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Authors:

Marcus Brühl (BKG)

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This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

Edge Matching

References

Ref.	Title/Version/Publication Date/Author
[1]	ELF D2.3 Data Maintenance and Processing Specification http://www.elfproject.eu/documentation/specification/data-maintenance-and-processing
[2]	ELF D2.7 ELF International Boundaries / v1.1 / 08.11.2013 http://www.elfproject.eu/documentation/specification/ib/1.1
[3]	ESDIN D9.1 General Specifications and Guidelines for the Maintenance of Edge Matched Features at Cross-Border Areas / v1.0 / 29.06.2010 http://www.esdin.eu/sites/esdin.eu/files/D9.1_EdgeMatching-ProcessSpec_v1.0.pdf
[4]	ESDIN D11.3 Best Practices and Pilot Implementations for Edge Matching and Generalisation in Web Services or GIS Environment / v1.0 / 22.02.2011 http://www.esdin.eu/sites/esdin.eu/files/ESDIN%20D11-3_v1.0%20BP_EdgeMatching_Generalisation.pdf
[5]	ELF Glossary http://www.elfproject.eu/documentation/glossary
[6]	ELF D2.9 Data Specification Regional/Global
[7]	ELF D2.10 Data Specification Master
[8]	ELF D4.4 Edge matching tools (will be drafted later)
[9]	ELF D2.3.1 Organisational Framework http://www.elfproject.eu/documentation/specification/data-maintenance-and-processing
[10]	Rule Speak http://www.rulespeak.com/en/

Figures

Table of content

1	Introduction.....	5
1.1	Purpose.....	5
1.2	Scope	5
1.3	Terminology.....	5
2	Edge Matching in the ELF framework.....	6
2.1	ELF organisational framework.....	6
2.2	ELF level of detail.....	7
3	Edge matching process overview	8
3.1	Basic principles	8
3.2	Edge matching process.....	8
3.3	Workflow scenarios	9
3.4	Reporting and confirmation of edge matching process.....	11
3.5	Creation and maintenance of connecting features.....	11
4	Detailed functional requirements	13
4.1	System platform requirements	13
4.2	Data Exchange	13
4.2.1	Import.....	13
4.2.2	Export	14
4.3	Cross-border quality evaluation	14
4.3.1	Evaluation rules	14
4.3.2	Initial report.....	28
4.4	Edge matching actions.....	29
4.4.1	Feature maintenance	29
4.4.2	Connecting feature maintenance.....	31
4.4.3	Edge matching quality report.....	31
4.5	Non-functional requirements.....	31
5	Use cases / data cases	31
6	Summary and conclusions	31

I Introduction

I.1 Purpose

The primary purpose of this document is to specify the requirements of the edge matching tools. The document also describes the edge matching process from a high level within the context of the ELF project.

This document neither specifies the location of edge matching within the overall ELF workflow, nor the detailed implementation as a geo-tool.

I.2 Scope

For the purpose of this document, the “system” refers to each of the ELF WP4 Edge matching tools to be provided by the tools providers.

I.3 Terminology

The ELF Glossary [5] defines basic terms relevant for the ELF project. Beside this generic glossary, the following terms are used in this document:

Acronym	Term	Definition
-	Boundary region	An area around an ELF International Boundary with a specified buffer width.
CF	Connecting feature	Location on the international boundary where edge matched geographic entities from neighbouring countries connect. CFs serve as anchor for repeatable edge matching. CFs have either point or line geometry.
-	Cross-border feature	A feature that either crosses an ELF International Boundary or follows an ELF International Boundary and belongs to each of the neighbouring countries sharing that boundary. A point, line or area feature may be located on or follow the ELF IB. A line or area feature may cross the ELF IB.
ELF IB	ELF International Boundaries	ELF dataset containing agreed international boundaries and connecting features. ELF IB is defined for all levels of detail. ELF IB is provided on the ELF platform as service.
-	Responsible country	The country using the system to perform edge matching on their data.
IB	International boundary	A line of demarcation between countries. International boundaries are agreed between neighbouring countries.
-	Neighbouring country	A country that shares a border with the responsible country.
-	Edge matched data	Data on which the edge matching tool has successfully run to

		completion.
-	Surface	INSPIRE term for an area.
-	Curve	INSPIRE term for a line.

2 Edge Matching in the ELF framework

2.1 ELF organisational framework

Edge matching (EM) is one component of the organisational framework needed for the maintenance of the European Location Framework. The general data supply chain, from national data to the ELF platform, is described in the deliverable [D2.3 Data Maintenance and Processing specification](#) [1].

The basic intention is to apply this EM concept to ELF data; that is, national data transformed to the ELF data specifications, see D2.9 Data Specification Regional/Global [6] and D2.10 Data Specification Master [7]. But this generic concept can also be adapted for other types of data, e.g. it can be used to match data between different partners in a thematic community.

ELF data shall be matched to international boundaries, which are agreed between neighbouring countries. These agreed boundaries will be provided on the ELF platform as services; alternative delivery can be discussed on request. The data model is defined in the deliverable [D2.7 ELF International Boundaries](#) [2]. Besides the international boundaries, the data model includes connecting features. These are locations on the boundaries where edge matched geographic entities from neighbouring countries connect.

The edge matching process will be implemented as ELF geo-tool, see deliverable [D4.4 Edge matching tools](#) [8].

The following picture portrays the link between edge matching and the other deliverables in the ELF framework.

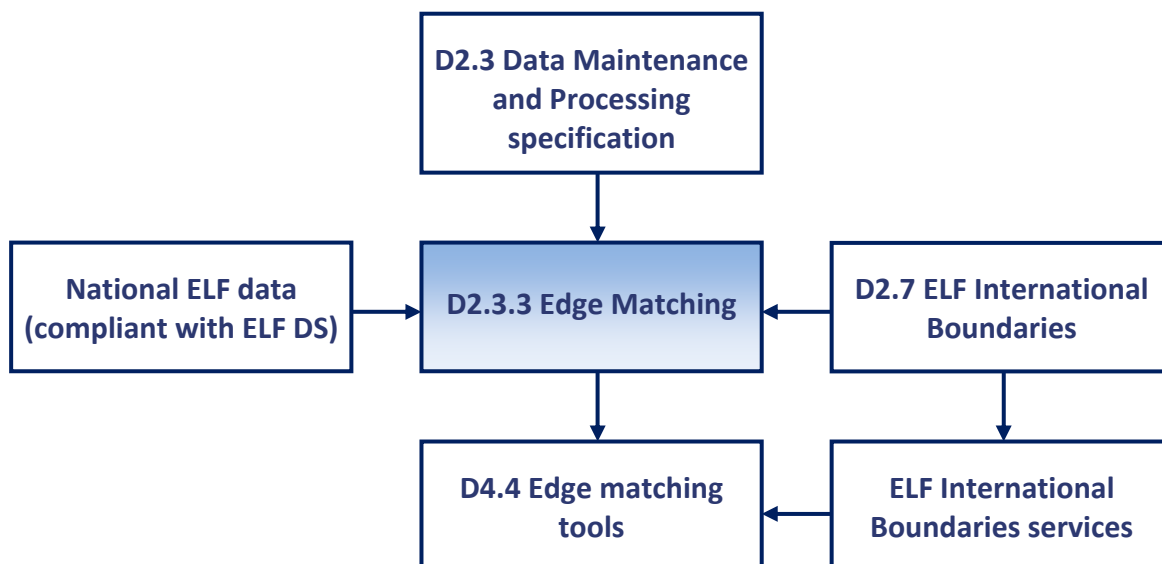


Figure 1 – Edge matching in the ELF framework

2.2 ELF level of detail

ELF has defined different levels of detail (LoD), from Master LoD (LoD0, LoD1 and LoD2) via Regional LoD to Global LoD. Edge matching has to be considered for these LoDs in the following way:

- **ELF Master LoD0:** This LoD contains only very specific themes which are not included in other LoDs. For some of them, e.g. Addresses (AD) and Buildings (BU), edge matching is not relevant. For the theme Cadastral Parcels (CP), the manipulation of national data is not allowed. For these reasons, Master LoD0 is out of scope for edge matching.
- **ELF Master LoD1:** This LoD is the main focus for edge matching. It's expected that most NMCAs maintain data and provide it for the ELF platform at this LoD.
- **ELF Master LoD2:** The long term aim is to generalise all other LoDs from Master LoD1. This implies that generalisation builds on already edge matched data. But the complete automatic generalisation is challenging. Additionally, it's not clear that all NMCAs can provide data at Master LoD1. It will be probably necessary to apply edge matching also at Master LoD2.
- **ELF Regional:** This LoD is also intended to be generalised from Master LoD1. But some NMCAs maintain specific national datasets at Regional LoD. Whether those NMCAs will agree to use automatically generalised data for ELF Regional or they will deliver this LoD with their national data on Regional LoD is yet to be discussed. Further, there are the current EG products (i.e. EBM and ERM) at this LoD, where edge matching is needed for update work. So for the time being, edge matching will be needed for Regional LoD.
- **ELF Global:** This LoD will be generalised from Regional LoD. Therefore, edge matching for this LoD will be considered out of scope.

The analysis shows the necessity of edge matching for different LoDs, at least for the time being. The edge matching solution, described in next chapter, will outline the process independent of scale.

The implementation of this concept as an ELF geo-tool (D4.4) requires the edge matching rules to be defined. Specific parameters have to be defined for the different LoDs. The implementation will focus on the specification of edge matching rules for Master LoD1. Additionally, the rules should be parameterised also for Regional LoD.

3 Edge matching process overview

3.1 Basic principles

National ELF data has to be edge matched to the ELF IB. The availability of international boundaries, agreed between neighbouring countries for a specific level of detail, is a pre-requisite to edge matching. Edge matching of features, which cross international boundaries, without the ELF IB will not be successful and is out of scope of ELF.

ELF data has to be matched to connecting features, if CFs are available in ELF IB. Advantages of CFs are:

- Previously fixed edge-matching cases can be retained,
- It's not necessary to have related data from neighbouring countries.

If CFs are not available, national data has to be matched across the international boundaries, taking into account the related data from neighbouring countries, if such data is available.

If neither connecting features nor data from neighbouring countries are available, national data should be snapped to the international boundaries, using a “best guess” procedure. The business rules underlying this procedure are defined later in this document.

Edge matching results should be verified by data providers. The process should be used also to improve ELF IB; that is, the ELF IB can be updated with new or modified CFs.

3.2 Edge matching process

The **edge matching process** consists of 4 basic process steps:

- 1) Load data
- 2) Evaluate cross-border quality
- 3) Edge match data
- 4) Return data and quality report

The **inputs** for this process are national ELF data and the ELF IB. The **outputs** are edge matched ELF data, quality reports and updated connecting features for ELF IB.

The **controls** for this process are rule sets for the two main process steps cross-border quality evaluation (2) and edge matching (3). The **resources** for edge matching will consist of the edge matching tools themselves and the NMCA staff assigned to the edge matching process.

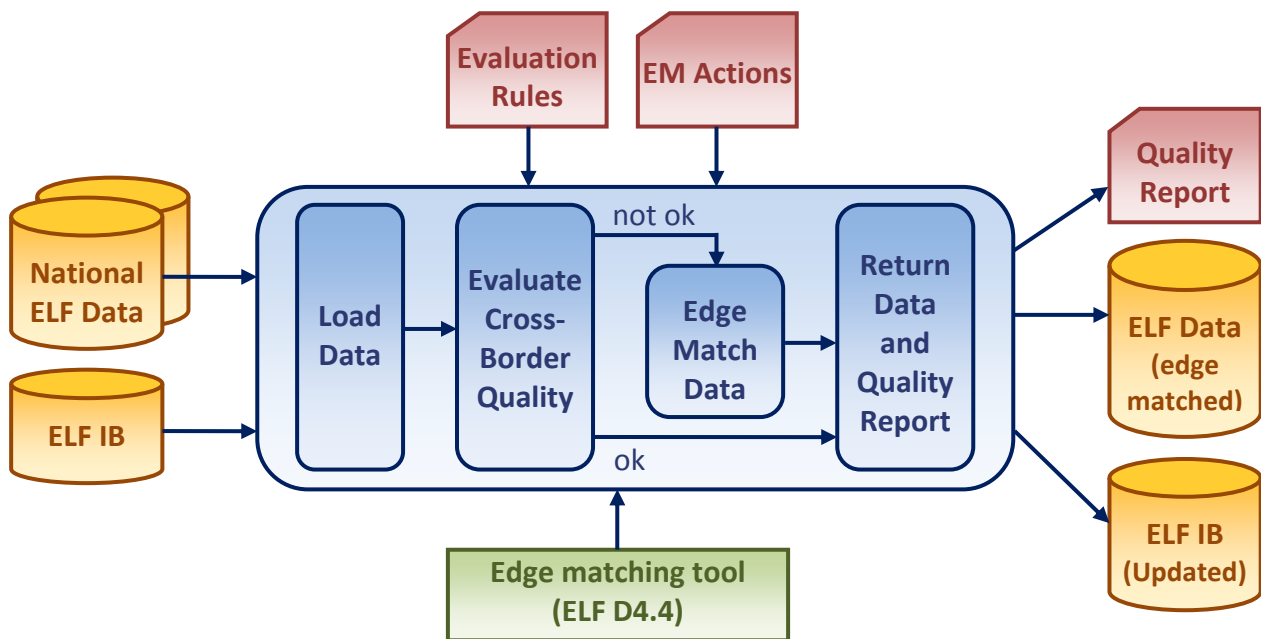


Figure 2 – Edge matching process

3.3 Workflow scenarios

There are different scenarios for the processing of the national ELF data in order to get edge matched results.

Scenario A is applicable when connecting features have been already established. In this case it's possible to edge match data from in the responsible country without accessing data from neighbouring countries. This scenario is ideal as the data can be returned with no remaining edge matching issues. There are no updates of the ELF IB.

This scenario occurs if edge matching has been already agreed between countries for previous data versions, but the edge matching results have not been adopted in the national data sources. Every time updates of the national data will be provided, the data is not matching the ELF international boundaries ad hoc, but the automatic snapping to CFs will ensure seamless data for the ELF platform.

This scenario is not applicable if new national data is provided, which is not linked to existing CFs.

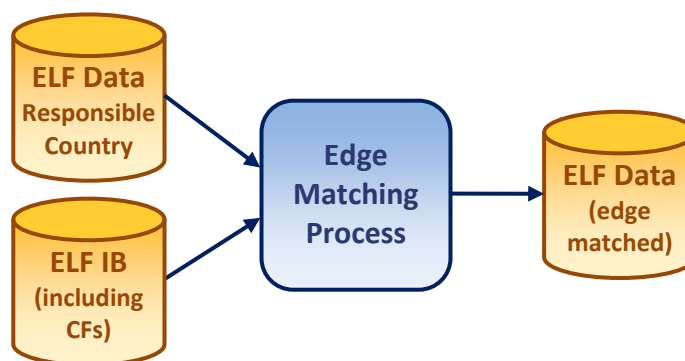


Figure 3 – Edge matching using connecting features (scenario A)

Scenario B describes the edge matching between data available from neighbouring countries, where connecting features have not been defined. Both national datasets should be of comparable level of detail and data quality. If this assumption turns out to be untrue, satisfying edge matching results might not be attainable.

The edge matching action in this case is to find appropriate locations on the international boundaries where cross-border objects should connect. These locations will create a proposal for new CFs.

As this scenario results in new edge matching solutions, it will be necessary to report them to the affected neighbouring countries. The neighbouring countries then have to agree or to correct the proposed edge matching solutions.

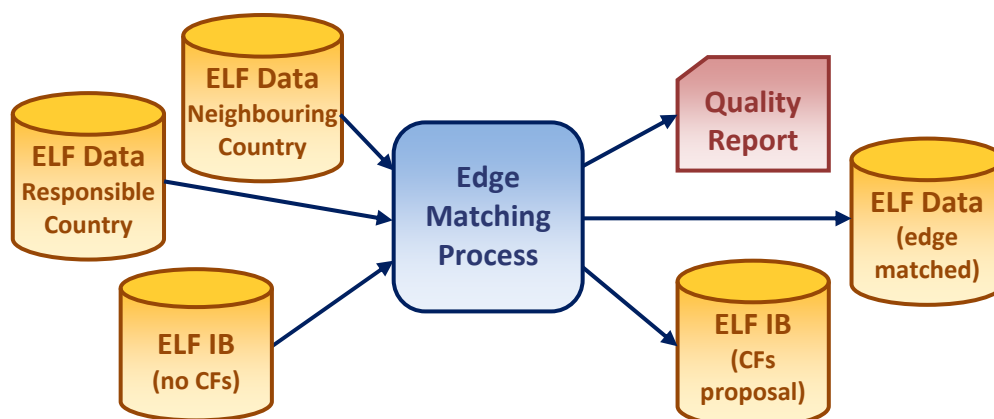


Figure 4 – Edge matching using data from neighbouring countries (scenario B)

Scenario C describes a simple case in which CFs have not been established and also data from neighbouring countries is not available. In this case, national data has to be matched to the ELF IB. This process may propose new CFs for feature types that usually have a cross-border context.

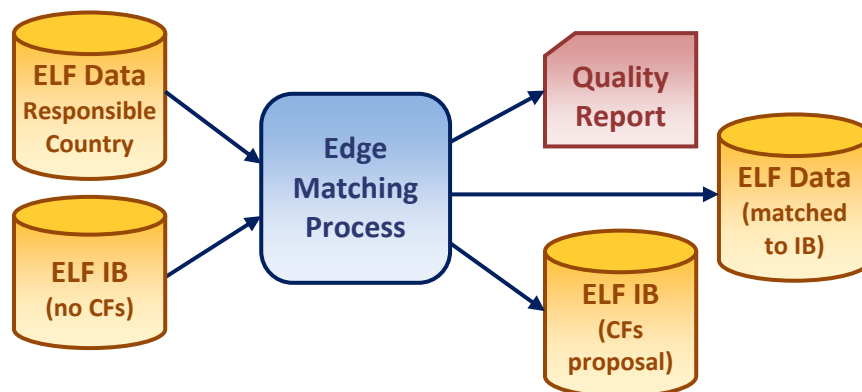


Figure 5 – Simple matching to international boundaries (scenario C)

Real edge matching issues will not strictly comply with only one of the described scenarios. Edge matching tools have to develop a workflow considering all three scenarios.

A typical edge matching use case may consist of the following steps: The process will start with the national data provided by one country. For a part of the data content it will be possible to snap it to existing connecting features (scenario A). This will not solve all issues. It will be probably possible to identify data from neighbouring countries to create new edge matching solutions (scenario B). Some open issues will remain, where no real cross-border edge matching is possible (scenario C).

3.4 Reporting and confirmation of edge matching process

The process may provide two types of reports:

- The initial report after the evaluation of the cross-border quality,
- The edge matching quality report at the end of the edge matching process.

The **initial report** will list all edge matching non-conformances. NMCAs will be able to run the process without automatic edge matching actions. Some NMCAs might want to apply manual fixes.

The **edge matching quality report**, as the final output of the edge matching process, will list all new edge matching solutions and list open issues, where automatic edge matching was not successful. These results should be verified by the NMCAs, as providers of the input data.

NMCAs of neighbouring countries are asked to confirm the new edge matching solutions. In cases of disagreement or open issues, there are a number of different options that may be considered:

- Improve the national data used as input,
- Modify parameter values for the edge matching process,
- Negotiate with the neighbouring NMCAs over edge matching solutions – an interactive process.

The responsible country NMCA is in charge of the negotiation process, where coordination between neighbouring countries is necessary. The EM quality report and the connecting features will form the basis for discussion.

3.5 Creation and maintenance of connecting features

Connecting features can be created in different ways:

- Derive CFs from already edge matched data: If a seamless cross-country dataset is available, it is possible to detect the locations on the IB, where the data is matched, and to create CFs on those locations. An example are the current EG products (EBM and ERM), where the most edge matching issues have been already solved for most ELF feature types. A first set of CFs, as part of ELF IB Regional, is ready to use.
- Adopt CFs from existing CFs in other LoD: In case of similar representations of the international boundaries in different LoD, it might be possible to use same CFs for more than one LoD. For instance, an existing CF defined for Regional LoD might be adopted for Master LoD, if it's located on a significant edge identifiable in both LoD.
- Get CF proposal as result of EM process: If the EM tool identifies unmatched data, where no CFs are available, it will create new proposals.
- Agree on new CFs by negotiations between NMCAs: If NMCAs discuss about edge matching, they can create new CFs on their own. This can simplify the negotiation process.
- Get CF proposal from one NMCA: If a NMCA is not able to find a point of contact in the neighbouring country to discuss about edge matching issues, it can, at least, match the national data properly to the ELF IB and create CF proposals.

All connecting features are stored in the ELF IB. CFs are defined specific for the different ELF LoDs, but can be reused for other LoDs, as discussed above.

The ELF feature type *ConnectingFeature* has a property *status*, which identifies a CF as approved or as proposal [2]. An approved CF is agreed by the concerning NMCA and can be used in the EM process without further confirmation. This does not mean, that it's not possible to propose changes or update approved CFs.

4 Detailed functional requirements

Not complete yet. Will evolve over time.

4.1 System platform requirements

Will be provided later.

Requirements around the platform itself needed, e.g. import and export formats, report attribution, etc. This has been under discussion as it has been suggested that overarching requirements could be specified in a single document for all work streams (generalisation, edge matching and validation).

4.2 Data Exchange

4.2.1 Import

EM.Import.1

A feature with type in the following table must be considered an 'EM Point Feature' if its geometry is GM_Point:

Theme	Feature type
Hydrography	HydroNode
	Falls
	DamOrWeir
	Lock
	ShoreLineConstruction

EM.Import.2

A feature with type in the following table must be considered an 'EM Curve Feature' if its geometry is GM_Curve:

Theme	Feature type
AdministrativeUnits	AdministrativeBoundary
Hydrography	LandWaterBoundary
	WatercourseLink
	Watercourse
	Falls
	DamOrWeir
	Lock
	ShoreLineConstruction
	Crossing

EM.Import.3

A feature with type in the following table must be considered an 'EM Surface Feature' if its geometry is GM_Surface:

Theme	Feature type
AdministrativeUnits	AdministrativeUnit
	AdministrativeUnitArea
Hydrography	StandingWater
	SeaArea
	Shore
	DrainageBasin
	RiverBasin
	Island
	Wetland
	Watercourse

4.2.2 Export

4.3 Cross-border quality evaluation

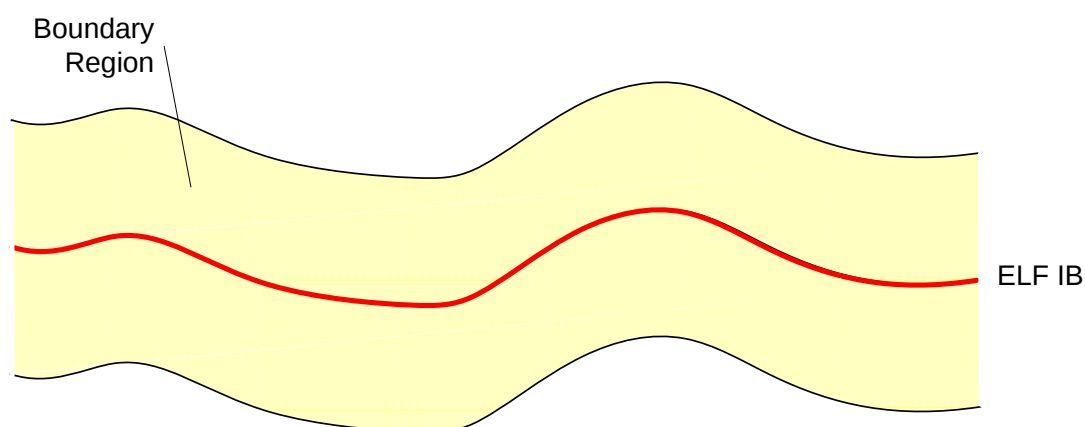
4.3.1 Evaluation rules

EM.Evaluation.1

A Boundary Region must be computed as a surface around the ELF IB with the following buffer width:

- Master LoD: 10 m,
- Regional LoD: 25 m.

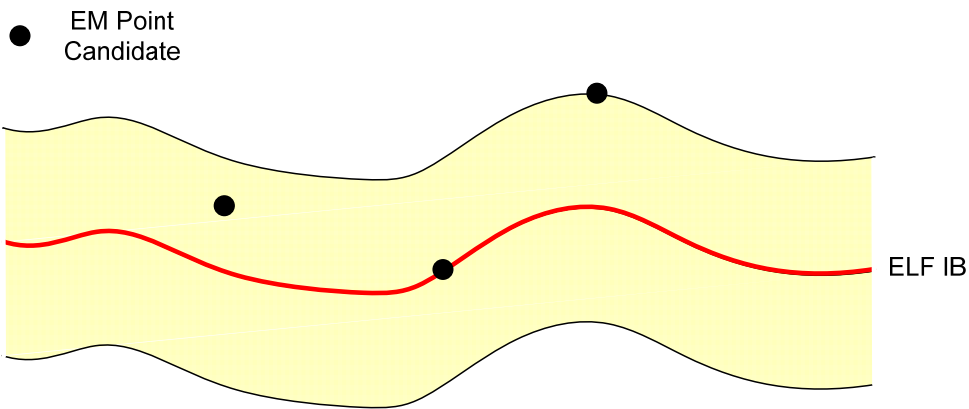
Example



EM.Evaluation.2

An EM Point Feature must be considered an 'EM Point Candidate' if it intersects the Boundary Region.

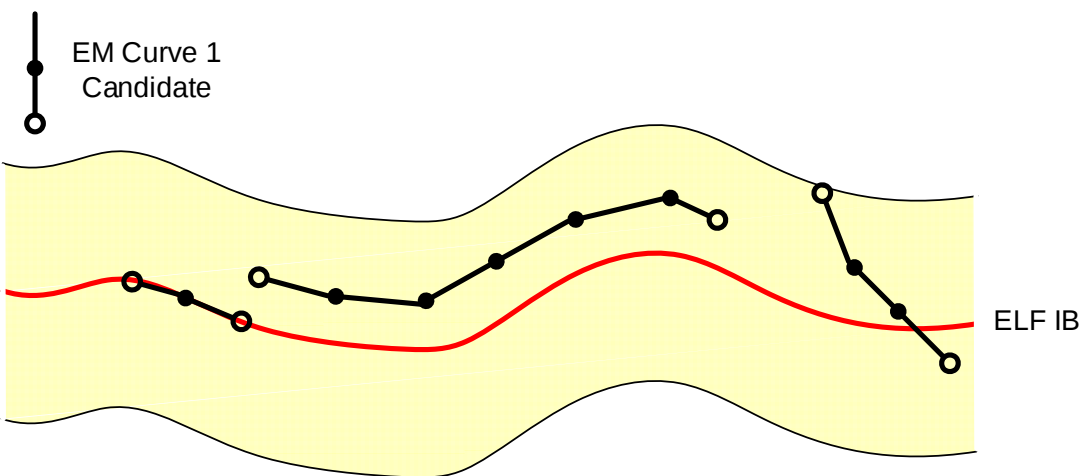
Examples



EM.Evaluation.3.1

An EM Curve Feature L must be considered an 'EM Curve 1 Candidate' if L is within the Boundary Region.

Examples

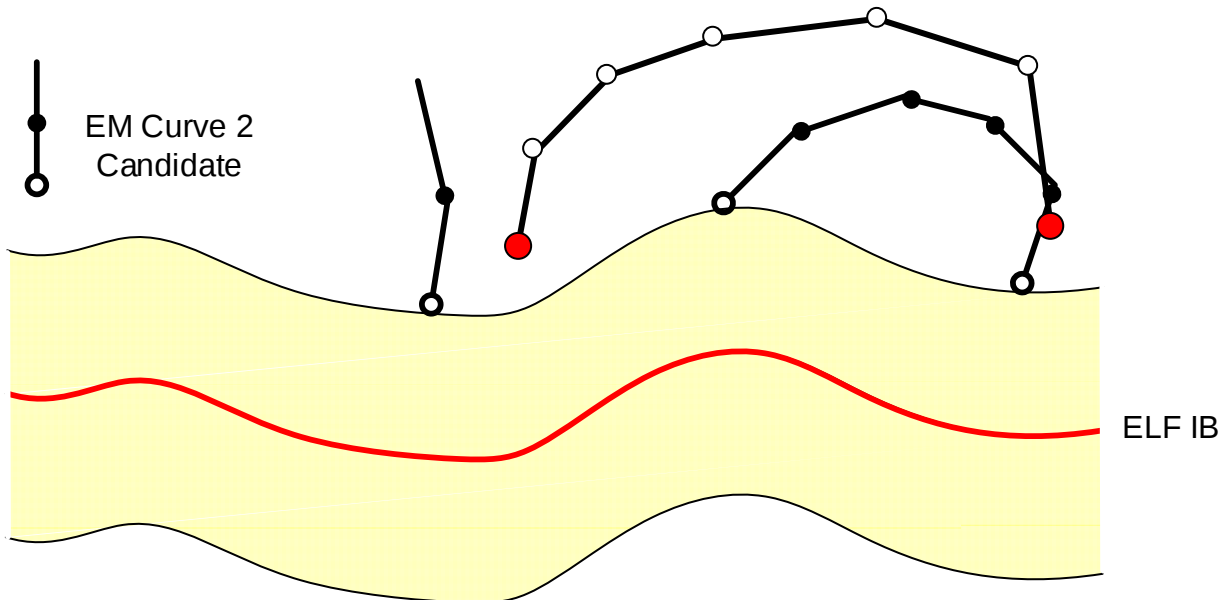


EM.Evaluation.3.2

An EM Curve Feature L must be considered an 'EM Curve 2 Candidate' if all the following are true:

- The boundary of L intersects the Boundary Region
- The interior of L does not intersect the Boundary Region.

Examples

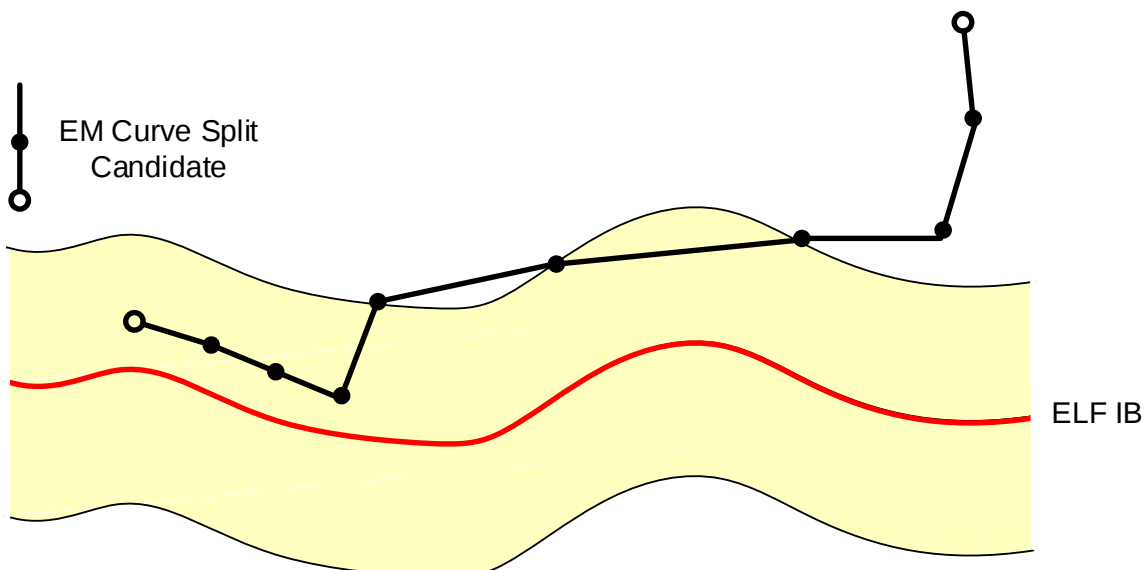


EM.Evaluation.3.3

An EM Curve Feature L must be considered an 'EM Curve Split Candidate' if all the following are true:

- L intersects the Boundary Region,
- L is not an EM Curve 1 Candidate,
- L is not an EM Curve 2 Candidate.

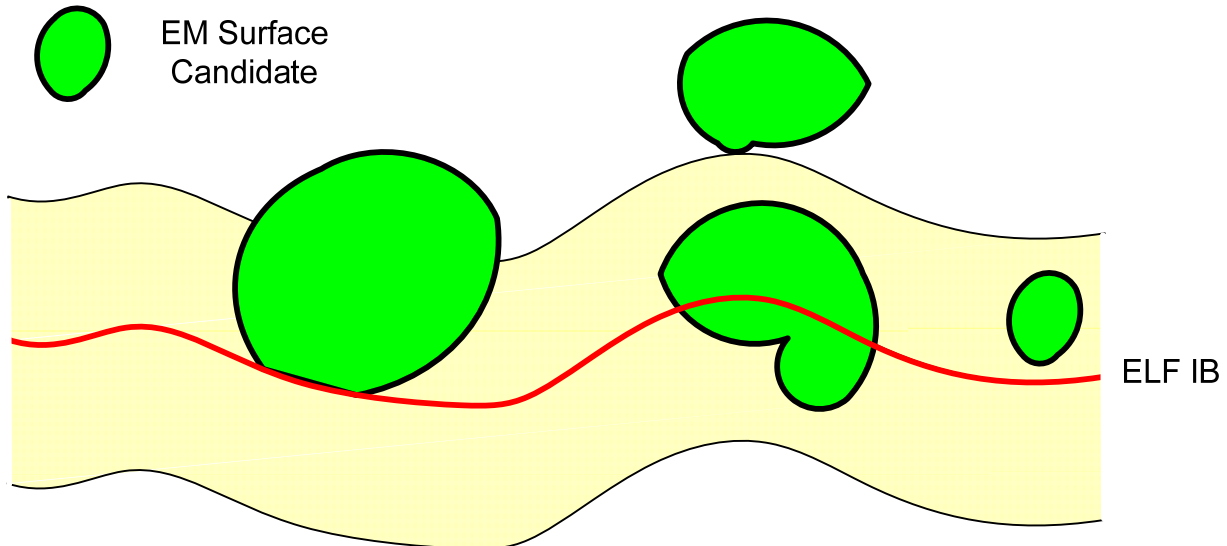
Examples



EM.Evaluation.4

An EM Surface Feature must be considered an 'EM Surface Candidate' if it intersects the Boundary Region.

Examples

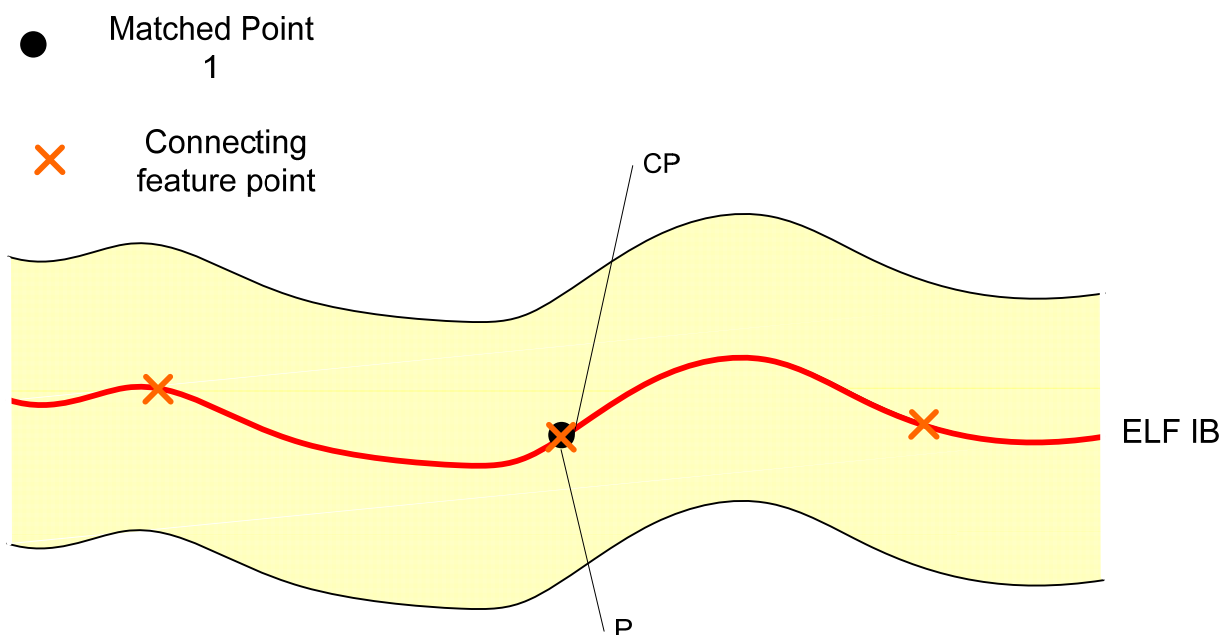


EM.Evaluation.5.1

An EM Point Candidate P must be considered a 'Matched Point 1' if all the following are true:

- P intersects a connecting feature point CP,
- CP.featureType contains the feature type of P.

Example

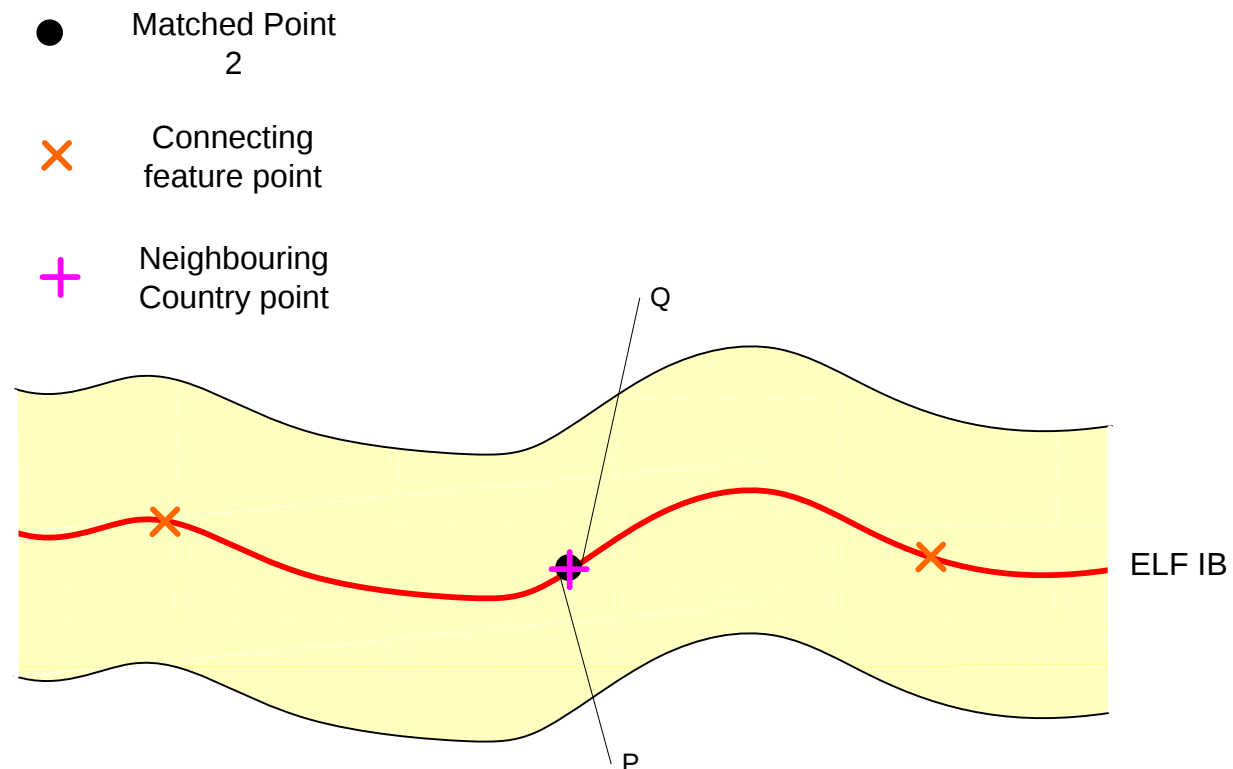


EM.Evaluation.5.2

An EM Point Candidate P must be considered a 'Matched Point 2' if all the following are true:

- P is not a Matched Point 1,
- P intersects the ELF IB,
- P intersects a Neighbouring Country point feature Q,
- Q has the same feature type as P.

Example



EM.Evaluation.5.3

An EM Point Candidate P must be considered a 'Matched Point 3' if all the following are true:

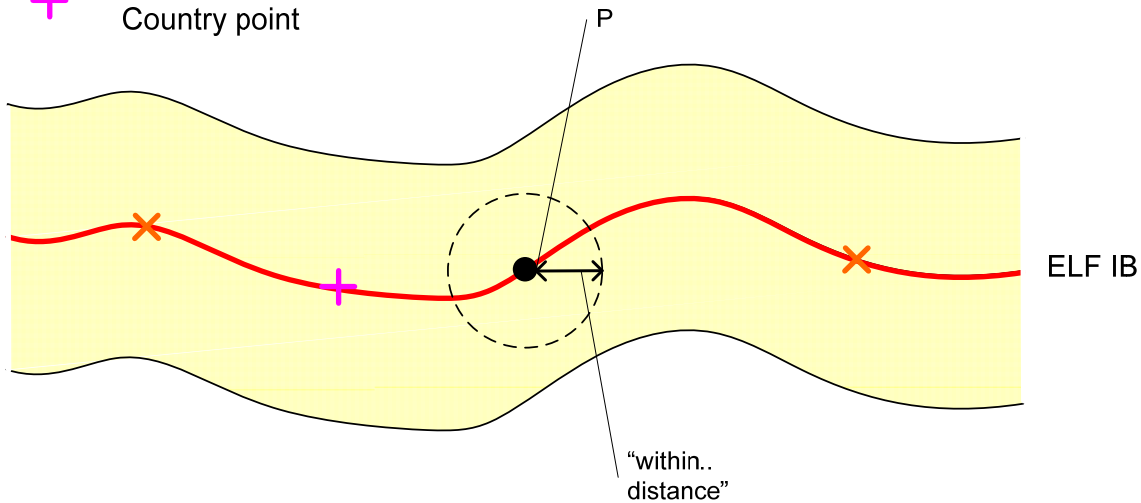
- P is not a Matched Point 1,
- P is not a Matched Point 2,
- P intersects the ELF IB,
- There is no Neighbouring Country point feature Q such that all the following are true:
 - Q is within the following distance of P:
 - Master LoD: 20 m,
 - Regional LoD: 50 m.
 - Q has the same type as P.

Example

● Matched Point
3

× Connecting
feature point

+ Neighbouring
Country point



EM.Evaluation.5.4

An EM Point Candidate P must be considered an 'Unmatched Point' if all the following are true:

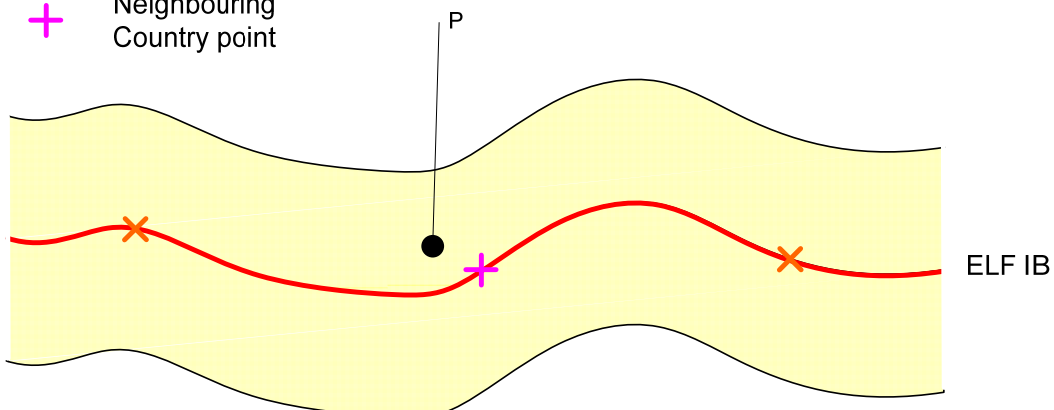
- P is not a Matched Point 1,
- P is not a Matched Point 2,
- P is not a Matched Point 3.

Example

● Unmatched
Point

× Connecting
feature point

+ Neighbouring
Country point

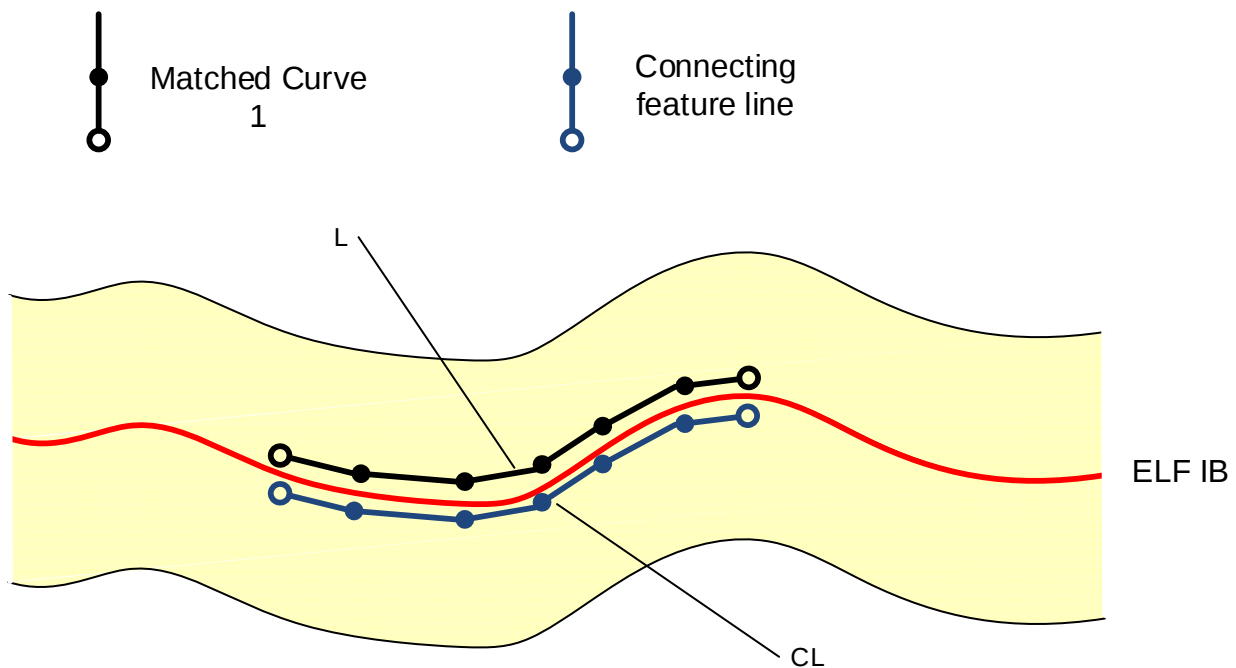


EM.Evaluation.6.1

An EM Curve 1 Candidate L must be considered a 'Matched Curve 1' if all the following are true:

- The geometry of L coincides with the geometry of a connecting feature line CL
- CL.featureType contains the feature type of L.

Example



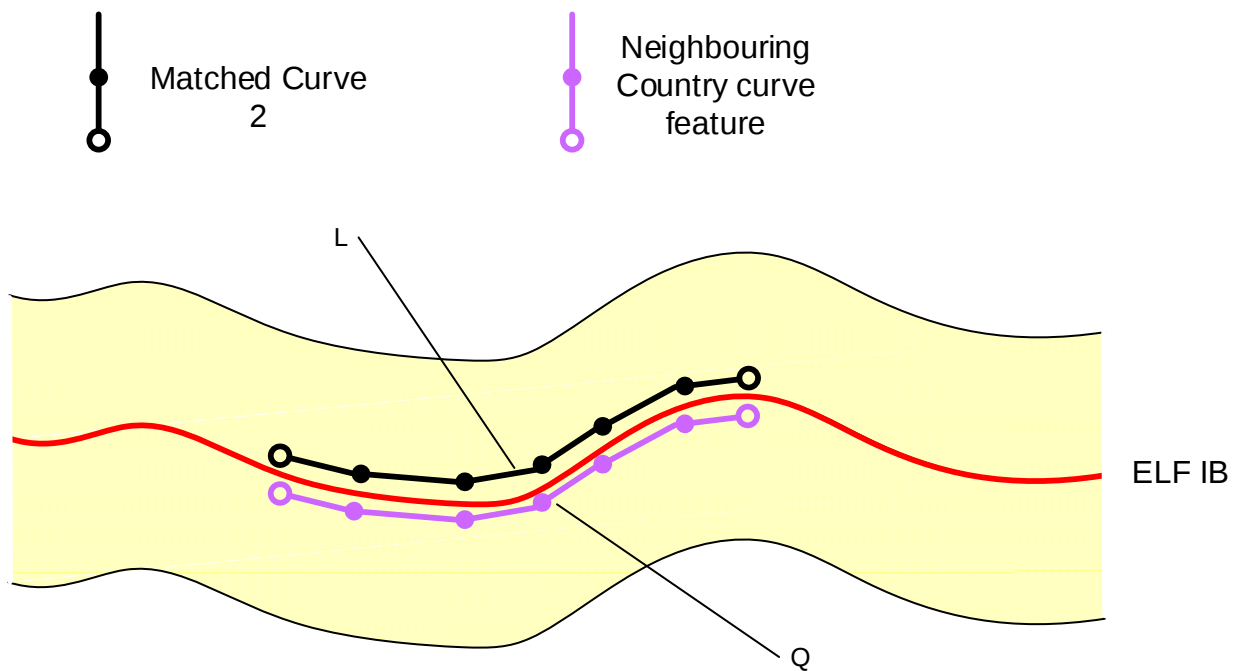
Note: The curves shown in the figure above have been offset from the ELF IB for illustrative purposes only.

EM.Evaluation.6.2

An EM Curve 1 Candidate L must be considered a 'Matched Curve 2' if all the following are true:

- L is not a Matched Curve 1,
- L is within the ELF IB,
- The geometry of L coincides with the geometry of a Neighbouring Country curve feature Q,
- Q has the same feature type as L.

Example

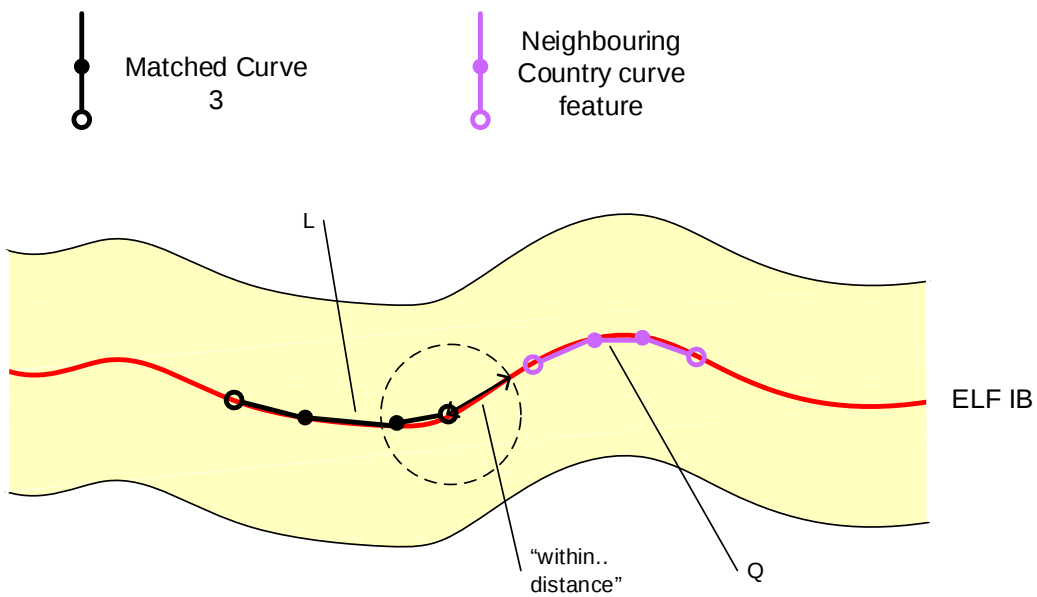


EM.Evaluation.6.3

An EM Curve 1 Candidate L must be considered a 'Matched Curve 3' if all the following are true:

- L is not a Matched Curve 1,
- L is not a Matched Curve 2,
- L is within the ELF IB.
- There is no Neighbouring Country curve feature Q such that all the following are true:
 - o Q is within the following distance of L:
 - Master LoD: 20 m,
 - Regional LoD: 50 m.
 - o Q has the same type as L.

Example

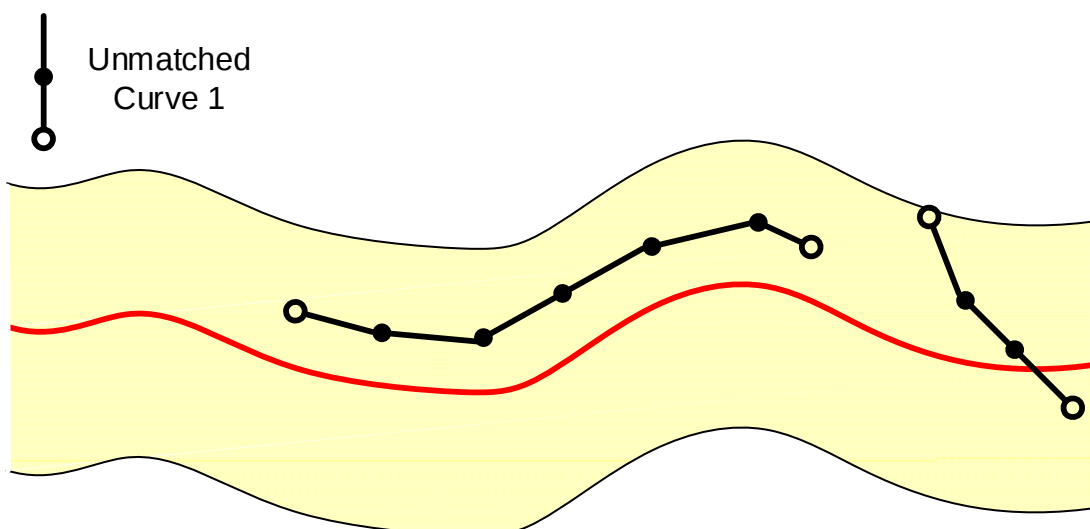


EM.Evaluation.6.4

An EM Curve 1 Candidate L must be considered an 'Unmatched Curve 1' if all the following are true:

- L is not a Matched Curve 1,
- L is not a Matched Curve 2,
- L is not a Matched Curve 3.

Examples

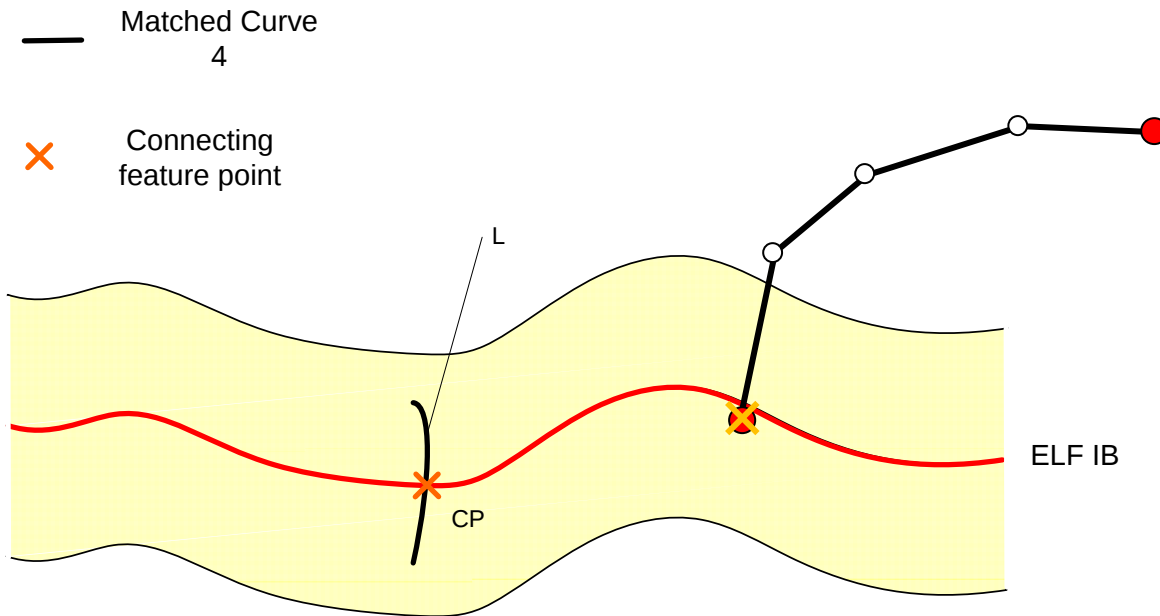


EM.Evaluation.7.1

An EM Curve 2 Candidate L must be considered a 'Matched Curve 4' if all the following are true:

- The boundary of L intersects L intersects a connecting feature point CP,
- CP.featureType contains the feature type of L.

Example

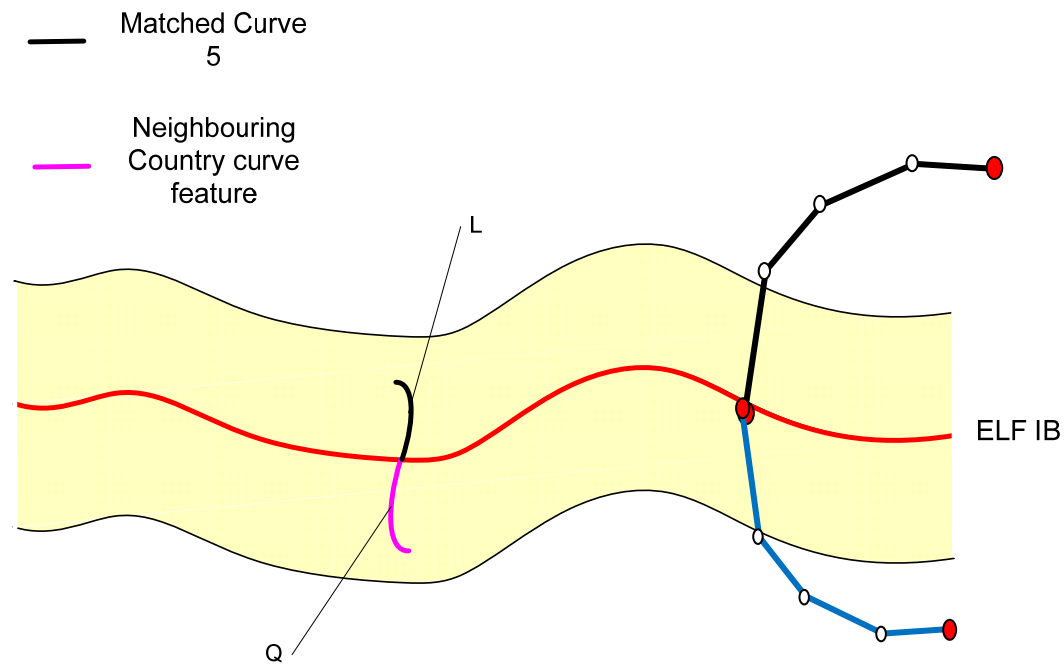


EM.Evaluation.7.2

An EM Curve 2 Candidate L must be considered a 'Matched Curve 5' if all the following are true:

- L is not a Matched Curve 4,
- The boundary of L intersects the ELF IB,
- The boundary of L intersects the boundary of a Neighbouring Country curve features Q,
- Q has the same feature type as L.

Example

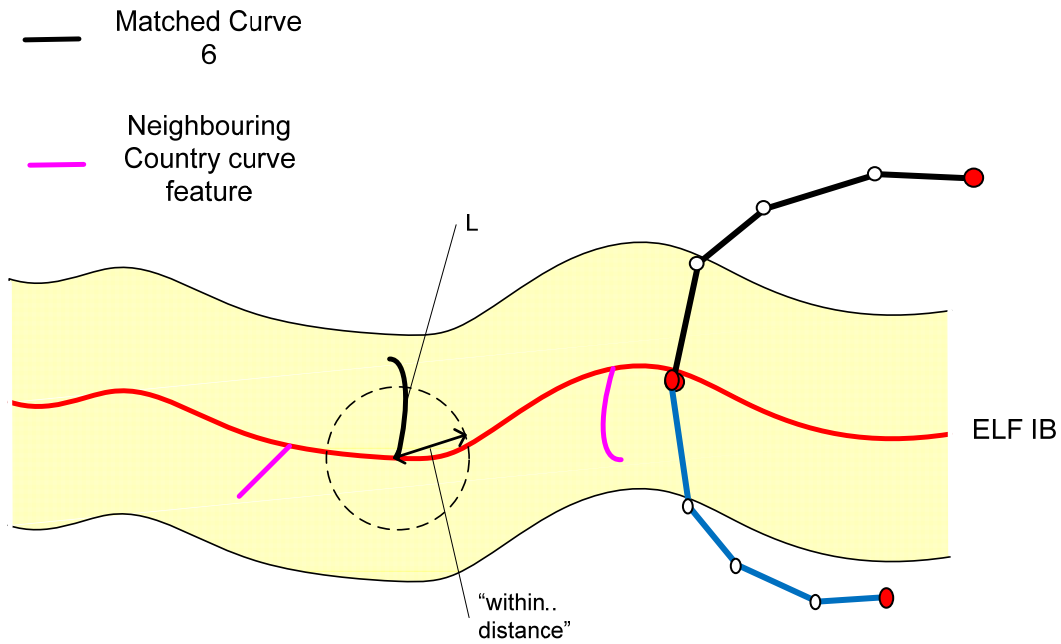


EM.Evaluation.7.3

An EM Curve 2 Candidate L must be considered a 'Matched Curve 6' if all the following are true:

- L is not a Matched Curve 4,
- L is not a Matched Curve 5,
- The boundary of L intersects the ELF IB,
- There is no Neighbouring Country curve feature Q such that all the following are true:
 - o The boundary of Q is within the following distance of L:
 - Master LoD: 20 m,
 - Regional LoD: 50 m.
 - o Q has the same type as L.

Example

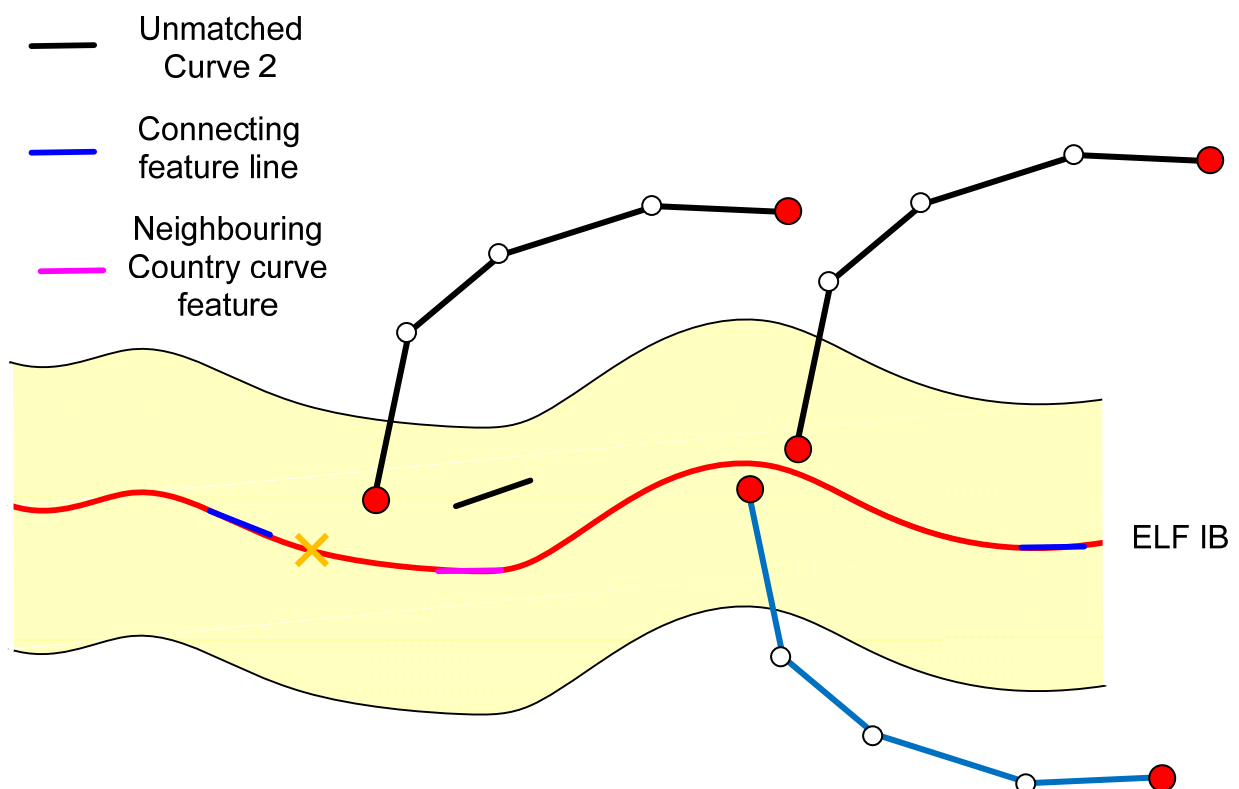


EM.Evaluation.7.4

An EM Curve 2 Candidate L must be considered an 'Unmatched Curve 2' if all the following are true:

- L is not a Matched Curve 4,
- L is not a Matched Curve 5,
- L is not a Matched Curve 6.

Example

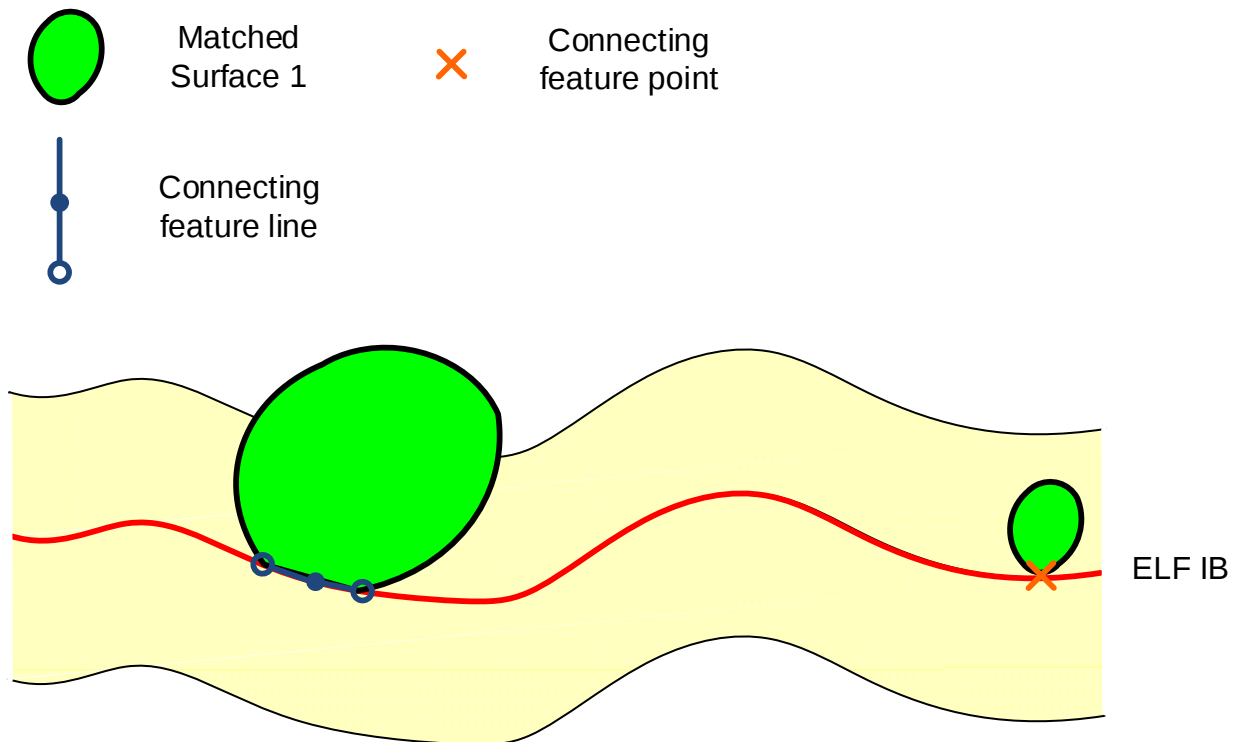


EM.Evaluation.8.1

An EM Surface Candidate A must be considered a 'Matched Surface 1' if all the following are true:

- A does not cross the ELF IB
- A's intersection N with the ELF IB is not null
- N coincides with a connecting feature CF,
- CF.featureType contains the feature type of A.

Examples

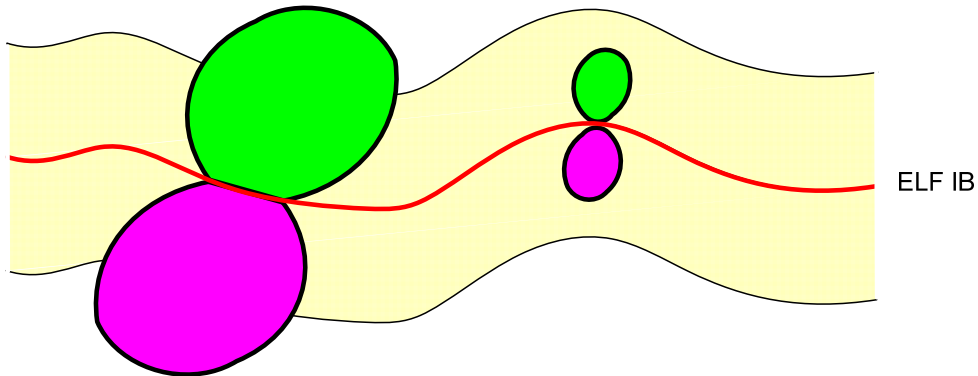
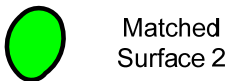


EM.Evaluation.8.2

An EM Surface Candidate A must be considered a 'Matched Surface 2' if all the following are true:

- A is not a Matched Surface 1
- A intersects the ELF IB
- A does not cross the ELF IB
- A touches at least one Neighbouring Country surface feature Q,
- Q has the same feature type as A.

Examples

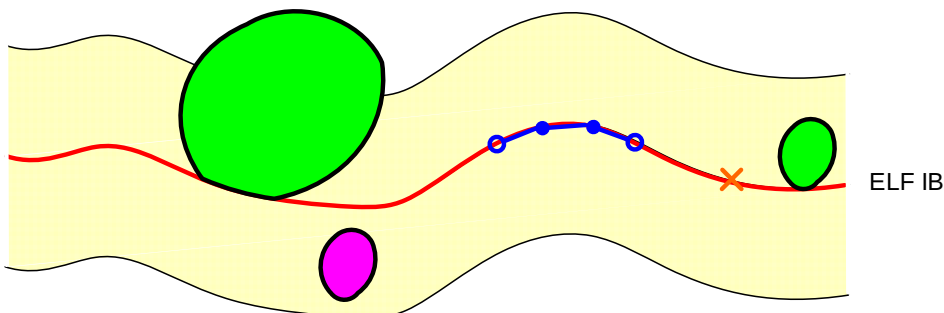
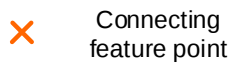
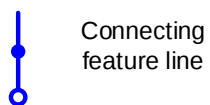
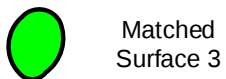


EM.Evaluation.8.3

An EM Surface Candidate A must be considered a 'Matched Surface 3' if all the following are true:

- A is not a Matched Surface 1,
- A is not a Matched Surface 2,
- A intersects the ELF IB.

Examples

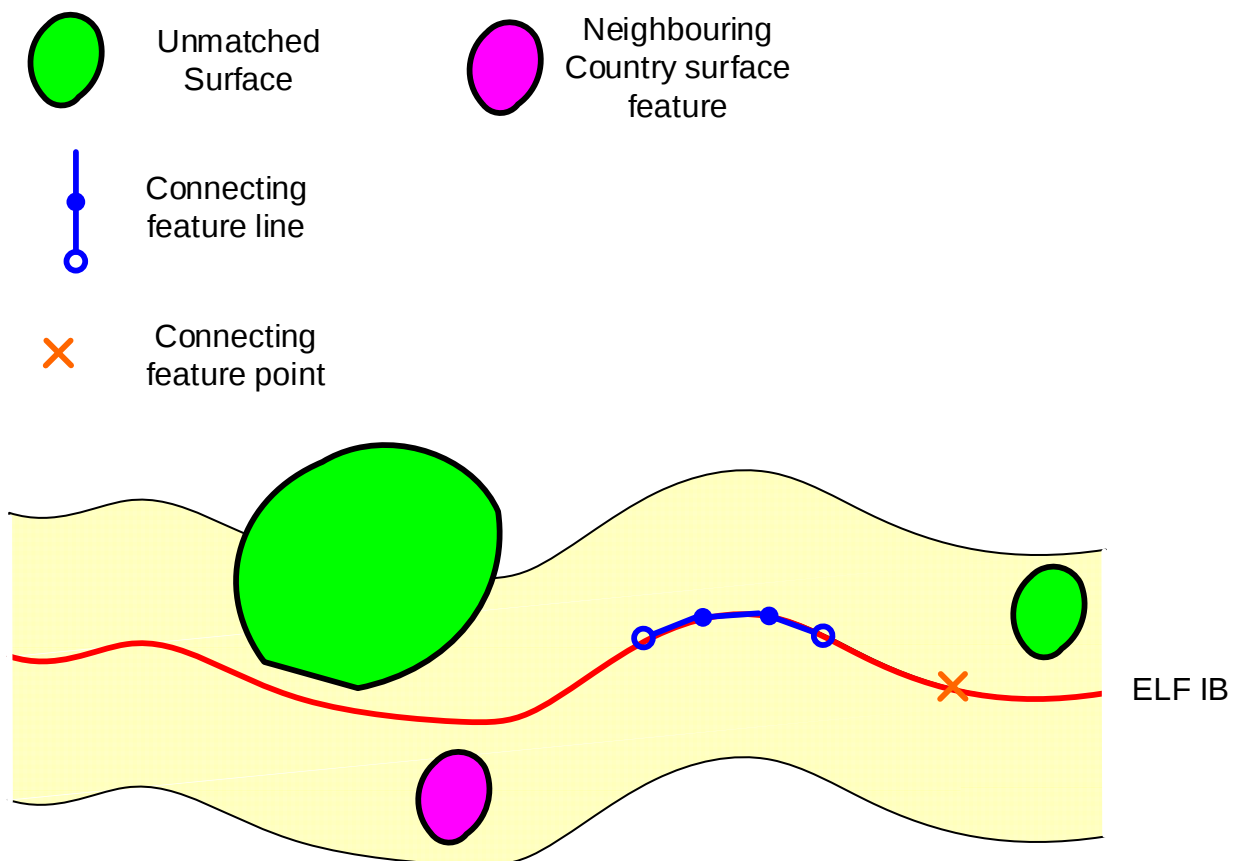


EM.Evaluation.8.4

An EM Surface Candidate A must be considered an 'Unmatched Surface' if all the following are true:

- A is not a Matched Surface 1,
- A is not a Matched Surface 2,
- A is not a Matched Surface 3.

Examples



4.3.2 Initial report

EM.Reporting.1

An EM Initial Report must list the following:

- EM Curve Split Candidate,
- Unmatched Point,
- Unmatched Curve 1,
- Unmatched Curve 2,
- Unmatched Surface.

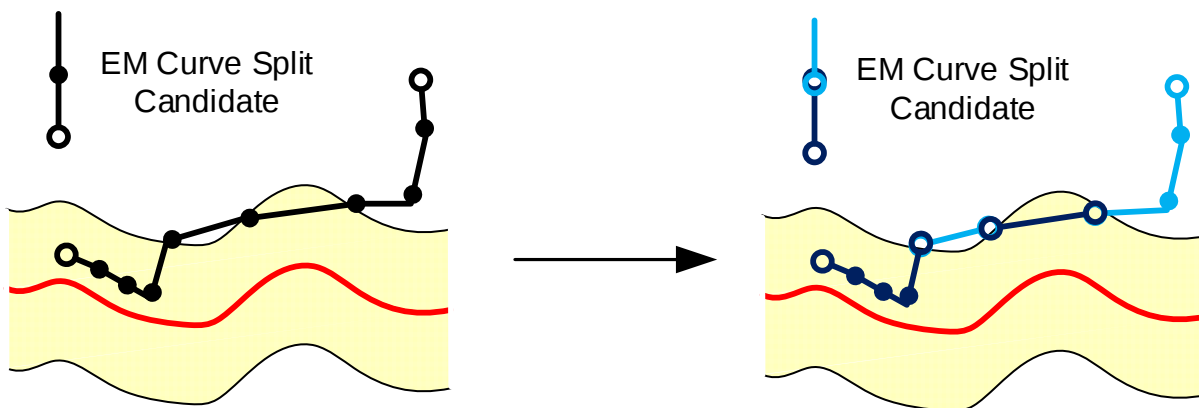
4.4 Edge matching actions

4.4.1 Feature maintenance

EM.Action.1

An EM Curve Split Candidate must be split at each point that it intersects the Boundary Region.

Examples

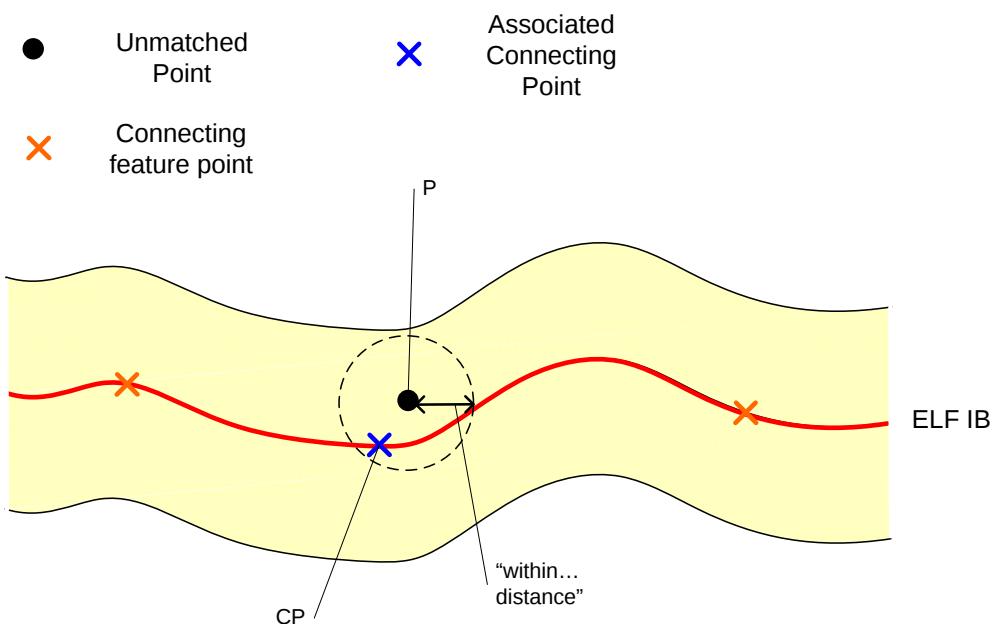


EM.Action.2.1

A connecting feature point CP must be considered an 'Associated Connecting Point' of an Unmatched Point U if all the following are true:

- CP is within the following distance of U:
 - Master LoD: 20 m,
 - Regional LoD: 50 m
- CP.featureType contains the feature type of U.

Example

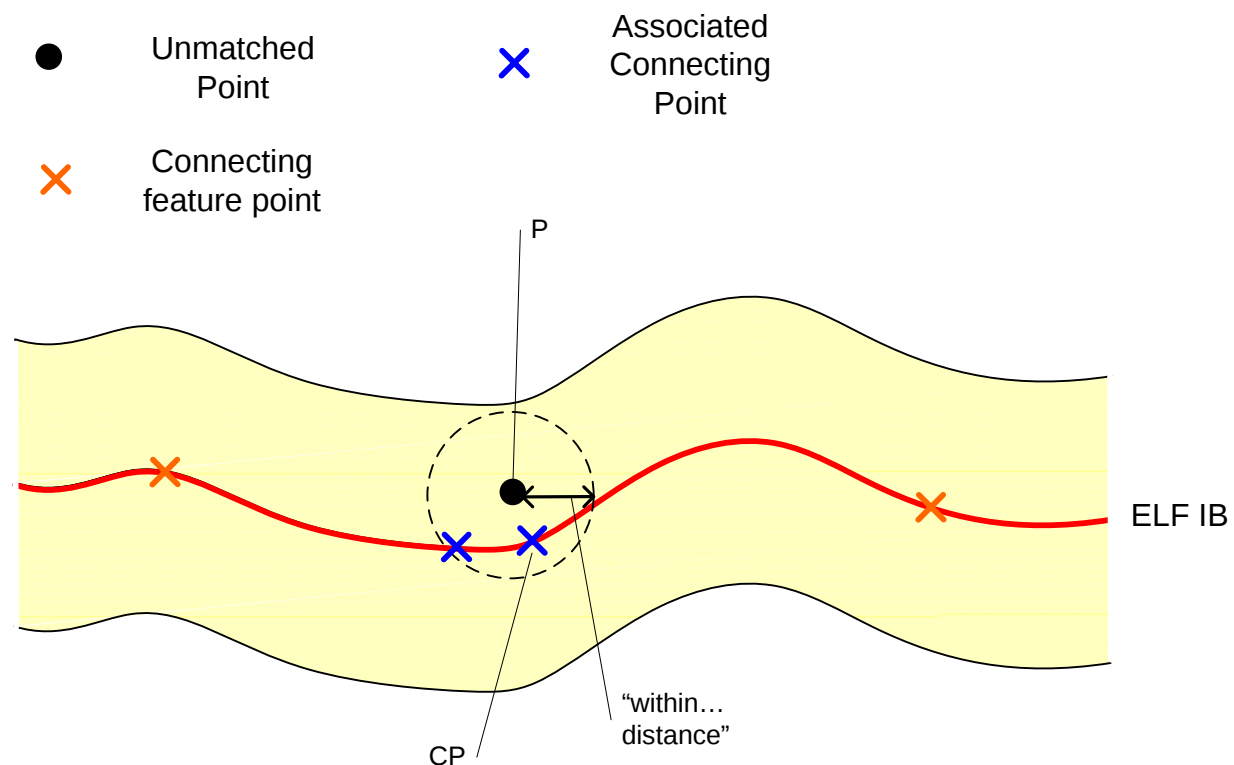


EM.Action.2.2

A connecting feature point CP must be considered the 'Matching Connecting Point' of an Unmatched Point U if all the following are true:

- CP is an Associated Connecting Point of U
- There is no other Associated Connecting Point AP of U such that the distance between AP and U is less than or equal to the distance between CP and U.

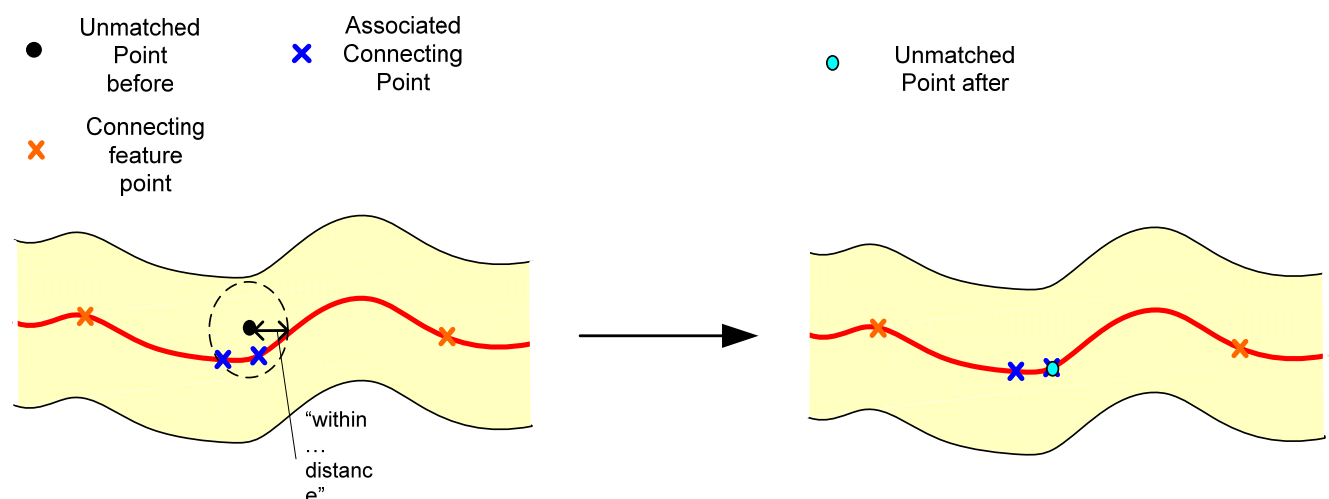
Example



EM.Action.2.3

An Unmatched Point must be moved to intersect its Matching Connecting Point.

Example



4.4.2 Connecting feature maintenance

EM.ActionCF.1

A feature in the following list must be considered a 'CF Update Trigger':

- Matched Point 2,
- Matched Point 3,
- Matched Curve 2,
- Matched Curve 3,
- Matched Curve 5,
- Matched Curve 6.

EM.ActionCF.2

A new Connecting Feature CF must be created for a CF Update Trigger U such that the following are all true:

- CF.geometry is geometry of U,
- CF.country is country code of U,
- CF.featureType is feature type of U,
- CF.status = 'proposedForAddition'.

4.4.3 Edge matching quality report

4.5 Non-functional requirements

Will be provided later.

5 Use cases / data cases

Will be provided later.

6 Summary and conclusions

Will be provided later.