the more abstract of these concepts: it may carry the feedback for various stakeholders, or give the managerial information needed for appropriate planning, reporting, and analysis of the upkeep activities. Analysing the instances of anomalies literally tells the managers what is going on.

The **Reference parcel** is the traditional core feature of LPIS. Correct, complete, relevant, and up-to-date attribute values of a processed reference parcel are the main is the objective of the upkeep processes.

2.2.2 Actors and anomaly threads
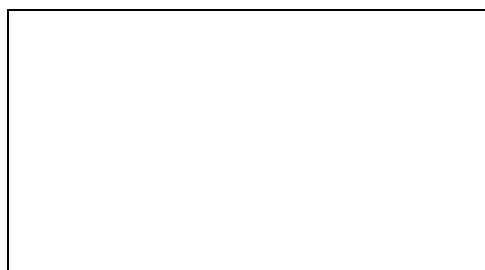
figure 1.2: main stakeholder loops: with agricultural parcel (left) and reference parcel (right)/ 1=farmer, 2=OTSC inspector, 3=LPIS custodian
In general, anomalies can be detected by five stakeholder threads and each LPIS should monitor and address anomalies of each of these threads (see illustration).

1. a <u>farmer</u> should "correct the pre-established form" 1122R2009 art 12.4
2. an <u>OTSC inspector</u> should indicate a "further control measure" 1122R2009 art 32.1.g
3. the <u>LPIS custodian</u> runs dedicated upkeep processes:

   a. <u>third parties</u> (mapping agency, cadastral institution) provide the updates and corrections of the databases under their custody
   b. <u>dedicated personnel or contractors</u> systematically review parcels during either a regular refresh cycle
   c. <u>operational (GIS) personnel</u> sporadically reports anomalies detected during their daily operations
   d. <u>database (RDBMS) personnel</u> reports anomalies detected during database operations
   e. <u>dedicated personnel or contractors</u> systematically review all parcels during an "once off" LPIS refresh project.

See this 2010 presentation for some details on the upkeep processes and their stakeholders.

The LPIS design (i.e. type of reference parcel such as agriculture parcel, farmer's block, physical block and cadastral system / topographic block) determines the relative importance of each thread as well as the conditions for the processes to operate: e.g. a farmer's block requires good farmer input facilities; a topographic block implies working protocols with the mapping agency, etc... This has, however, little effect of this guidance.

2.2.3 Exclusions

What is **NOT in scope** of this guidance, apart from the already mentioned elements of the aid application/control process are:

- LPIS **RP quality** (i.e. the criteria for non-conformity or critical defect, other than those caused by a change of land)
- **frequency of refresh cycles**, to be made on LPIS QA findings and other criteria
- organisation of **third party protocols**, to be made based on local conditions and design considerations
- **standalone mapping methodologies** (i.e. CAPI, use of RFV, survey), where common best practices are expected.
- **rules for retroactive recovery** in cases where undue payments were made

2.3 Definitions

anomaly: observed non-conformity
non-conforming: failure to fulfill one or more specified requirements
observation: act of measuring or otherwise determining the value of a property (ISO 19156:2001 (E))
property: facet or attribute of an object referenced by a name (ISO 19143:2010)
value: element of a type domain (ISO/IEC 19501:2005)

2.4 Abbreviations

AABB : axis aligned bounding box
AP : agricultural parcel
CAPI : computer assisted photointerpretation
CwRS: control with remote sensing
EAEA: expected area error amplitude
IACS: integrated administration and control system
ID: identifier
LPIS: land parcel identification system (also: identification system of agricultural parcels)
OTSC: on the spot check
QA: quality assurance
QC: quality control
RDBMS: relational database management system
RFV : rapid field visit
RMS : root mean square
RP : reference parcel
RA : reference area

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3 Upkeep - Non-conformities

3.1 Updates and refreshes

There is extensive update guidance offered in the following chapters

3.2 All other non-conformities
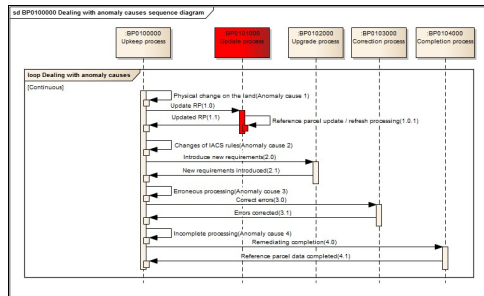
figure 2a.1: dealing with non-conformities by cause
Figure 2a.1 addresses failed update (in red), but also three other causes. For these other causes, guidance is rather straightforward:

- **Either:**

  ◊ **correct any error**,
  ◊ **complete any ommission**,
  ◊ **apply the new rules to the appropriate reference parcels,**

- **log this remediation via the anomaly and**.
- **investigate whether retroactive recovery is appropriate**

There is no dedicated JRC guidance on the three processes because they have to be implemented according to each particular LPIS specification. However, some update techniques, such as on merging surveys or creating new RP identifiers can be applicable.

Obviously, the resulting reference parcel attribute values of these processes should be up to date where appropriate.

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4 Upkeep - Anomalies

<u>SECOND DRAFT</u>

5 Dealing with anomalies

5.1 The concept of anomalies

In the LPIS context, an anomaly materialises a message originating from stakeholders? observation stating that "something is different from what it is supposed to be". This message will start a process to address the issue. This, in turn, involves confirming the non-conformity, taking remedial actions and recording all the connected transactions.

Obviously one or more reference parcels can be affected by the same anomaly and one reference parcel can be affected by more anomalies. Anyway, each affected reference parcel should be uniquely identified. Some of the anomalies are connected with the LPIS specification. Anomalies can be observed in any spatial or alphanumerical attribute value of the reference parcel.

ISO 19156 provides a framework to model observations but this has yet not been applied to LPIS reference parcels of the LCM.

5.2 Properties of anomalies

In database terms, each anomaly and the related observations can be regarded as "objects" or "features". Here we list the attributes that an anomaly should possess if it is used to drive the upkeep process (i.e. confirmation, remediation, and logging the actions related to a suspected non-conformity).

- **Identification**. A unique identification of the anomaly (e.g. an automatically generated sequential number)
- **Object**: Primarily, this should be the identifier of the affected the reference parcel (RPID), which can be further supported by its location (geometryLocation). Alternatively, the object could be a region of interest, whose coordinates (geometryLocation) are used to create "second generation" anomalies through spatial overlay. This approach is particularly useful when changes are reported by third parties (e.g. road builders).
- **Cause**. The cause of non conformity, as soon as it is established. The LPIS QA methodology identifies different types of causes.
- **Observation(s)**. The details on the observation, including:

    1. Author (processOperator)
    2. Values that are suspected non-conforming (OM_GeometryObservation, OM_Measurement, etc.)
    3. Observation date (phenomenonTime)
    4. Other comments (parameter)

- **status in the process**. Details on the processing of the anomaly, including:

    1. Date of reception (resultTime)
    2. Status of actions regarding the confirmation
    3. Status and logged consequences on the LPIS objects
    4. Other comments

5.3 Processing anomalies

The sequence of processing anomalies can be summarized in the following steps:

1. Anomalies can be **observed** by any stakeholder (actor) using the LPIS. This can happen at any time and the anomaly should be described in detail. A **report** is sent to the LPIS/GIS custodian.
2. The operator of the LPIS/GIS custodian **registers** the anomaly in the database of reference parcels. The operator of the LPIS/GIS custodian may observe or collect additional (extra) anomalies that are in turn registered.
3. The anomalies are **processed** by dedicated personnel of the data custodian or alternatively by contracted parties. These actors retrieve the data of the affected parcels from the database and after processing deliver it to the GIS/LPIS custodian.
4. The operator of the GIS/LPIS custodian **validates** the proposed remedial actions. The operator **commits** the corresponding changes to the database and changes the status of the anomaly.

Some actors are expected to report specific types of anomalies as listed below:

- a **farmer**- reports anomalies holding a new area of the reference parcel.
- an **OTSC inspector** - reports anomalies with *an area determined* and a position of the affected boundaries of the reference parcel.
- **third parties** - (partners and contractors) ? report anomalies on images used for control, area and boundaries of the reference parcels.

5.4 Anomaly process sequence diagram

The process described in the previous section is shown in diagram 1 using UML sequence diagram:
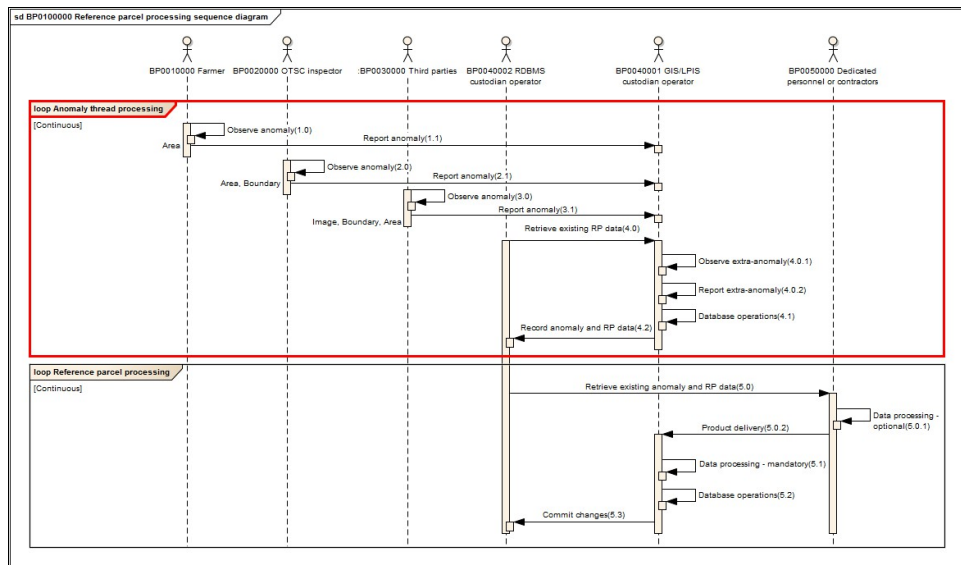
diagram 2.1: Anomaly processing sequence diagram

Please contact the JRC if you wish to share your developments.

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6 Upkeep - Determination of cause

6.1 Determination of cause of non-conformity

If the cause is not delivered with the anomaly, it should be determined during the processing of the reference parcel(s). The cause should be determined before an anomaly can be closed in order to facilitate monitoring and analysis. The diagram bellow shows the steps for determinating the cause for non-conformity:

- verify the anomaly
- check for the causes of anomaly
- check whether the anomaly affects neighboring parcels
- check whether the anomaly is only parcel based
- register the status of anomaly as open or pending

The diagram below provides an illustration of determination of the cause for a non-conformity:
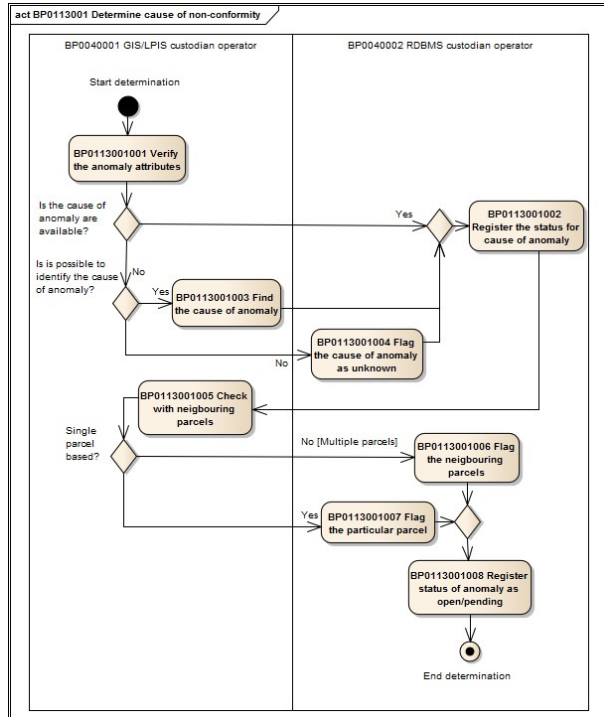
figure 3a.1: Determination of cause for non-conformity

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7 Upkeep - Categorization

<u>SECOND DRAFT</u>

7.1 Imagery

The anomaly detection processes frequently relies on aerial or VHR orthoimagery.

It's not straightforward to specify the usability of imagery in temporal terms (expressed as a maximum age) for all applications and uses. However, depending on the particular application three groups of requirements can be defined:

- For the **systematic review cycle leading to application of art 31a** (thread 3b) or a **refresh project** (thread 3e), the system's imagery should support retroactive recovery up to three years. In other words for any year N, image acquisition dates shall never precede January 1, N-3.
- It should not take more than **3 months to process raw image captures** (the flight) into an orthoimage product, regardless whether the processing is done in house, by a contractor or by a government partner.

    In cases where that processing takes longer (i.e. the three months passed over), the processed imagery shall still be made available to support the following farmer's aid application and other IACS operations. In short, it has to be available by the time the pre-established form is produced.

- Upon receipt, the orthoimagery should be **immediately made available** to all farmers, inspectors and other personnel, even for zones not yet processed in the refresh cycle or project.

7.1.1 Non-imagery

A number of reported anomalies are based on other data sources, not on imagery. They may carry attributes values of the reference parcel with or without geospatial component:

- An OTSC inspector can provide a valid reference area value.
- A part of the boundary can originate from topographic surveys.
- An appropriate "as built" plan can be delivered from a third party partner.

Depending on the particular conditions, data from non-image sources might be more appropriate than the image. This is especially justified when such data is more current than imagery.

7.1.2 Assessment of data sources

It is obvious that addressing a non-conformity can only be based on data that are both **current** and **suitable**. Indeed, it makes little sense to process a reference parcel according to a situation that no longer matches reality. Neither does it make sense to process a change that is only half covered by the image. Therefore, the workflow involves assessing usability in terms of suitability and relevance of source data. The diagram bellow can be split in two phases:

- Phase 1(upper part of diagram) dealing with:
    - ♦ data availability
    - ♦ data usability
- Phase 2(lower part of diagram)
    - ♦ categorization of suitable data (single or in combination)
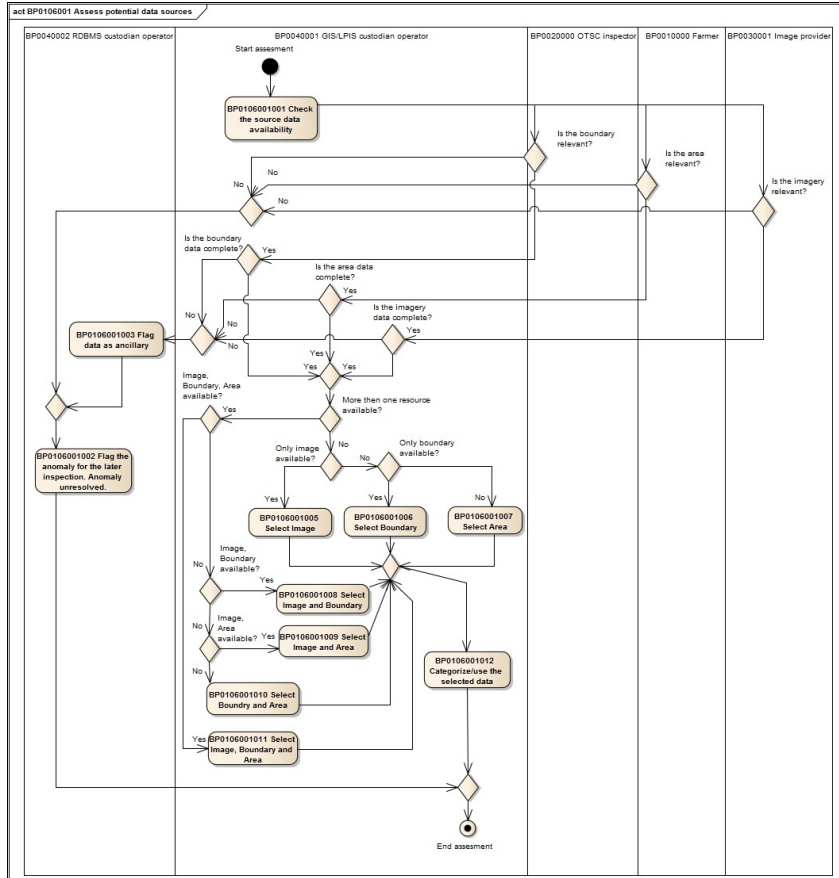
figure 3b.1: Activity diagram to assess suitability of data sources for upkeep

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8 Upkeep - Congruency test

SECOND DRAFT

8.1 Introduction

"Congruent" refers to a situation where two polygons (parcel representations) have the same shape and dimension. As a result, all their corresponding sides (perimeter segments) have the same length, and the angle between any two corresponding segments has the same value. In a simplified form, this concept is used for two purposes:

8.1.1 Vindication of a reported change

When the visual inspection could not detect alledged changes on the land, this congruency test offers a way to **demonstrate that no change has occured**.

The test does not check the full perimeter nor the interior of the reference parcel as these were investigated by the prior visual inspection. It relies on (the lack of) displacements on well identifiable ground points in each cardinal direction.

8.1.2 Calculation of coordinate shift between two shapes

The congruency test procedure and formulas can also be used to determine the **length and direction of the local translation** (coordinate shift) between two congruent representations of a single object. For instance between:

1. the object?s vector and image representation
2. two separate images covering that object.

8.2 The procedure of the LPIS congruency test

8.2.1 Activity diagram
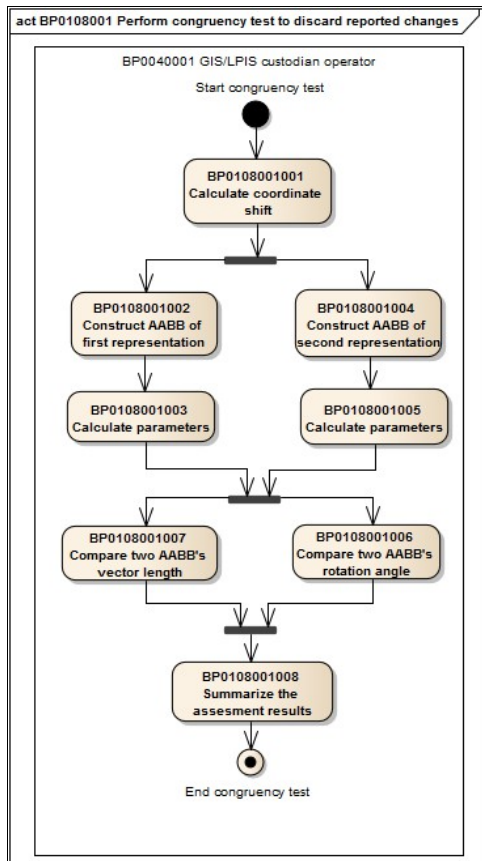
figure 3cii.1: Congruency test activity diagram

Since a congruency test on the full reference parcel perimeter (all sides of the polygon) would result in numerous tests of shapes, sides, angles and dimension, we resort to a very simplified representation of the shape's perimeter, namely the AABB.

The test involves three steps:

1. construct the AABB for one representation (LPIS RP) and calculate its parameters
2. construct the AABB for the other representation (orthoimage) and calculate its parameters
3. compare the two derived vector parameter sets for the absence of scale variation and rotation.

Note: The formulas involved are simple geometric and in a GIS environment, the automation of this process with a user-friendly application and user interface is <u>essential</u>.

8.2.2 1. Defining the AABB of a LPIS RP

Follow the instructions for the AABB construction:

- Select the 2 vertices on the perimeter that represent the most distant from each other. These vertex points should be

    1. ground level points (i.e. not on an elevated positions as tree tops, hedges, walls)
    2. visible (i.e. the view should not be obstructed by a nearby object.)

Record the (x,y) coordinates of each vertex and visualize the long diagonal on screen (A and C)

- Select the vertex on one side of the long diagonal has the largest euclidean distance perpendicular to that diagonal, record the (x,y) coordinates (B)
- Select the vertex of the other side of the long diagonal and record the (x,y) coordinates (D).

BB1 is now the origin of the AABB vector.

The quality and correspondence of the cardinal points is paramount, if several candidates are possible, select those with the best identification potential considering <u>both</u> representations. Restart the process of AABB construction if no suitabe correspondence can be assured.

8.2.2.1 Formulas

Given the coordinates from the collected cardinal points A (Ax,Ay), B (Bx,By), C(Cx,Xy) and D(Dx,Dy)

1. Calculate the orientation of the long axis with help of

$$\tan \alpha_1 = \frac{\Delta y_{AC}}{\Delta x_{AC}}$$

2. Calculate the distance from point B to the long axis

dB = ((Ay-Cy)*Bx + (Cx-Ax)*By + (Ax*Cy - Cx*Ay)) / sqrt((Cx-Ax)^2 + (Cy-Ay)^2)

3. Calculate the distance from point D to the long axis

dD = ((Ay-Cy)*Dx + (Cx-Ax)*Dy + (Ax*Cy - Cx*Ay)) / sqrt((Cx-Ax)^2 + (Cy-Ay)^2)

4. Calculate the coordinates for the four AABB corners as:

AABB corner	x-coordinate	y-coordinate
BB1	Ax+dB*cos(alpha1 + 90)	Ay+dB*sin(alpha1 + 90)
BB2	Cx+dB*cos(alpha1 + 90)	Cy+dB*sin(alpha1 + 90)
BB3	Cx+dD*cos(alpha1 - 90)	Cy+dD*sin(alpha1 - 90)
BB4	Ax+dD*cos(alpha1 - 90)	Ay+dD*sin(alpha1 - 90)

8.2.3 2.Defining the AABB of land on an orthoimage

- Select the 2 vertices on the perimeter that seem the most distant from each other. These vertex points should be:

    1. ground level points (i.e. not on an elevated positions as tree tops, hedges, walls)
    2. visible (i.e. the view should not be obstructed by a nearby object.)

Record the (x,y) coordinates of each vertex and visualize the long diagonal on screen (A' and C')

- Select the vertex on one side of the long diagonal has the largest eucledian distance perpendicular to that diagonal, record the (x,y) coordinates (B')
- Select the vertex of the other side of the long diagonal and record the (x,y) coordinates (D').

BB1' is now the origin of the AABB vector.

8.2.3.1 Formulas

The formulas are *mutatis mutandis* the same as those on the previous paragraph.

8.2.4 3. Comparing both AABB vector parameters for change detection

The formulas to calculate these the angle between the vectors and their difference in length:

The angle between two vectors:

$$\tan \beta_1 = \frac{\Delta y(BB_1 BB_3)}{\Delta x(BB_1 BB_3)}$$

$$\tan \beta_2 = \frac{\Delta y(BB_1' BB_3')}{\Delta x(BB_1' BB_3')}$$

$$\Delta\beta = \beta_2 - \beta_1$$

The length of two vectors:

$$v_1 = \overline{BB_1 BB_3} = \sqrt{\Delta y_{BB_1 BB_3}{}^2 + \Delta x_{BB_1 BB_3}{}^2}$$

$$v_2 = \overline{BB_1' BB_3'} = \sqrt{\Delta y_{BB_1' BB_3'}{}^2 + \Delta x_{BB_1' BB_3'}{}^2}$$

$$\Delta v = v_2 - v_1$$

To pass the test, calculate the difference in angle and length and confirm that:

1. the **angle between AABB RP and ABMM image** is **less than 1 degree**. No relative rotation more than 1 degree has been observed.
2. the **difference in dimension**, measured as the length of the two AABB diagonals is **less than 2.5 meter**. This indicates no compression or stretching has occurred in the direction of the long axis.

Note: in surveying, relative accuracy (scale effects such as compression or stretching) are often expressed via formula with parts per million. At scale 1/5000, such specification could be 0.5mm + 200ppm and for a length of 500 meter, results a threshold of 2.5m + 0.1m. Clearly, it would only affect very large or elongated parcels so is not used here.

8.3 3. Processing the AABB vector parameters for coordinate shift calculation

Shift is calculated through the vector parameters and results as translation between two vector centers (M and M', for illustration see figures 2.1, 2.2, 2.3 and 2.4). The formulas are:

Mid point of source LPIS RP AABB vector	Mid point of new representation AABB' vector	
$\Delta y_M = \frac{v}{2} \sin \beta$	$\Delta y_{M'} = \frac{v'}{2} \sin \beta'$	
$\Delta x_M = \frac{v}{2} \cos \beta$	$\Delta x_{M'} = \frac{v'}{2} \cos \beta'$	
$M_y = BB_{1(y)} + \Delta y_M$	$M'_y = BB'_{1(y)} + \Delta y_{M'}$	
$M_x = BB_{1(x)} + \Delta x_M$	$M'_x = BB'_{1(x)} + \Delta x_{M'}$	

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9 Upkeep - Visual inspection

SECOND DRAFT

9.1 Introduction

This visual inspection, possibly followed by a Upkeep_-_Congruency_test determines if a land change anomaly does indeed exist and represent a manifest change. It offers a quick and simple stepwise method for inspecting LPIS reference parcels for the occurrence of such manifest change.

The main outcome of a visual test is to verify if there is a manifest change. This test has three possible outcomes:

1. The parcel has been stable and there is no need for a remedial action.
2. The test's outcome is inconclusive and the parcel is subjected for a congruency test if a change was reported externally.
3. The parcel has indeed changed and remedial action is needed.

Note: This visual inspection procedure can "*mutatis mutandis*" also be applied for application during the OTSC, measuring a agricultural parcel that wholly occupies one reference parcel. (see 2.6.1 of the art34 guidance)

9.2 Procedure

9.2.1 Activity Diagram

9.2.2 Preparation

Ensure all issues of this checklist are met:

- LPIS, past and actual orthoimage are all set up to ensure good display functionality.
- The visual test conditions are the same as for delineation:

    The visual scale primarily depends on the image resolution and the MMU for the features concerned, parcel size and local ground conditions. A case by case assessment is needed, however, within the range of imagery used for LPIS upkeep:

    - that visual scale should always be larger than 1:5,000
    - the largest recommended scale is 1:1,000 (i.e. a slightly larger scale is possible if the resolution and local conditions allow)

    The decision thresholds defined in this guidance are, unless specified otherwise, not dependent on this visual scale.

- If possible, any systematic shift of image is detected and locally corrected. Use the procedure to determining distance and direction of the shift.
- The RP land can be displayed together with parcel perimeter in LPIS (RP) on both past and present orthoimage.
- The operator is familiar with the specific ancillary data and metadata and can access these during the inspection:

    - the life cycle of the vegetation
    - the boundary delineation precision of the LPIS
    - an indication of the scene view angle or approximate camera position.
    - an estimation of distance and area on the working scale.
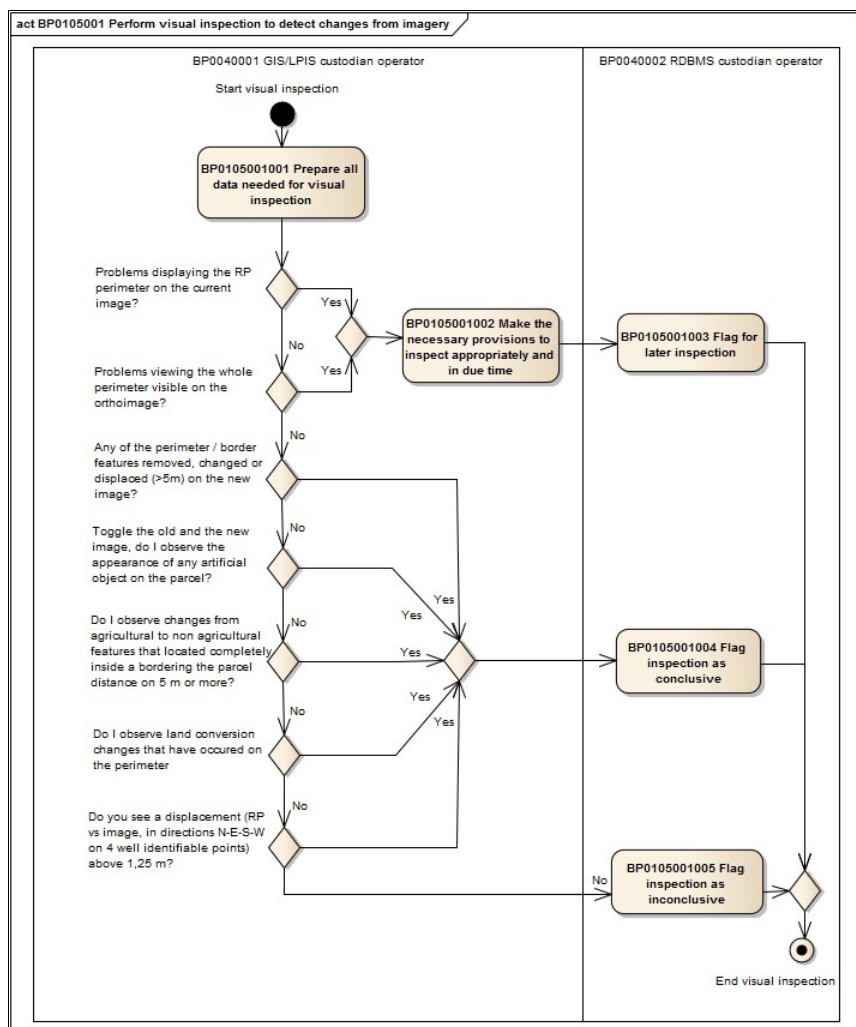
9.2.3 Inspection

diagram 3ci.1: visual inspection activity diagram

During visual inspection, the following questions should be answered in sequence. The test procedure is completed as soon as a positive reply (?yes?) occurs. The inspection and its steps lead to qualitative answers. They do not require digitization, only an assessment by a ?trained eye?.

1. Do I experience problems in displaying the RP perimeter on the locally geocorrected current image? (e.g. does the joint display make obvious sense?)
2. Do I experience problems in viewing the whole perimeter visible on the orthoimage (e.g. nothing is blocked by clouds)?
3. Has any of the perimeter/border features been removed, changed or displaced (> 5m) on the new image?
4. When I toggle the old and the new image, do I observe the appearance of a new building, road or artificial object, etc. on the parcel?
5. When I toggle the old and the new image, do I observe changes from agricultural to non-agricultural features that are located completely inside or along the perimeter of the parcel that represent an estimated ground distance of 5 m or more?
6. When I toggle the old and the new image, do I observe land conversion changes that have occurred on the perimeter, even when appropriately taking into account:

- any displacement due to image processing (max 1-2 pixels)
- any displacement due to the life cycle of vegetation (caused by temporary growth processes)
- any relief displacement of above ground and below grand features (estimated for the image viewing angle and height/depth of the feature)?

7. Identify four, well identifiable _ground level_ perimeter points in each of the four cardinal directions (N-E-S-W). Does any of these show a displacement (RP vs image) above 1.25 m?
8. Can I confirm my replies to the above questions (with ancillary data if needed)?

9.2.4 Outcomes

The outcome depends on the first occurence of a positive reply:

- If all questions but question 8 are answered with ?no?, the parcel has not been subject to change. No remedial action is needed.
- If question 1 or 2 is answered with ?yes?, a full visual inspection is not feasible with the given image. Make the necessary provisions to inspect the parcel appropriately and in due time.

  In cases where an anomaly has been reported (and a visual inspection is not feasible in the foreseeable future), a dedicated field visit should be considered to confirm the anomaly and collect appropriate data for updating the reference parcel.

- If question 3, 4, 5, or 6 is answered with ?yes?, a manifest change has been detected and confirmed. You should register its type and proceed with the upkeep procedure.
- If question 7 is answered with "yes"

  1. the visual inspection is inconclusive _in case_ an anomaly had already been reported by other means than this visual inspection. A congruency test should follow.
  2. Without such anomaly from external sources, the parcel can be considered unchanged.

Record the outcome of the test and the date when the visual test was performed on this anomaly.

Go back to the main upkeep article

10 Upkeep - Detection

<u>SECOND DRAFT</u>

10.1 Detection of manifest changes

The first step in updating is a visual inspection to determine whether a change has occurred. Further processing will only take place if a change is detected or confirmed.

From update point of view, the EC services consider three generic cases of manifest change:

- **type I**: <u>irreversible conversion of agricultural land covers</u> inside reference parcel into a land cover ineligible for activation of SPS entitlements (2009R73 art34) or into land covers other than utilised agricultural area (2009R73 art 124), respectively for SPS and SAPS schemes (and vice versa).
- **type II**: the appearance of <u>permanent constructions</u>, regardless of their width and size, on the RP
- **type III**: any <u>change in the perimeter</u> of RP that causes agricultural <u>land to be exchanged</u> between at least two former reference parcels or allocates previously united land to at least 2 new reference parcels.

Note: type IV changes are considered as the correction of an ommission
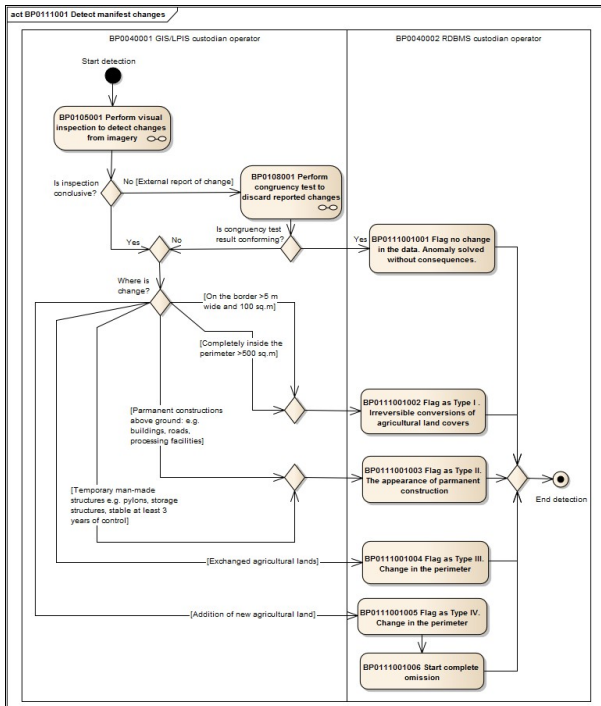
diagram 3c.1: detection of manifest change. Go back to the main upkeep article

11 Upkeep - Area difference

SECOND DRAFT

11.1 Background

A technical tolerance is an expression of uncertainty or precision. Such uncertainty comes from two main component:

1. the nature of the object measured, which is stable and independent from the actual measurement. It can be calculated (semi-)automatically in the LPIS for each parcel
2. the effects of the actual measurement, in case a delineation on digital orthoimagery. This component is measurement dependent and has to be entered on a case by case basis.

Assuming the second component is duly selected and controlled as one would expect for a **reference** parcel, only the first component is considered. The remaining uncertainty is expressed as the expected area error amplitude (EAEA)

11.2 Procedure

The procedure for the calculation of significance of reference area difference:

- input manifest changes by type
- proceed with **types I and III**

     (for type II changes, make Anew the new reference area and finish the procedure)

- determine the reference area for types I and III

     use the EAEA formula that takes parcel properties into account

- calculate the difference |Aold - Anew|

     ◊ if |**Aold - Anew| >= EAEA** than the difference is significant - replace Aold with Anew

     ◊ if |**Aold - Anew| < EAEA** than the difference is not significant - keep Aold

- finish the procedure

Please follow the sequence on the diagram bellow

figure 3dii.1: activity diagram for assessing significant area difference

11.3 Formulas

It's scientifically possible, but rather impractical to establish the probability for each individual image, land cover feature and landscape. Rather a simplified formula is proposed.

The Expected Area Error Amplitude is then calculated as

EAEA = C(RMSp) * B [m2]

11.3.1 RMSp - resolution

RMSp accounts for the map scale represented by the pixel size of the map (note that the guidelines impose a relation between GSD and pixel size, dependent on the sensor type. For CAPI, the RMSp equals the pixel size in meter

11.3.2 C - shape and size

The C-value depends on the shape of the parcel (regular, elongated, irregular?). It is calculated from the Gaussian formula and is a function of the pixel size RMSp:

$$C = \text{RMSp}\sqrt{\frac{n\text{RMSp}^2}{8} + \frac{1}{2}\sum_{i=1}^{n}\left\{\left(\frac{x_{i+1} - x_{i-1}}{2}\right)^2 + \left(\frac{y_{i+1} - y_{i-1}}{2}\right)^2\right\}}$$

where n is the number of vertexes, (x_i, y_i) are the coordinates of the i-th vertex and where the following conventions are adopted

$$x_0 = x_n \quad , \quad y_0 = y_n$$
$$x_{n+1} = x_1 \quad , \quad y_{n+1} = y_1$$

11.3.3 B - border properties

B relates to the nature of the parcel boundary perimeter, it is estimated by the following table, based on the abundance of border quality:

Perimeter composition	>60% precise borders	>25% vague borders	all other conditions
B value	1.96	2.94	2.45

where:

1. **precise borders**: those composed of ground level features that have an identification precision better than 50 cm. Examples are: crop boundaries, base of fences, base of walls, road sides,....
2. **vague borders**: are composed of features NOT at ground level (raised or sunk for 2 meters or more), that block visibility to the ground level and that are subject to cyclical dynamics. Examples are: Lines of threes, high hedges, deep ditches, terraces....
3. **intermediate borders** can be identified for border qualities which do not qualify as either precise or vague: e.g. low hedges, degraded walls.

Note: Any third party boundary (e.g. cadastral boundary, topographic map line) is considered a precise border **IF** it represents a physical (fence, boundary marker) rather than a virtual (legal) feature.

Go back to the main upkeep article

12 Upkeep - Merging surveys

12.1 Introduction

This article describes a reference parcel perimeter can be constructed from components that originate from separate survey activities. It allows merging perimeter parts from

- two different CAPI surveys
- a CAPI and GNSS survey

Merging perimeter parts that originate from two separate GNSS surveys is considered straightforward and not in the scope of this article. As a result there is always at least one background orthoimage involved.

This guidance goes beyond the earlier guidance available on combining Field and CAPI methods during OTSC area measurements]

12.2 Procedure

This instruction detail action BP0110001 of the model.

figure 3di.1: activity diagram for merging surveys

Follow these steps to ensure the relative accuracy of all sources is maintained.

1. Identify the reference parcel subject to perimeter editing.
2. Identify the reference orthoimage to serve as background.
3. Perform the procedure to determine the shift of the LPIS parcel vectors and the reference orthoimage. The test returns a local translation vector between the LPIS vector and the reference image.
4. Make a local correction on the reference image to perfectly georefence with the parcel (i.e. shift the image to exactly compensate the result of the congruency test}.
5. Perform the congruency test between the newly surveyed part of the perimeter and the locally corrected image from the previous step to determine the coordinate shift between that new survey and the locally corrected image.
6. Make a local correction of the coordinates of the new survey to exactly compensate for the shift found during the second congruency test.
7. Replace the old perimeter segment with the locally corrected new survey segment.
8. Connect the newly surveyed part with the remainder of the perimeter, but only between the closest primary vertices (i.e. visible on the reference image) of each component.
9. Calculate the area of the resulting polygon with your GIS software.
10. For type I and III changes, check if the new area is significantly different.

Go back to the main upkeep article

13 Upkeep - Finalize processing

SECOND DRAFT

13.1 Properties and consequences of manifest changes by type

The type of manifest change will, to a large extend, determine the further processing.

1. Type I and III changes require an investigation on the need to input of a "new" reference area value in the concerned reference parcels. Type II changes need an new reference area by default.
2. Some changes will need a change of the spatial (vector) information, either to establish the new reference area value or to demonstrate that this particular anomaly has been accommodated for. Type III changes always need a modification in the common boundary.
3. The requirement to uniquely identify land, entails that type III changes require a new Reference parcel (with its new unique identification) to be created.

The complex interaction of these requirements are laid down in diagram 3d.1.

diagram 3d.1: activity diagram for processing of manifest changes

Go back to the main upkeep article

14 Upkeep - Reference parcel processing
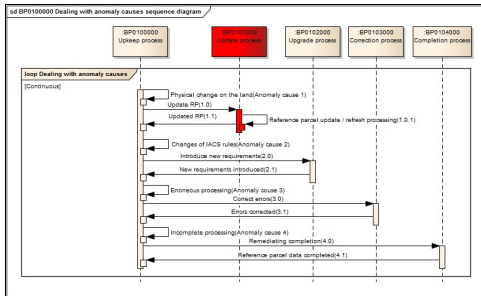
14.1 Updates and refreshes

Figure 3.1: dealing with non-conformities by cause

As a part of upkeep (see the highlighted part of Figure 3.1), **update is the process of addressing non-conformities due to the changes on the land**. It involves all the operations and database interventions necessary to give a reference parcel **up to date** attribute values. Any change that cannot be attributed to the life-cycle dynamics of the land but is due to appearance or dissappearance of physical features is called a " manifest change".

The EC services consider four generic cases of **manifest changes**:

- **Type I**: irreversible **conversion of agricultural land covers**. It involves conversion into a land cover unsuitable for agrictultural activaties (?inclusions? that are 1000m2 or more and/or **along the perimeter** that results in average more than 5 meters wide and measure more than 100m2). Type I also includes the opposite conversions from non-agricultural into agricultural land cover.
- **Type II**: the appearance of **permanent constructions, regardless of their width and size** such as building, processing facility, artificial surface pavement, or other man-made structure that remains more than three years onsite, which changes the land cover or soil condition in a way that normal agriculture activities cannot be carried out.
- **Type III**: **change of the perimeter** at least **between two reference parcels** manifesting in splitting, merging, or mutual exchange of land.
- **Type IV**: **change in the perimeter** of a **single reference parcel** that is caused by inclusion of previously unidentified agricultural land to that reference parcel.

For details please see the support articles in more details and typical examples.

Figure 3.2 represent the UML process diagram of update.
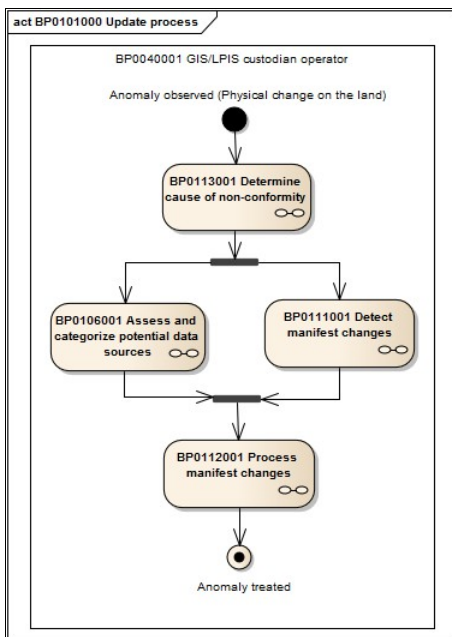
figure 3.2: Activity diagram for updates

- In summary, updates for

1. changes of type I follow the detailed processing schema for confirming the change and committing a new reference area when the difference is significant.
2. changes of type II require reduction of the reference area to take into account the newly appeared feature.
3. changes of type III require the digitization of the new perimeter segments.
4. changes of type IV need to be treated as completion of an omission. From that that point on, they are no longer in scope of the update guidance but follow the non-update processing

Area modifications triggered by type I and type III are subject to the threshold set by the expected area error amplitude (EAEA), inherent to the border of the polygon.

In all cases, completely new reference parcel(s) can be created from scratch and act as completely new reference parcel. At that point, they are no longer in scope of the update guidance but follow the non-update processing

14.2 Update process and sequence diagram

Figure 3.3 provides a general overview of reference parcel processing (the part bounded by red line):
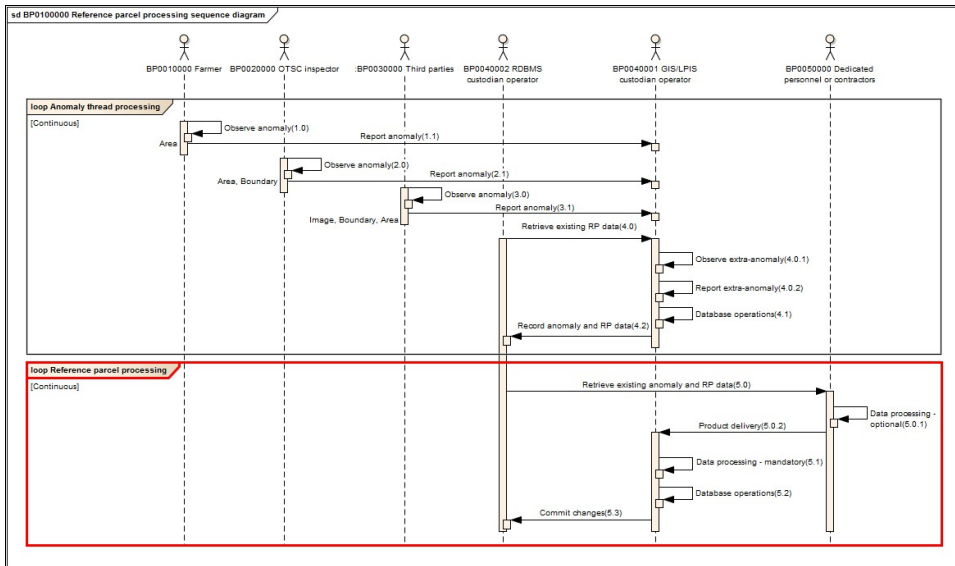
figure 3.3: Sequence diagram for reference parcel processing

As shown in the red highlighted part of the diagram the update process consists of the following steps:

- dedicated personnel or contractors retrieve an existing anomaly and RP data (5.0), review parcels and deliver data (5.0.2). They may perform some data processing (5.0.1), which is optional, since data processing is mandatory at the level of LPIS custodian only.
- the LPIS custodian operator retrieves existing anomalies and RP data (5.0). The operator describes and assesses the anomalies, carries out data processing and testing (5.1) and then performs the necessary database operations (5.2).
- before committing the change (5.3) to the RDBMS, the LPIS custodian reviews the reference parcel against the existing anomaly and RP data (5.0).

Go back to the main upkeep article

15 Upkeep - Manifest changes

15.1 Manifest change

Changes that cannot be attributed to the life-cycle dynamics of the land but are clearly due to appearance or dissappearance of physical feature are called "manifest changes". Manifest changes require an intervention into the database.

The EC services consider four generic cases of manifest change:

- **type I**: irreversible conversion of agricultural land covers inside reference parcel into a land cover ineligible for activation of SPS entitlements (2009R73 art34) or into land covers other than utilised agricultural area (2009R73 art 124), respectively for SPS and SAPS schemes.

    1. combined patches, individually distinguishable, on the border of the reference parcel that are in average more than 5 meters wide and measure more than 100m2.
    2. combined patches completely inside the perimeter (?inclusions?) that are well delineated and cover 1000m2 or more. Given the higher resolution of imagery available to date, JRC recommends to bring into upkeep, insofar scale permits, any well bordered patch larger than 500m2 and so help prevent conflicting OTSC measurements.

- **type II**: the appearance of permanent constructions, regardless of their width and size, on the RP

    1. a building or processing facility (see example 1)
    2. a road or other artificial surface pavement (e.g. concrete floor)
    3. Any other man-made structure that remains more than three years onsite that changes the land cover or soil condition in a way that normal agriculture activities cannot be carried out without significant investment or action (e.g. pylons, storage structures, dumpsters,silos, dung piles?). Even if more than three years may be difficult to assess, detection of a feature on two consecutive images would provide a alternative indication of its permanent character.
    Note: unpaved ground works and planting are considered land conversion and not construction activities.

- **type III**: Any change in the perimeter of RP that causes agricultural land to be exchanged between at least two former reference parcels or allocates previously united land to at least 2 new reference parcels.

    1. Splitting of a parcel into two or more
    2. Merger of two or more parcels into one
    3. Mutual exchange of land between two or more parcels

- **type IV**: Any change in the perimeter of a single reference parcel that causes new agricultural land to be added to that reference parcel.

    1. Parcels extruding into land that was previously outside IACS

Notes:

1. one physical change can cause several manifest changes: i.e. a newly constructed road can easily split a parcel in two.
2. "conversion of land cover" is determined by applying the characteritics referred to in the eligibilty profile.
3. In what follows, the term boundary can relate to either of two concepts introduced above.

    1. on the **"border"** relates to the **land cover / eligibility component** of LPIS as land conversion is concerned;
    2. at the **"perimeter"** relates to the **land identification / tenure component** (production block perimeter, topographic block lines, cadastral parcel) if exchange of land is concerned.
    In pure production block design, both concepts coincide, but other design types can and must differentiate the concepts appropriately.

15.1.1 Properties and consequences of manifest changes by type

The type of manifest change will, to a large extend, determine the further processing.

1. Type I and III changes require an investigation on the need to input of an "new" reference area value in the concerned reference parcels. Type II changes need an new reference area by default.
2. Some changes will need a change of the spatial (vector) information, either to establish the new reference area value or to demonstrate that this particular anomaly has been accommodated for. Type III changes always need a modification in the common boundary.
3. The requirement to uniquely identify land, entails that type III changes require a new Reference parcel (with its new unique identification) to be created.

The table below gives an overview of the manifest changes and their direct effects.

Change	min area	min dimension	new parcel?	new reference area?	new survey?	comment
Land conversion at RP border	0.01 ha	5m	very rare	if significant	affected border	
Land conversion of inclusions	0.05 ha	n/a	rare	if significant	affected inclusion	
New building	n/a	n/a	unlikely	always	when possible	
New road surface	n/a	n/a	possibly	always	when possible	
Other infrastructure	n/a	n/a	unlikely	always	delayed	3 years control
Split RP	0.01ha	n/a	always	if significant	common boundary	
Merged RP	n/a	n/a	always	if significant (sum)	No	
Exchange between RP	0.01ha	n/a	always	if significant	common boundary	
RP extrusion	0.01ha	n/a	always	if significant	affected boundary	

Each type of manifest change is clarified and illustrated in a separate article

15.1.2 Detecting manifest changes to the reference parcel

Manifest changes through land conversion at the border of the reference parcels come with both a specified MMU and minimum dimension. Those inside the parcel have only their MMU specified. But on these borders one can also expect to observe some typical landscape dynamics phenomena as well as technical artifacts as image shifts or changes in cropping pattern. How can one easily distinguish a true conversion of land from an innocent artifact?

It would not be practical if one has to delineate all land ever declared under each anomaly to confirm if a manifest change has truly occurred. Rather, JRC proposes a simple two tier methodology, based on visual inspection

On the other hand, when certain changes have been reported but that report is in fact a "false alarm", there should be a way to demonstrate no further action is needed. In such cases, the subsequent congruence test enables the LPIS custodian to vindicate the reported anomaly.

Pending on the outcome of these combined tests, each observed land change anomaly can either

- be recorded as irrelevant without further processing
- be subject to processing by the upkeep processes and to recording of transaction results.

Go back to the main upkeep article

16 Upkeep - Examples manifest changes

SECOND DRAFT

17 Manifest changes

This article provides examples of the various types of manifest changes. The reference parcels in these illustrations are all real world examples, provided for the sake of illustration of each concept. Note that, with other LPIS design rules, another parcel perimeter might result in the situations here provided. Please apply the concepts *mutatis mutandis* for your actual design.

17.1 Type I: irreversible conversion from agricultural land covers with a minimum extend

These changes relate to a conversion of agricultural land covers into a condition that makes agricultural activities (growing crops, raising livestock or keeping in GAEC) impossible.

1. Irreversible means that the original condition cannot be restored with normal agricultural cultivation measures alone.
2. conversion means the change into any land cover ineligible for activation of SPS entitlements (2009R73 art34) or into land covers other than utilized agricultural area (2009R73 art 124) respectively for SPS and SAPS schemes:
3. the extend (size/dimension) is measured on a individual patches of land, identified after the intersection results of an ineligibility "mask" with the land identification perimeter of the individual Reference parcel. Therefore:

- an individual patch must not be homogenous regarding its land cover, it suffices that all the land covers in the combined patch are non-agricultural
- in larger non-agricultural land features, every intersection with the RP perimeter (land identification) counts as an individual patch.

17.1.1 inclusion: completely included inside the parcel's agricultural borders and/or perimeter

combined patches completely inside the perimeter (?inclusions?) that are well delineated and cover 500m2 or more

figure 4b.1: example of the conversion of agricultural land inside the parcel perimeter - only the area criterion applies.

17.1.2 border side: crossing or touching the parcel perimeter

combined patches, individually distinguishable, on the border of the reference parcel that are in average more than 5 meters wide and measure more than 100m2.

figure 4b.2: example of the conversion of agricultural land crossing the parcel perimeter both the area and dimension criteria apply.

17.2 Type II: irreversible conversion of agricultural land covers regardless their extend

the appearance of permanent constructions, regardless of their area, width and size, inside or crossing the border/perimeter

17.2.1 into buildings and processing facilities

Constructions above ground such as buildings, barns, processing facilities,

If the agricultural land cover is converted beyond the footprint of the building itself, all the converted land should be taken into account as if it was a type II manifest change. Examples:

1. if a windmill is built on a newly established platform, the whole platform becomes relevant.
2. if the surroundings of a new cabin are fenced off, the fence perimeter becomes relevant

figure 4b.3: appearance of a building - always relevant

17.2.2 into roads and other surface pavements (e.g. concrete floor)

Constructions at ground level or underground

figure 4b.4: appearance of a hard surface on the agricultural land - always relevant

17.2.3 involving other man-made structures

Structures that remain more than three years onsite that changes the land cover or soil condition in a way that normal agriculture activities cannot be carried out without significant investment or action (e.g. storage materials, dumpsters, pylons,?).

Some structures can require a case by case evaluation: e.g. a pylon in grassland may not affect the pastoral activities, whereas a similar pylon in an arable field would make future plowing impossible.

figure 4b.5: appearance of an infrastructure component (windmill) - always relevant

17.3 Type III: perimeter modifications that involve an exchange of agricultural land

Any change in the perimeter of RP that causes agricultural land to be exchanged between at least two former reference parcels or allocates previously united land to at least 2 new reference parcels.

17.3.1 Splitting of a parcel into two or more

One reference parcel is divided into two or more new parcels. The general external perimeter of the land concerned is not altered, but the old ID is archived and new ID's are created.

figure 4b.6: appearance of a road causing the split of two parcels from one

17.3.2 Merger of two or more parcels into one

Two or more reference parcels that are merged into a single new parcel. The external perimeter of all land concerned is not altered, but the old IDs are archived and new RPID is created. If no type I or type II change has happened, the new MEA is simply the sum of the MEA's of merged originals.

figure 4b.7: Merger of several reference parcels into one

17.3.3 Mutual exchange of land between two or more parcels

Whenever two adjacent reference parcels have a change in their common boundary. All affected IDs are archived and new ID's are attributed. New IDs are necessary all parcels affected by the swap because the land represented by the ID cannot be unambiguously identified over time.

figure 4b.8: Mutual exchange of land between two reference parcels.

17.4 Type IV: Reference parcel extruding into land that was previously outside IACS

This occurs when non-agricultural land is developed into agricultural land to create a joined production block with a neighbouring reference parcel. A new ID is necessary for the resulting enlarged reference parcel. The parcel is processed as if dealing with an omission.

This case should not be confused with the conversion of non-agricultural land completely inside the perimeter of an existing reference parcel, which constitutes a type I change.

figure 4b.x: An illustration will be published when ready.

Go back to the main upkeep article

18 Upkeep - Examples visual inspection

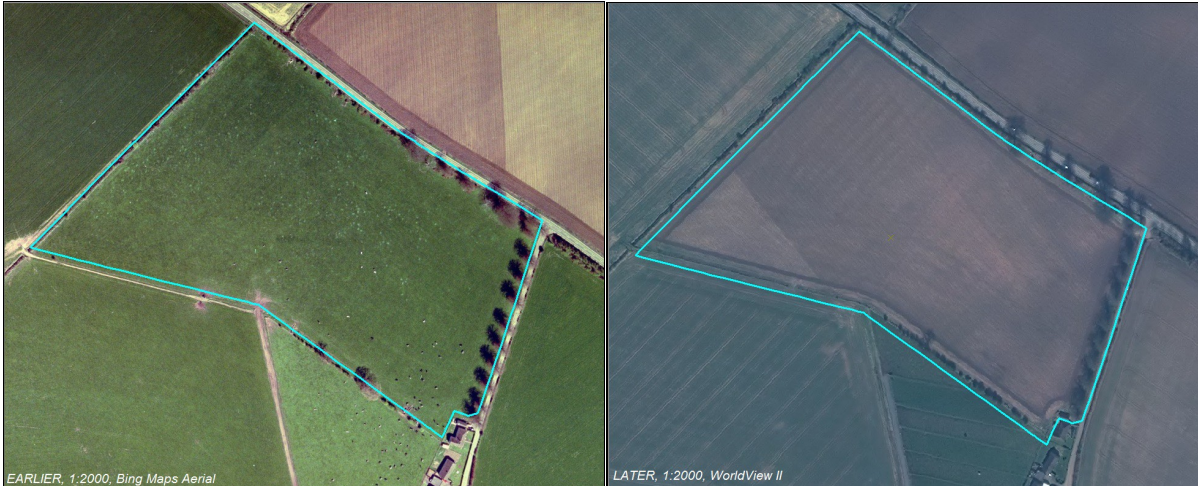## 18.1 Example of the visual inspection

figure 4c.1: An example where visual inspection is inconclusive.

1. the overall situation makes sense
2. the parcel perimeter can be visualized
3. the perimeter is still valid
4. no constructions appear,
5. no conversion into non-agricultural land occurs,
6. no part of the boundary is subject to displacements (the tree base is visible).
7. the displacement of the corners is larger then 1.25: "YES" and a congruency test has to be performed.

as this particular congruency test has not confirmed change, this reference parcel has not changed:

Go back to the main upkeep article

19 Upkeep - Examples congruency test

<u>SECOND DRAFT</u>

19.1 Definitions

Congruent: situation where two polygons (parcel representations) have the same shape and dimension as a result, all their corresponding sides (perimeter segments) have the same length, the angle between any two corresponding segments has the same value.

In general, congruency indicates that one object can be transformed onto the other by a combination of translation and rotations (but not resized). In LPIS context, both representations need to be in the national CRS, so rotations are not expected and only translation are relevant.

LPIS polygons are congruent if they have the same number of sides, all the corresponding sides have the same length and orientation. It follows that all corresponding interior angles have the same opening (in the theory).

Shape: geometrical description of the part of the (2-dimensional) space occupied by an object, as determined by its external boundary.

Dimension: distance between two opposite sides of a feature.

Angle: measure of rotation by the diagonal axis.

Side: segment of a shape between two vertices.

Axis-aligned bounding box (AABB): generalized polygon representation of the parcel, with the coordinate axis aligned to the longest axis of the parcel. It can be constructed using of four specific vertex points:

- the 2 vertices on the perimeter that have the longest possible line segment between them (i.e. the define the long diagonal).
- the vertices removed at the longest distance from either side of the long diagonal. The sum of the respective (not necessarily collinear) distances offers the total length of the perpendicular axis.

It is the box, aligned with the local coordinate axes, with the area that fully contains the polygon.

19.2 Illustration of the congruency test to detect manifest change

Figure 4d.1 presents the RP representation (= the polygon) retrieved from the LPIS and the new representation (=the image) on the orthoimage of a later date.
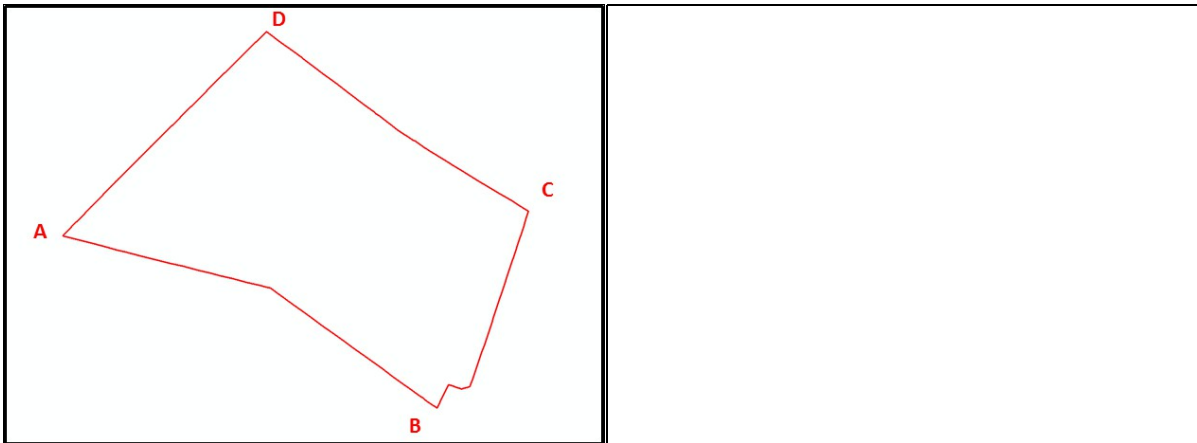

figure 4d.1: Existing parcel representation (left) and new parcel representation (right)

Figure 4d.2 shows the construction phases of the AABB derived from the existing RP representation. Key elements are the determination of the longest diagonal [AC] and the two perpendicular axis [DD'][BB'] where the dimension is maximal.
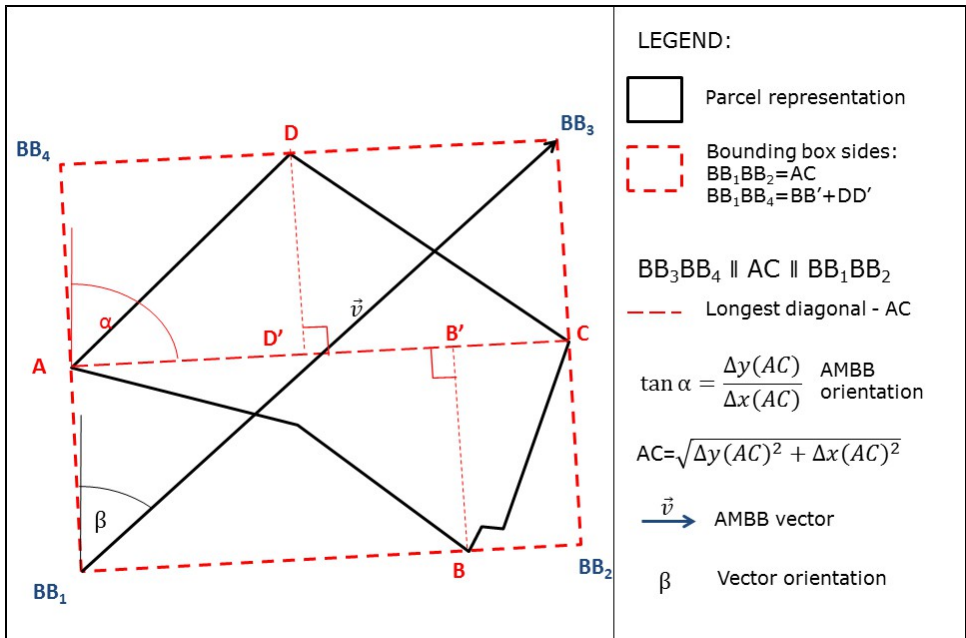
figure 4d.2: the axis-aligned bounding box construction (the dashed rectangle)

Figure 1.3 compares the original vector and associated AABB with the corresponding cardinal points on the orthoimage representation.
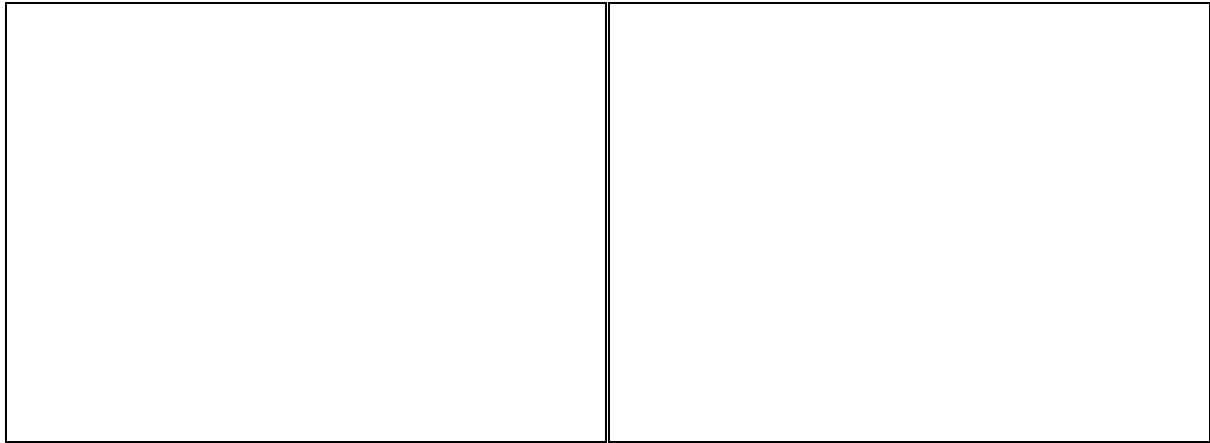

figure 4d.3: LPIS parcel and AABB (left), Cardinal points of vector and orthoimage representation (right)

Figure 4d.4 shows on the left the two aligneed minimum bounding boxes superimposed on the the orthoimagery. The shift between the two AABBs is obvious. In the right image, the LPIS AABB is translated so that the origins of the AABB coincide. Only the small rotation remains visible.

figure 4d.4: original AABBs superimposed (left), translated LPIS AABB and image AABB superimposed (right)

The AABBs derived above yield the following parameters.

AABB	coordinate	Start point	End point	parameter	observed value	decimal
1	Easting(Y)	327575.217	327998.139	length	574.2841	
1	Northing(X)	705215.785	705604.294	angle	47°25'42.505	47.428474
2	Easting(Y)	327578.387	328003.573	length	573.2119	
2	Northing(X)	705220.766	705605.199	angle	47°52'53.794	47.88161

As a result:

       ◊ the observed difference in length is 1,0722 meter, less than the 2.5 m threshold
       ◊ the observed difference in angle is 0,453136 degrees, less than the 1 degree threshold

No manifest change has been detected, the conclusion must be that the reference parcel has not changed.

19.3 Illustration of the congruency procedure to determine coordinate shift

Figure 4d.5 presents the RP representation (= the polygon) retrieved from the LPIS and the new representation (=the orthoimage) at a later date.
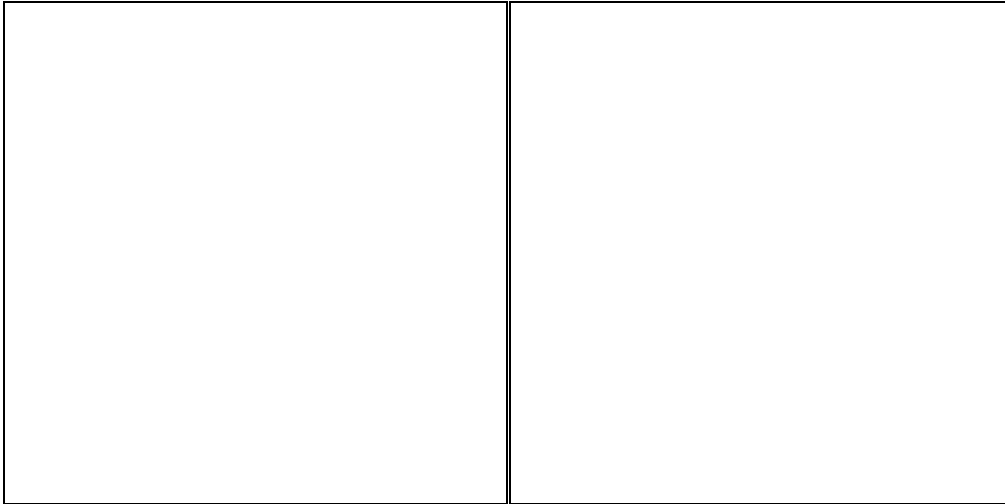

figure 4d.5: Existing parcel representation (left) and new parcel representation (right)

Figure 4d.6 compares the original vector and associated AABB with the corresponding cardinal points on the orthoimage representation.
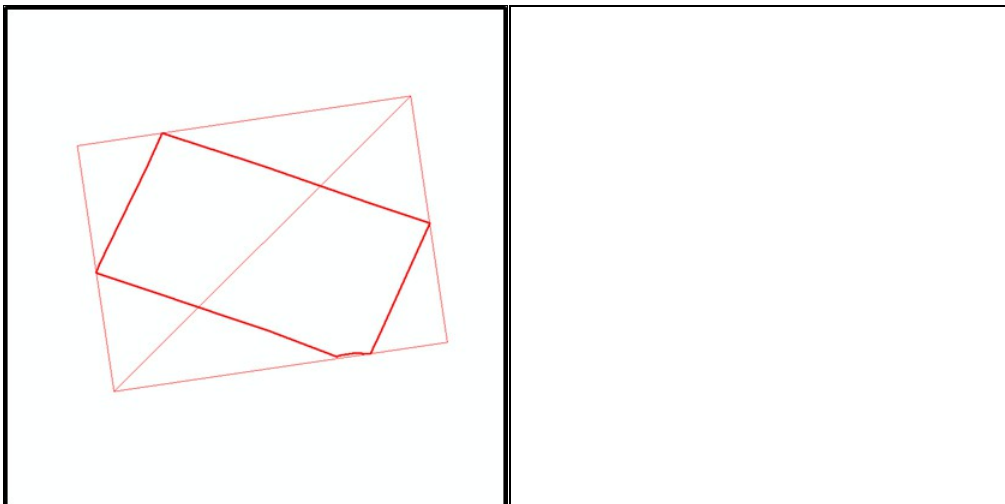
figure 4d.6: LPIS parcel and AABB (left), Cardinal points of vector and orthoimage representation (right)

Figure 4d.7 shows on the left the two axis aligned bounding boxes superimposed on the orthoimagery. The shift between the two AABBs is obvious. In the right image, the LPIS AABB is translated so that the origins of the AABB coincide. Only a very small rotation remains visible.

figure 4d.7: original AABBs superimposed (left), translated LPIS AABB and image AABB superimposed (right)

The AABBs derived above yield the following parameters.

Go back to the

20 Upkeep - Examples merging surveys

This article graphically illustrates how the congruency test is applied on two surveys and how the results are used to ensure both are correctly represented in a single local spatial reference.

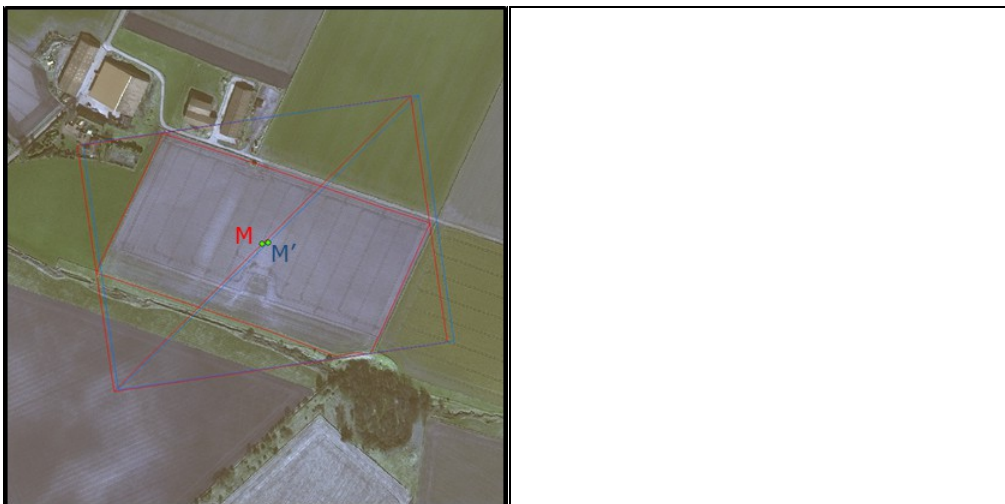**Phase 1**: local georeferencing of the reference image

figure 4e.1: original (left) and georeferenced (right) reference image. The image is translated.

Phase 2: local georeferencing of the newly surveyed segment

figure 4e.2: original (left) and georeferenced (right) survey vector. The survey vector is translated.

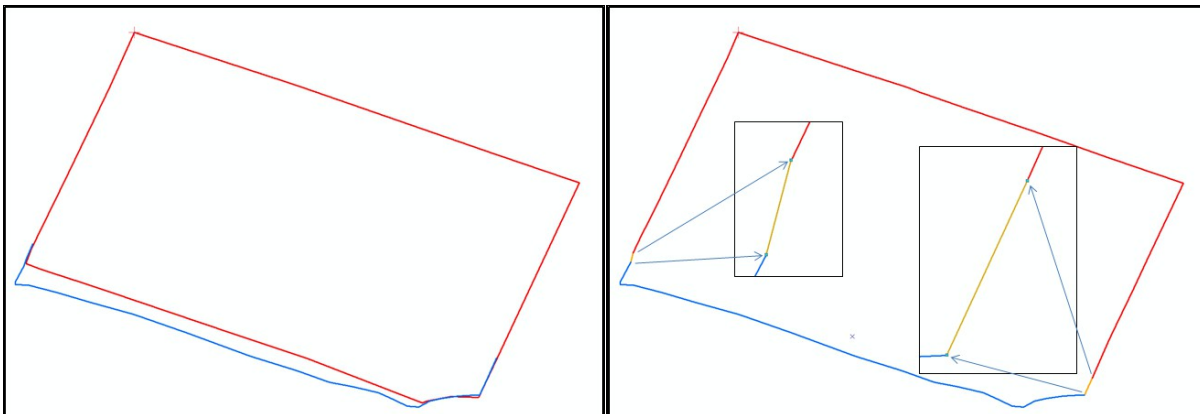**Phase 3**: selection of primary vertices

figure 3e.3: Original (left) and selected (right) boundary segments for construction of the new perimeter. The dangling segments beyond confirmed primary vertices are removed from both original perimeter and new survey vector.

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21 Upkeep - Expected area error amplitude

21.1 Basic concepts

21.1.1 Background

A technical tolerance is an expression of uncertainty or precision. Its value depends on the measurement methodology and conditions such as source material and the nature of the object measured.

A tolerance should be known for any particular method and can only be applied to that specific measurement. It then serves a pass/fail function: if there is a significant difference between that specific measurement and an older one of the same object, the new measurement value should be used, else, one must accept the old value as remaining true and valid.

This article approaches such tolerance from its two main component:

1. the nature of the object measured, which is stable and independent from the actual measurement. It can be calculated (semi-)automatically in the LPIS for each parcel
2. the effects of the actual measurement, in case a delineation on digital orthoimagery. This component is measurement dependent and has to be entered on a case by case basis.

21.1.2 Incertainty (or error components)

The main contributors to incertainty are:

- **Normal variation**: Even in ideal conditions, no two measurements of an object will provide exactly the same result: A series of repetitions will follow the normal distribution so the probability of a result can be estimated by gaussian theory. Significance is then based on a threshold probability of the value being measured. Traditionally, this probability is set to 0.95 (two sided) meaning that, if 20 repetitions of the measurement would be made, 19 of these would be in the range. Clear instructions and trained operators are the instruments to keep the normal variation to a minimum.
- **Parcel conditions**: In the real world, ideal parcels are rare.

    ◊ not all measurement vertices (boundary markers) can be measured with the same precision: fence pole, crop boundary corner, hedge each has a different "identification accuracy".
    ◊ the area of simple square polygons are measured more precisely than irregular or elongated polygons

- **Image resolution**: Image resolution influences the precision similar to marker spacings of a ruler: Lower resolution (=larger pixel size) brings in more incertainty. Other image qualities are not considered in the tolerance as the imagery is assumed "fit for purpose".

21.2 Setting the tolerance for CAPI operations

21.2.1 Main formula

It's scientifically possible, but rather impractical to establish the probability for each individual image, land cover feature and landscape. Rather a simplified formula is proposed.

The expected area error amplitude of the measurements is then calculated as

$$EAEA = C \, (RMSp) * B \, [m2]$$

Where:

1. **RMSp**: the map scale represented by the pixel size of the map (note that the guidelines impose a relation between GSD and pixel size, dependent on the sensor type
2. **C**: the shape of the parcel (regular, elongated, irregular?):
3. **B**: the nature of the parcel boundary perimeter and its length

21.2.2 Supporting formulas

21.2.2.1 C shape, size and resolution

C is calculated from the Gaussian formula and is a function of the pixel size RMSp:

$$C = \mathrm{RMSp} \sqrt{\frac{n\mathrm{RMSp}^2}{8} + \frac{1}{2} \sum_{i=1}^{n} \left\{ \left(\frac{x_{i+1} - x_{i-1}}{2}\right)^2 + \left(\frac{y_{i+1} - y_{i-1}}{2}\right)^2 \right\}}$$

where n is the number of vertexes, (x_i, y_i) are the coordinates of the i-th vertex and where the following conventions are adopted

$$x_0 = x_n \quad , \quad y_0 = y_n$$
$$x_{n+1} = x_1 \quad , \quad y_{n+1} = y_1$$

RMSp = pixel size in meter

21.2.2.2 B: border properties

B is estimated by the following table, based on the abundance of border quality:

Perimeter composition	>60% precise borders	>25% vague borders	all other conditions
B value	1.96	2.94	2.45

where:

1. **precise borders**: those composed of ground level features that have an identification precision better than 50 cm. Examples are: crop boundaries, base of fences, base of walls, road sides,....

2. **vague borders**: are composed of features NOT at ground level (raised or sunk for 2 meters or more), that block visibility to the ground level and that are subject to cyclical dynamics. Examples are: Lines of threes, high hedges, deep ditches, terraces....
3. **intermediate borders** can be identified for border qualities which do not qualify as either precise or vague: e.g. low hedges, degraded walls.

Note: Any third party boundary (e.g. cadastral boundary, topographic map line) is considered a precise border **IF** it represents a physical (fence, boundary marker) rather than a virtual (legal) feature.

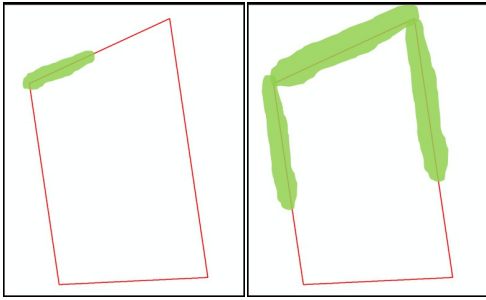Figure 4f.1 illustrates the concepts of precise border and vague border.

figure 4f.1: left: parcel with predominantly precise border (red); right: parcel with predominantly vague borders (green).

The determination of the B-value for a given parcel solely depends on the abundance of these precise and vague borders along its perimeter, intermediate borders play no role at all.

In general, there should be no need to measure the abundance of precise and vague borders in detail. An estimation procedure adapted to the landscape should do in the vast majority of cases. If doubt remains, the 2.45 as B-value can be taken. Figure 4f.2 provides examples and details of cases where the abundance of border classes prevents the use of this 2.45 B value.

figure 4f.2: The green shaded shape indicates vague borders that can not be delineated accurately. Left example: 301m precise border (red) on a 375m perimeter or 80.2% > 60% and the B value is set to 1.96). Right example: 240m vague border (green) on a 295m perimeter or 81.3% > 25% and the B value is set to 2.94.

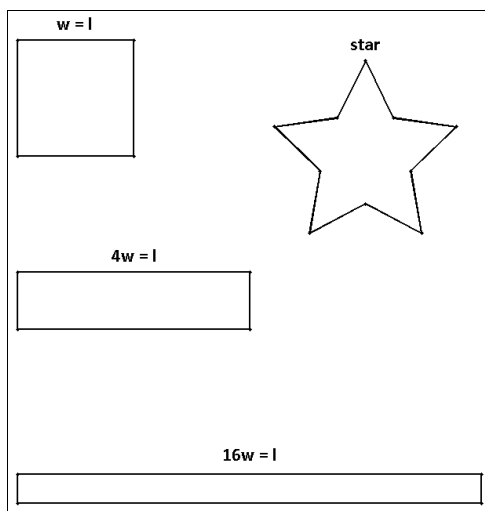## 21.3 Illustration of polygon error by shape and size

figure 4f.3: shapes used for simulation
The results from the above formula are calculated for various sizes of four simple and symmetric shapes: a square (w=l), a rectangle (l=4w), an elongate rectangle (1=16w) a 5-pointed star .

The resulting area errors are calculated for shapes with precise borders (B = 1.96). Vague borders cause an increase of these results with 50% (= 2.94 / 1.96).

21.3.1 Area and Perimeter of the shapes

The relation between area and perimeter (the basis for buffer tolerance) is provided below for 4 different shapes. Each line holds the area and perimeter for each of the 4 shapes. Area is expressed in square meter (and ha), perimeter entries are in meter.

Area	w=l	4w=l	16w=l	Star
100 (0.01ha)	40	50	85	55
1000 (0.1ha)	126	158	269	173
5000 (0.5ha)	283	353	601	387
10000 (1ha)	400	500	850	548
50000 (5ha)	894	1118	1901	1225
200000 (20ha)	1789	2236	3801	2450

21.3.2 Area errors for the shapes using measurement based on 50cm RMSp

The table below lists the expected area error amplitude as calculated for each shape for a given area and an RMSp of 0.5 meter. All entries are expressed in square meter.

Area	w=l	4w=l	16w=l	Star
100	9.80	14.29	27.77	8.40
1000	30.99	45.18	87.83	26.57
5000	69.30	101.02	196.38	59.40
10000	98.00	142.86	277.73	84.00
50000	219.13	319.44	621.02	187.83
200000	438.27	638.88	1242.03	375.67

21.3.3 Area errors for the shapes using measurement based on 20cm RMSp

The table below lists the expected area error amplitude as calculated for each shape for a given area and an RMSp of 0.2 meter. All entries are expressed in square meter.

Area	w=l	4w=l	16w=l	Star
100	3.92	5.71	11.11	3.36
1000	12.40	18.07	35.13	10.63
5000	27.72	4.41	78.55	23.76
10000	39.20	57.14	111.09	33.60
50000	87.65	127.78	248.41	75.13
200000	175.31	255.55	496.81	150.27

21.3.4 Effect of additional vertices

The EAEA formula relies on meaningful polygon vertices. Adding collinear points inbetween primary vertices improves the measurement and reliability and so reduces the amplitude.

For a 1 hectare square polygon

- with only 4 corner vertices, EAEA = 98m²
- with 20 vertices (1 every 20m on the perimeter), EAEA = 58.80m²

both calculated using RMSEp = 50cm and B = 1.96

21.4 Further discussion

21.4.1 Some trivial observations

- By using such technical tolerance, there still remains a 5% chance that a the new measurement will indicate a difference where there is none.
- As the old value is taken as reference, there is no tolerance applied to this value. The appropriate tolerance is only applied to the new measurement .

- The advances in technology generally cause the new measurements to be more precise (i.e. with a smaller tolerance) than the methodologies used to obtain the old value. However, this is not guaranteed in these update processes, as recent imagery may be coarser than the reference image used for the reference values.
- Technical tolerances should not be confused with thresholds, which are conventional baselines controlling a decisions.

  ◊ There is no uncertainty involved with thresholds, but it does imply that any method used to collect information is precise enough to make such threshold meaningful. Setting a threshold lower than technical tolerance used for the measurement is in fact nonsense. On the other hand, using a method that comes with a tolerance larger than the threshold is equally unacceptable.
  ◊ A well known threshold is the limit for the area difference of 3%/5%/7%, pending on parcel size. This threshold determines area non-conformity during the LPIS QA and is dependent of parcel-size.

21.4.2 Implications regarding the image acquisition

Dividing the AE derived from the formula by the parcel area results in the relative area error. If follows that, in all but the very small reference parcels, the 3% threshold is met by applying orthophoto of:

1. 0.5 m pixel size for regular parcels
2. 0.2 m pixel size for elongated parcels
3. 1.0 m pixel size for regular parcel of area greater than 2000 m2 and for elongated parcels of area greater than 10000 m2.

This knowledge is crucial when planning your data acquisition. If measurements consistently (consider more than 5 % of the cases) overshoot the thresholds, the imagery is not appropriate for that particular zone.

21.4.3 Implications regarding the LPIS design

The ability to correctly quantify by delineation the MEA for direct aids is a key functional requirement of the LPIS reference parcel. If, despite using optimal imagery, the AE derived from the formula keeps overshooting the 3% threshold, one should check if the parcel design is truly appropriate in the given landscape.

Some landscapes and parceling pattern pose real challenges to the LPIS design, but in some cases the sub-parceling and parcel aggregation can cause small or irregular parcel borders/perimeters. As a general rule, reference parcels that closely reflect the actual land management are less likely to cause problems (see slides 24-34 of this presentation

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22 Upkeep - EAEA experimental data

22.1 Introduction

Pending a dedicated experiment, the expected area error amplitude (EAEA) formula was applied to parcel coordinates of existing surveys. The variability of point survey measurements was analyzed using data set from the GNSS validation for buffer tolerance.

22.2 Test conditions

Coordinates are recovered from GNSS validation test for area measurement made by Finish Services and Paying Agency in January 2010. Key data characteristics:

- The point surveys were made with a GeoXH GNSS receiver using real time Trimble VRS differential corrections, with estimated point accuracy (RMSp) of around 50 cm.
- The data set represents 6 sets of 4 independent repetitions of total for each of the 6 parcels.
- The parcels differ both in shape and size. Their areas range from 0.07 to 1.57 hectares and their perimeter from 190 to 515 meters (see Table 1).
- The set of coordinates per repetition is collected within a time frame that compatible with the dGPS settings and normal field practices.
- All parcels have a B-value of 2.45 except the smallest parcel that has a B-value of 2.96 (fully surrounded by trees)

==Test Results

Parcel ID	S1	F1	S2	S3	F2	F3
Area (ha)	0,0663	0,2456	0,3014	0,3164	0,5447	1,5671
Perimeter (m)	237,5	192,2	287,4	343,4	284,6	514,4
# of vertices	13	12	14	14	10	17

table 4g.1: area, perimeter and number of vertices of each of the 6 parcels
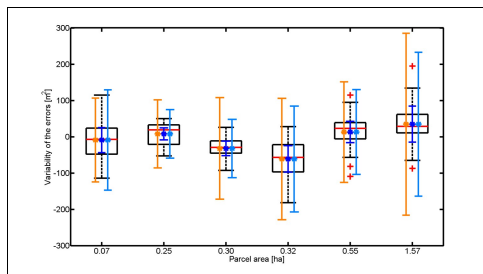

figure 4g.1: boxplot of oberserved areas
Figure 4g.1 provides the boxplots with

- In black/red: the observed variation during the test represented with a boxplot:

    1. the observed 1st and 3rd quartile (black box);
    2. the observed median (red line);
    3. the minimum and maximum observations not detected as potential outliers (black lines);
    4. potential outliers (red crosses).
        An observation is set as potential outlier if it is not in the interval [1st quartile - 1,5 x IQR ; 3rd quartile + 1,5 x IQR] where IQR is 3rd quartile - 1st quartile. This interval theoretically contains approximately 99% of the distribution

- In orange: the 99% interval of the distribution calculated as ?perimeter x validated buffer value?
- In blue:

    1. the estimated 1st and 3rd quartile calculated from the proposed EAEA formula (blue)
    2. the estimated 99% interval of the distribution calculated by from the proposed EAEA formula (light blue)
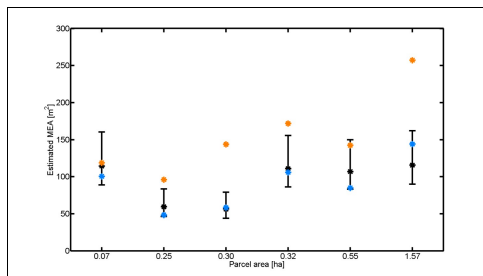

figure 4g.2: Comparison between area errors
Figure 4g.2 provides the comparison between the observed EAEA (i.e. 1.96 x the observed standard deviation; black stars) and the estimated EAEA from the perimeter buffer tolerance rule (orange) and the proposed formula (light blue). The intervals in black represent the uncertainty of the observed EAEA. This interval is based on the chi square distribution with a degree of freedom equal to 23 (i.e. 6 x 4 repetitions - 1).

22.3 Discussion

This preliminary test supports the relevance of the expected area error formula:

- All repetitions measured an area that lays well inside the predicted 99% intervals for both methods (see Figure 1).
- All the statistical outliers (but one for the proposed formula) fall inside the predicted 99% intervals (see Figure 1).
- Contrarily to the perimeter buffer tolerance rule, the proposed formula produces predicted EAEA values that all fall in the 95% confidence intervals (Figure 2)

- It also shows that in all cases, for this type of area measurement, the MEA is a closer estimator of the observed variation than the perimeter buffer method (see Figures 1 and 2).

A dedicated test will shortly be set up for a more advanced assessment of the proposed formula that is:

- More precise measurement tools (e.g. RTK system);
- Uncorrelated measurement errors;
- More repetitions for each parcel;
- Parcels with different shapes but sharing the same perimeter

In such conditions, the perimeter buffer tolerance rule will produce exactly the same area error amplitude for each parcel while the proposed formula will produce specific one for each parcel

The formula should be used before the settings of the field test in order to identify in advance the shapes that will better highlight the differences of predicted area error amplitude.

22.4 Further reading

- expected area error amplitude formula

Fasbender, D., Lucau, C. and Bogaert, P. (2013). A new theoretical framework for the assessment of error propagation on polygonal area measurements, working paper.

- uncertainty of the observed EAEA

Cochran, W. G. (1934). The distribution of quadratic forms in a normal system, with applications to the analysis of covariance, Mathematical Proceedings of the Cambridge Philosophical Society, 30(2): 178?191. or see wikipedia

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23 Upkeep - Downloads

23.1 Tools

There currently no tools available for download. We do invite MS to share tools (e.g. to document anomalies or to perform a congruency test)

23.2 Models

This first release of the LPIS upkeep business model is identified as v09. It is a pre-release, missing the glossary and maybe some bugs. A stable version, if any, and updates will be published on this article in due time.

The project file contains LPIS the full upkeep business model including actors, use cases, activity and sequence diagrams. These diagrams illustrate LPIS upkeep wikiCAP guidance. Each UML-element has a unique identification code to support communication and traceability. The model can be used for various scenario simulations.

The model is developed using and tested with Enterprise Architect v 10.0.1004 Professional version (http://www.sparxsystems.com.au/). It opens under different versions (tested with v7.5.850) but the scenario simulation depends on the license and version you use.

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24 Upkeep - LPIS specification issues

This reflection article is not intended to provide specifications, nor to change any existing specification.

24.1 The minimum mapping unit (MMU)

In LPIS terms, the minimum mapping unit at a given scale is the size (expressed in area units) below which a legend "feature" can be reasonably represented by a polygon or as individual area. Note that the legend consist of the agricultural land classes and one, combined, non-agricultural land (ineligible) class. There are currently two different mapping units in operation in IACS.

- The 2004 LPIS creation guidance allowed for an MMU on ineligible inclusions up to 0.1 ha for calculating the MEA. This provision directly applicable to all production blocks, whose exterior perimeters were expected to follow agricultural land borders. There was no MMU at production block perimeters.
- The OTSC specifications required individual accountability for all combined ineligible features larger than 0.01 ha, resulting in an area measured and area determined.

Comparing the MEA and area determined of a parcel can lead to an anomaly on the MEA, even when both measurements were correctly established according to the respective specifications. Such anomaly cases show that the MMU truly represents a LPIS "design" issue and that this MMU is an important element with a role in the update guidance.

In this LPIS update guidance, a MMU is defined based on the nature of the change. In addition, a parcel specific "maximum area error" is introduced for vindicating anomalies detected via area measurement repetitions.

24.1.1 Dynamics of agricultural land covers

Agricultural land changes all the time and so does the land cover that was delineated for LPIS purposes. But many observed changes represent dynamic phenomena inherent to the agricultural land cover: arable land has an annual cycle of crop and bare soil, hedges grow large for some years and are then trimmed back. Such dynamics are an essential life-cycle element of the agricultural land covers and should not affect the LPIS nor require an update.

This LPIS upkeep guidance is not intended to model such life-cycle dynamics, but to detect and process manifest changes.

MS are invited to describe and document particular dynamics that affect the appearance of the landscape and agricultural lands. The eligibilty profile is good starting point for this documentation as it holds all eligible land cover types and represents a legend for both CAPI and field identifications of these lands.

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25 Upkeep - Future

SECOND DRAFT

The anomaly concept is essential to any upkeep process. Although it had a central position on any schema of the LPIS update processes (see e.g. the 2009 LPIS dataflow article, little modeling has been done to date.

Still, as with the LCM, some good arguments can be found to develop a "core" model for application in LPIS context:

- strengthen a common understanding of the LPIS upkeep processes.
- sharing tools to process anomalies (e.g. crowd sourcing via web services)
- sharing methods and algorithms to analyze LPIS change behavior and patterns.

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26 Upkeep - Support

These are the support pages for the LPIS upkeep guidance.

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