Nationaal Lucht- en Ruimtevaartlaboratorium
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Executive summary

Re-using Real World Data for the Fictitious Missionland Continent

Problem area
Training via distributed mission simulation has the potential to enhance force readiness and operational effectiveness in coalition operation. An essential condition for an effective mission simulation environment is a correlating representation of the real-world natural and cultural environment in the distributed simulations. Correlating existing environment databases is costly, both in effort and in money, and the end result will always be hampered by technical incompatibilities. A generic and geo-unspecific, widely available simulation environment could overcome these problems.

The NATO RTO task group MSG-071 Missionland started to construct a coherent dataset of the static environment. The generation of such a dataset of a fictitious continent involves a number of challenges, since most tools and techniques are focussed on generating simulation environments of real world areas.

Description of work
The task group has been evaluating different approaches to generate the

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dataset. The three main approaches available are manually generation, using procedural techniques and reusing pieces of real world data.

A concern with using real world data is that this can lead to political or intellectual property right restrictions on the dataset, while it is the aim of the task group to generate a dataset without such restrictions. This needs attention while selecting data that can be used.

To generate the elevation data of the Missionland procedural techniques were applied first. Since these results lacked the large terrain features of real world terrain, the elevation data has been enhanced afterwards by blending in pieces of real world elevation data. Seamlessly connecting these pieces of elevation data was made possible by a dedicated tool developed by FFI.

For the vector data both procedural techniques and using of real world vector data was tested.

And a case-study has been performed whereby the data of the Swedish island of Gotland was integrated into the Missionland continent.

Results and conclusions

Manually generating data for the dataset is too labour intensive for an entire continent the size of Missionland.

To generate elevation data applying only procedural techniques does not result in realistic terrain, with large terrain features like valleys. Therefore the task group is using real world elevation data to enhance the procedurally generated base elevation of the entire continent.

For the generation of the vector data both procedural techniques and real world vector data will be used. The procedural techniques work best for vector features on continental scale, like a complete river systems. While real world data is the best approach to get feature rich data for smaller areas, like cities.

The case-study taught the task group that it is possible to minimize distortions while transforming existing data and that the feature attributes of the data have to be translated to give consistent results over the entire dataset.

To be able generate a dataset of an entire continent a combination of the different approaches is needed in the end to get the most realistic results.

Applicability

With the experiences gained the task group could set up the process for generating the Missionland dataset. Besides that the techniques and approach identified can also be applied in the process of making simulations environments for other projects or simulators.

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Re-using Real World Data for the Fictitious Missionland Continent

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ABSTRACT: An essential condition for a distributed mission simulation environment is an effective representation of the natural and cultural environment, correlated across all participants. The NATO RTO task group MSG-071 Missionland is in the process of developing an environment dataset for a fictitious continent located in the Northern Atlantic Ocean. To satisfy the heterogeneous needs of the users the continent should exist of a wide variety of terrain and climate types. This dataset will cover an entire virtual continent, offering a range of terrain types and climate zones, including coasts, mountains, deserts, jungles and urban areas. The dataset should be freely available to all NATO and Partnership for Peace (PfP) countries, without security or political limitations. Therefore MSG-071 is focusing on generating high-fidelity geo-typical data.

The MSG-071 task group uses different techniques in the construction of the dataset, ranging from procedural data generation to re-use of real world geographical data. This paper will mainly look at the latter approach. Topics covered include the pros and cons of using real world geo data and the challenges encountered while trying to generate a fictitious continent using patches of real world data. This will be illustrated using a case-study performed by the task group. Sweden contributed real world data of an island, which has been integrated into the Missionland continent.

1 Introduction

Distributed mission simulation is nowadays more and more used for military training, concept development and experimentation. An essential condition for an effective mission simulation environment is a realistic and correlated Synthetic Natural Environment (SNE). An SNE consists of representations of different types of objects, like terrain skin, vegetation and man-made structures.

This paper introduces the NATO Research and Technology Organisation (RTO) task group MSG-071 "Missionland" and discusses the possibilities of using real world geographical data to develop a dataset that will meet the requirements established for the SNE of the Missionland continent.

In Chapter 2 the Missionland task group background is introduced, as well as the high level requirements for the Missionland continent, the dataset products and a brief overview of the development process for these data products is presented. Chapter 3 discusses three possible approaches that can be used in the Missionland data generation process. Chapters 4 to 6 will discuss which approach is the most suitable one for each of the Missionland dataset products. Chapter 7 provides an illustrative case-study of how real-world data of an existing Swedish island can be moved into Missionland. Chapter 8 presents the conclusions and the way forward for the task group.

2 MSG-071 Missionland Task Group

This section explains the objectives of the Missionland task group and outlines the requirements for the different environmental data products in the Missionland dataset.

2.1 Objectives

When performing distributed (joint) simulations, selecting a suitable and correlated SNE for all participants is usually a challenge. The participants often have different requirements or different technical capabilities. In addition, legal and political restrictions often impose limitations to sharing the environment data. An example of such a political restriction is that countries often do not want to share high resolution environment data about their own country with others. Another example of political concerns is when an SNE is composed of real world data and one of the participants in an international exercise using the SNE, has a troublesome history with the respective real world areas.

The NATO RTO task group MSG-071 was formed in 2008 by the following countries and centres: Belarus, Canada, Germany, Netherlands, Norway, Sweden, Turkey, United Kingdom and the NATO Joint Warfare Centre. The objective of the task group is to ease the identified difficulties in creating suitable and correlated SNEs by creating an environment dataset that can be freely shared by NATO and Partnership for Peace (PfP) countries [1].

Missionland will provide a fictitious continent of roughly 2000 x 2000 km in size in the middle of the Atlantic Ocean. This continent will have a variety of climate zones and terrain types. To support a wide range of M&S needs, the environment will be richly populated with data representing different aspects of the real world. See Figure 1 for the basic design of the Missionland continent. The colours in the figure represent different climate zones. The size of the continent and its coastline allow for joint synthetic training, while high resolution areas make the dataset attractive for simulation of local ground based operations. Because the continent is fictitious, there are less political limitations on sharing the data.

Besides the requirements for a visual representation of the environment, the dataset needs to contain data used by other components in a simulation. For instance, data used by simulated infrared or radar sensors will be included, making it a multi-spectral dataset. Data used by computer generated forces applications will also be included [2][3].

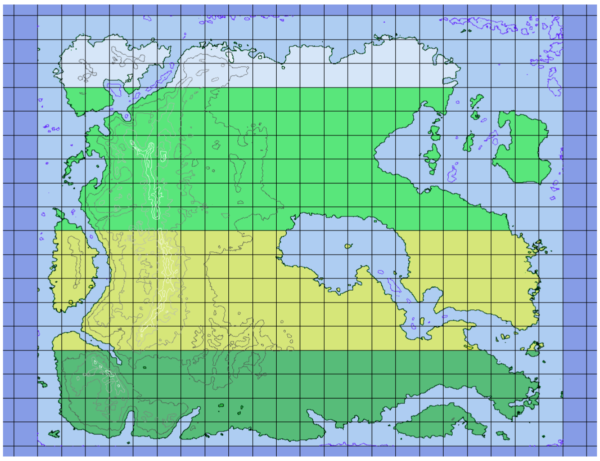

Figure 1: The basic design of the Missionland continent

2.2 Missionland dataset products

The Missionland dataset will provide a number of products to the end users. These end users will have to compile a runtime database of the environment for the specific simulation system at hand. The Missionland dataset will be delivered in common formats, to ease the process of creating this runtime version. Currently the task group is working on generating the content of the dataset. In the sections below the formats used in this phase are mentioned. These are most likely also the formats that will be provided to the end users, although that has not been decided yet.

The dataset will contain a number of core products: elevation data, vector data, 3D feature models, material textures and imagery. Other products, like maps, will be derived from these core products.

Elevation data

The elevation data is provided as a regular grid. The resolution of the elevation data varies, with the highest resolution being provided in the areas of interest. The whole continent will be provided at a resolution that allows air operations above the continent. The elevation data is stored as GeoTIFF files.

Vector data

The vector data represents different features in the environment. Vector data consists of point, linear and areal features. The point features are used to define the location of objects, like a house or a tree. The linear features are used to define roads, rivers or power lines, while areal features are used to define areas with certain land cover types, for example forest or city, or to define the footprint of a building. The vector data is stored in the ESRI Shapefile format.

Additional information on a feature is captured by its metadata, often called feature attributes. One of the most important attributes is the feature classification attribute. Other examples of feature attributes are the width of a road, the height of a building or the maximum load for a bridge. There are a number of commonly used schemas for these feature attributes such as the Feature and Attribute Coding Catalogue (FACC) and DGIWG Feature Data Dictionary (DFDD) from the Defence Geospatial Information Working Group (DGIWG) [4], and the Environmental Data Coding Specification (EDCS) from SEDRIS [5]. The task group is generating a list of the features that will have to be present in the Missionland dataset. This list will also contain a mapping to these commonly used attribution schemas.

3D feature models

Man-made features (e.g. buildings, bridges, light posts) are represented in the Missionland dataset by 3D feature models and associated textures. The dataset will also contain 3D models for natural objects like trees and bushes. These models will be stored in a common file formats like OpenFlight or COLLADA. The position of these 3D feature models in the environment is defined using point features in the vector data.

Material textures

Material textures are used to give features and objects in the environment the right material representation for visualization and sensor simulation. This can be in the form of textures used by the visualization, but also by providing the parameters to be able to generate a sensor image. For visual textures a common format like RGB is used. A common and widely used standard does not yet exist for multi-spectral data used by sensor simulations, but the task group will try to provide this data in such a way that most end users can easily use it in their systems. The task group is looking into initiatives like SEDRIS and Common Database (CDB) to evaluate if these can provide means to deliver the dataset in a common way that most end users can work with effectively.

Imagery

The Missionland dataset will also contain imagery of the continent. This is mainly used for two purposes. First imagery is often used in simulation systems to drape over the terrain skin to give the environment a realistic look. Secondly the imagery can be directly provided to the operators of the simulation system as reference material.

The imagery data is provided as a raster image. The resolution of the imagery varies, with the highest resolution being provided in the areas of interest. The imagery is stored as GeoTIFF files.

Maps

Maps are important in most military applications but differ significantly from application to application. For example, maps used for air and ground operations differ both in scale and in the features that need to be represented on them. Yet these maps still have to be consistent with each other. The maps must not only realistically represent the terrain of Missionland, but they must also contain cultural information such as borders, municipalities and population types. The Missionland dataset should therefore contain enough information to allow for the generation of such maps.

3 Approaches for data generation

For real world environments geographical data is gathered by recording imagery and measuring the elevations in an area. From this data additional information, like vector data, is then derived. But since the Missionland continent is fictitious this approach of obtaining geographical data for the continent will not work. Therefore, one of the biggest challenges for the Missionland task group is to generate the data for this vast continent.

The task group adopted a basic data generation process for Missionland that starts with the generation of the elevation data. Next the vector data is generated, which has to conform to the elevation data. This is helps to ensure that for example rivers are not flowing uphill or that big cities are not located on steep mountains. After both the elevation and vector data have been generated, the next step in the process is the production of the imagery data from these two products. So in a sense the Missionland data generation process is partly the reverse of the data generation process that would be used for real world areas.

In general there are three approaches that the task group has considered for the generation of the different products in the Missionland dataset: manual generation, procedural generation and reuse of real world data. Each of these approaches has its pros and cons, which will be discussed in the next three sections. In chapter 4 to 6 these approaches are further examined to determine which is the most suitable data generation approach for each of the Missionland products (Section 2.2).

3.1 Manual generation

The first approach is to manually generate the geographical data of the continent. Someone with geological or geographical knowledge, as well as artistic talents, would in theory be able to create realistic looking data through the use of manual methods. The obvious downside of this approach is that it is very labour intensive. Given the huge size of the Missionland continent, the task group tries to minimize the amount of manual work.

3.2 Procedural generation

Procedural modelling methods are characterized by their ability to produce relatively large amounts of data from a relatively small number of parameters. A tool for procedural generation of geometric building models would typically take parameters as: number of floors, type of roof, shape of foot print, etc. as input, and then generate all the polygons that make up the geometric model and the textures that are applied to it. Other geometric models, like terrain skins, road networks and vegetation models can be generated in the same way. The definition of procedural modelling as adopted by the task group is: modelling through a computer program that takes a set of parameters as input and outputs data that represent an instance of an object class (terrain elevation, geometric models of vegetation or man-made structures, etc.) [6].

The advantages of procedural techniques are that they can generate large quantities of data using only a limited number of input parameters, thereby decreasing the amount of work needed to cover an entire continent. Other advantages are that the data can be generated at any desired resolution and that no political restrictions apply to the usage of the data.

The downside of such procedural techniques is that the generated data does not always realistically represent the wide variety of features one would encounter in the real world. For example, procedurally generated elevation data is usually missing features like river systems and valleys. Another problem encountered by the task group was that procedural techniques are less suitable to generate an environment with a lot of variation. For example generating the elevation data for a continent with both flat and alpine areas did not give realistic results [7].

3.3 Reusing pieces of real world data

The third approach for generating a fictitious continent is to generate it from pieces of real world geographical data that are patched together. One of the biggest challenges of this approach is how to combine the different pieces of real world data seamlessly into a new consistent dataset of the continent. This typically requires a significant amount of manual work.

The biggest benefit of this approach is that the resulting environment looks very realistic. Using real world data will for example ensure that the road network of towns and cities looks realistic or that elevation data will contain realistic looking valleys and rivers. Especially for complex features, like a city, using real world data is the easiest way to ensure that a realistic and feature rich environment is provided.

The biggest downside of using real world data is that it can introduce intellectual property rights (IPR) or political restrictions on the usage of the Missionland dataset, while it is one of the objectives of the task group to create a dataset without such restrictions. IPR restrictions can be prevented by making sure that the license of the data used allows sharing with other NATO or PfP countries. For example the countries participating in the task group that have contributed data to the dataset agree with the conditions under which the dataset can be shared with other NATO and PfP countries later on.

The political restrictions that might result from using real world data are harder to prevent. These often result from military operations being simulated over an environment that represents another country. So if large continuous areas with real world data are used in the Missionland dataset, the resulting environment could be recognisable as a certain piece of the real world. The best approach to prevent political restrictions is to make sure that small and not so recognisable pieces of real world data are used.

4 Elevation data

For the elevation data the task group first tried to use procedural algorithms, since this would be the easiest way to generate elevation data for an entire continent. After evaluating available tools to generate an entire continent, the L3DT tool [8] was used to generate a basic elevation model of the entire Missionland continent. However, the quality of the resulting elevation data did not meet the expectations. The resulting elevation data did not provide realistically looking areas for the different terrain characteristics of the Missionland design. For example the mountainous areas were not mountainous enough, while flat areas were still too hilly. The task group concluded that the available tools and algorithms do not cope well with an area that has different terrain characteristics. This is understandable since most of these tools and algorithms are mainly used for smaller areas that typically address one terrain characteristic.

To increase the variation in the elevation profile the first idea was to enhance the procedurally generated elevation data manually. Using operations to lower or raise the elevation it is possible to manually flatten certain areas, while making others more mountainous. However, performing this for an entire continent would be labour intensive.

The Norwegian Defence Research Establishment (FFI) is developing an application for the processing of elevation data, the Interactive Terrain Editor (ITED) [7]. ITED was developed as a prototype tool for research in ways to enhance existing elevation data and as an aiding tool for the Missionland task group. ITED uses the Graphics Processing Unit (GPU) of COTS graphics cards to interactively process raster elevation data loaded from common GIS format files. A user can edit the terrain using simple, but effective low level brushes in much the same way as a user can edit an image using air brushes in an image editor. This tool was used to manually enhance the elevation data in certain areas.

Another feature of the ITED is the capability to blend two pieces of elevation data. This offers another approach for the generation of the elevation data for Missionland. When pieces of elevation data can be seamlessly blend into each other, it becomes possible to use pieces of real world elevation data as well. This process would still require a significant amount of manual work. However, this approach enables the preservation of large terrain features like rivers and valleys, Therefore this approach gives more realistic looking elevation data than what can easily be obtained by the use of procedural methods and low-level editing. Figure 2 shows a comparison of real and procedural generated terrain

When the areas of real world data that are blended into the environment are not too large, the resulting terrain will not be so recognisable as a piece of real world terrain. In that case no political restrictions should apply on the distribution of the dataset. The task group has had a positive experience with the performance of the blending approach while enhancing high resolution areas. Based on this, the task group has decided to use this approach to generate the elevation data for the entire low resolution version of the Missionland continent. The public domain elevation data from the United States

Geological Survey (USGS) will be used as the basis for this.

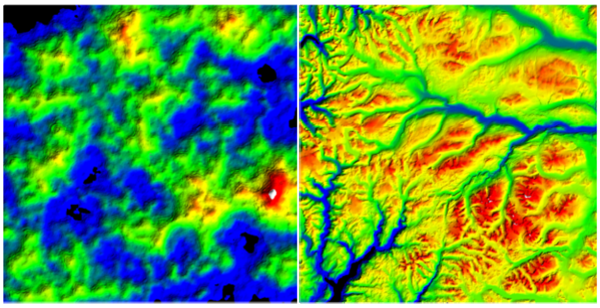

Figure 2: Visualizations of procedural terrain on the left and real terrain on the right

5 Vector data

When it comes to the vector data of the Missionland continent, two types of vectors should be considered. First there are global features that cover a big part of the continent. Examples of these are rivers or main road networks. The second type of vector data are the highly detailed features used to represent the areas of interest, for example a city, harbour or airport.

For the global features it is important that they follow the elevation profile correctly. For example a river should take a natural path down from the mountains into the sea. Although these features do not have to be represented in very high detail everywhere, they do cover long distances over the entire continent. Drawing them manually would require a lot of effort. Therefore the task group is looking into the possibilities of generate such features with algorithms, based on the elevation data of the continent.

Figure 3 shows the results of some experimentation with this approach. It shows a river system for Missionland that has been generated from the elevation data using the GRASS plugin for QGIS [9]. Similarly, the task group will also try to use GIS tools to generate a basic road network for the Missionland continent.

For generating the second type of vector features, the high detailed features representing areas of interest, the use of algorithms is also one of the options that the task group is looking into. There are for example multiple tools available that can create a random city using a set of rules. The road network and buildings for the city are then generated by the tool [10].

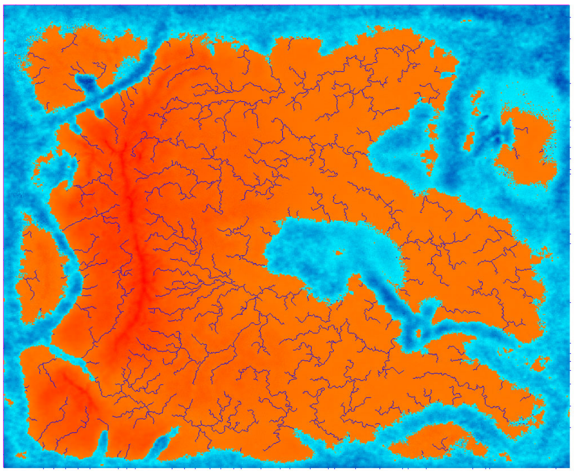

Figure 3: Rivers for Missionland generated from the elevation data

However, such tools do not exist for all types of areas of interest. For example a harbour is harder to generate with this approach. Besides that another drawback of such tools is that resulting cities will often look relatively similar. Since the Missionland continent provides a wide range of climate zones and terrain types, the vector data of the areas of interest is expected to differ in these different zones.

Therefore, the task group is also looking at alternative approaches to generate the vector data of the areas of interest. Manually drawing them is not an attractive solution, since these areas are typically very rich in features. Using pieces of real world vector data seems a suitable approach though. Real world vector data is usually already rich in features, so using it will ensure realistically looking areas.

Like for the elevation data there is a risk of political restrictions on sharing the vector dataset, when pieces of the Missionland continent are recognisable as a certain real world area. But when only a town or airport is used from a certain real world area and placed within the Missionland context it is expected this will not prove to be a big problem.

When using real world vector data and fictitious elevation data, there is by definition a mismatch between the two components. For example when a city from a flat region is placed in a mountainous area the result will not be very realistic because the vector data does not conform to the natural constraints of the elevation data. The hillier the area is, the bigger the problem becomes. One approach is to manually edit the two data components to obtain correlation, but this is potentially a difficult and time consuming process. Another approach is to locally blend in the real world elevation data that matches the vector data used. This is a task that could be performed with the ITED tool as discussed in Chapter 4.

6 Imagery

The task group has not started the work on the imagery of the Missionland dataset yet. The reason for this is that the imagery needs to correlate with the elevation and vector data. Therefore it can only be generated once these products have been finished.

The approach for generating the imagery will most likely be based on the Missionland vector data product. For each land usage type, as defined in the vector data, a representative material texture will be used to fill the imagery for that area. The information from the elevation data will be used to further enhance the resulting imagery, for example by ensuring that on high altitudes or on slopes different terrain characteristics are displayed. This approach to generating imagery is used in some computer games [11] and also companies in the modelling and simulation world are starting to use this technology. However, such an approach is not widely available in COTS tools yet. This approach for generating the imagery seems very suitable for the Missionland needs. But until the right tools are available, the task group might have to decide to use other approaches which produce imagery with less quality.

It is expected that little use will be made of real world imagery for the Missionland dataset. Technically it would be possible to include the imagery for a real world area that has been used in the vector data. But doing so will make the area much more recognisable and is therefore more likely to result in political restrictions. Besides that the approach of generating the imagery from the vector data, also has the advantage to ease the process of generating multi-spectral representations of the area. To enable the generation of such a presentation, one would also need material information for the other regions of the electro-optical spectrum. The material library of the Missionland dataset aims to provide such information as well.

7 Test case real world data integration

In this chapter an illustrative case-study is presented for the actions that typically have to be performed when moving real world vector data into Missionland. For this test-case Sweden offered geographical information about the island of Gotland. The idea of the case-study was to move this island to a location on the Missionland continent and to change some of the city names. If successful this case-study should provide a piece of Missionland with a rich set of features and also demonstrates the possibility to add more features from real world data.

The data itself is unclassified and sold publicly to anyone who has interest in it. The Swedish Armed Forces have free access to this data. By moving the data to Missionland, the data is slightly distorted, due to the different projection. This data is further changed by the changing of city names. The task group believes that the name changes combined with a new geographical context is enough to prevent political restrictions on using the data.

Moving the real world data of Gotland to Missionland involved two main activities. The first one was changing the geographic location, without distorting the shape of features too much. The second task dealt with the attributes used in the metadata. Both of these tasks will be discussed next.

When moving geographical data to a different position on the globe, deformations could be introduced. For example geodetic data that is relocated will be distorted when the local radius of the earth is different at the new location. When moving real world data to Missionland it is important to minimize such distortions. When features like footprints of houses or the runway of an airport are distorted too much the end result will no longer look realistic.

For Gotland the task group made use of the Proj4 library [12] and some scripts to relocate all vector data. Since the data was provided in an UTM projection, an offset was applied to move it to the position of Missionland and afterwards it was re-projected to geodetic coordinates. For other data a similar approach can be used, although the exact approach depends on the projection in which the data is available.

The metadata used in real world vector data often varies depending on the supplier of the data. Many countries also have their own specific attribution schema that is used for the metadata. For the vector data in the Missionland dataset it is important that the attribution used is consequent over the entire continent. That way the end user knows what amount and type of metadata can be expected in the dataset. Therefore the attribution of the real world data has to be mapped to the one used in the Missionland dataset. This task also has to be performed for the data of Gotland.

When the two steps described above are performed, real world data can be inserted into the Missionland dataset. In this case the data was from an entire island, so there was a natural boundary for the city. If real world data of for example an urban area is used, it has to be ensured that there is a realistic transition to the remaining vector data in the dataset. Else the resulting environment will not look realistic.
The task group is currently experimenting with other sources of real world data, but the results of the test case of Gotland show that it is feasible to use real world vector data for the Missionland dataset. Such real world vector data can indeed provide a feature rich area for relatively little effort.

8 Conclusion

The NATO RTO task group MSG-071 is creating a coherent dataset of a fictitious continent that can be freely used by NATO and PfP countries. This dataset contains elevation data, vector data, imagery and libraries of 3D feature models and material textures. From this dataset the users can construct the environment databases which are needed in distributed simulation environments for visual out-of-the-window and sensor views, as well as terrain servers and computer generated forces applications.

To generate the content for these different products a number of approaches are available. The first one is to manually generate all data, but this is too labour intensive given the scale of the entire continent. Procedural techniques can relieve the manual work. However, the downside of this approach is that the generated data often does not represent the complexity of the real world realistically enough.

User controlled blending of real elevation data is a promising technique to enhance procedural generated terrain to higher levels of realism. By using real world data and patching this to the procedural generated terrain the task group can ensure that the simulation environment is sufficient realistic and rich in features. Seamlessly connecting pieces of real world data can be hard, therefore FFI generated a dedicated tool that provides the task group with the capability to produce fictitious terrains with use of real-world elevation data. Further the task group has to make sure that no IPR issues or political restrictions are raised when using real world data.

A case-study with the real world data of the Swedish island of Gotland has shown that using real world data is a feasible approach to create a feature rich environment dataset for Missionland. Two important lessons learned from the case-study is that one has to ensure that the distortion is minimized when moving real-world data to the Missionland location and that the feature attributes have to be translated to be consistent with other features in the Missionland dataset.

Another lesson learned from the case-study is that the Missionland task group will have to utilize a combination of all three approaches to achieve its objectives. For each product in the dataset the most suitable combination of these approaches will be selected to generate the data.

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10 References

[1] Arjan Lemmers, Arno Gerretsen, Frido Kuijper, Marcel Kleijhorst, 2009, “Missionland, a multinational co-operation program to construct and share a generic mission simulation environment”, 09E-SIW-010, European Simulation Interoperability Workshop, Istanbul, Turkey

[2] Arjan Lemmers, Arno Gerretsen, Marcel Kleijhorst, 2010, “Missionland: User Needs for a Virtual Continent”, 10E-SIW-005, European Simulation Interoperability Workshop, Ottawa, Canada

[3] NATO RTO Task group MSG-071 Missionland, 2010, “User Needs Report”, NATO RTO, Neuilly sur Seine, France

[4] DGIWG, "DGIWG Feature and Attribute Data Registry website", 2011, Online: https://www.dgiwg.org/FAD/

[5] SEDRIS, "SEDRIS EDCS website", 2011, Online: http://www.sedris.org/edcs.htm

[6] R. M. Smelik, K. J. de Kraker, and S. A. Groenewegen, 2009, "A Survey of Procedural Methods for Terrain Modelling", Proceedings of the CASA Workshop on 3D Advanced Media in Gaming and Simulation (3AMIGAS), Amsterdam, The Netherlands

[7] Martin Ferstad Aasen, Arno Gerretsen, Simon Skinner, 2011, ”Environment data for a high fidelity fictitious continent”, 11E-SIW-046, Simulation Interoperability Workshop, Boston, USA

[8] A. Torpy, "L3DT website", 2010. Online: http://www.bundysoft.com/L3DT

[9] QGIS, “QGIS website”, 2011, Online: http://www.qgis.org

[10] B. Weber, P. Müller, P. Wonka, and M. Gross, "Interactive Geometric Simulation of 4D Cities", in *Computer Graphics Forum in Eurographics*, 2009.

[11] Adam Szofran, “Global Terrain Technology for Flight Simulation”, 2006, Game Developers Conference (GDC)

[12] Proj4, "Proj4 website", 2011, Online: http://trac.osgeo.org/proj/