Missionland, a multinational co-operation program to construct and share a generic mission simulation environment

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ABSTRACT: A simulation environment is a virtual representation of the real-world natural and cultural environment. Such an environment contains dynamic elements, for example weather, time of day and moving vehicles, as well as static elements, for example vegetation, buildings and infrastructure. When performing distributed (joint) simulations a number of problems exist concerning the selection and use of a simulation environment. These problems can either be caused by the different requirements of the participating users or by different technical capabilities.

As training via distributed mission simulation has the potential to enhance force readiness and operational effectiveness in coalition operations, these problems with the environment representation should be solved. Normally, this can be done by correlating existing environment databases, but that is costly, both in effort and in money, and the end-result will always be hampered by technical incompatibilities. It also does not address security and political limitations. Therefore it is preferable to create a generic and geo-unspecific simulation environment, Missionland.

In 2008 the NATO RTO task group MSG-071 'Missionland' started. Its prime objective is to construct a coherent dataset from which environment databases can be constructed for a wide scope of simulators. These environment databases are generally needed for visual out-of-the-window and sensor views, but also terrain servers and computer generated forces applications often make use of such databases. In support of the prime objective, there is the need to implement a deployment and continuation process to ensure proper use and continuation after the life of MSG-071. This includes guidelines and support in using Missionland.

1. Introduction

Imagine ... a whole new continent is planted in the middle of the Atlantic Ocean. It is a continent with a variety of climate and eco system types: arctic cold, tropical green, warm deserts and more are represented in this intriguing continent that is populated with a ditto variation of cultures. The most interesting feature of this new continent is that it has a very enthusiastic and well-equipped Modelling & Simulation Geodata Office that is capable of delivering whatever data you need to enable simulated exercises on their continent. Everything is available - remote sensing imagery, ground imagery, terrain elevation data, detailed vector data and all required model libraries - to give your simulators a kick start into (networked) simulation exercises on this continent.

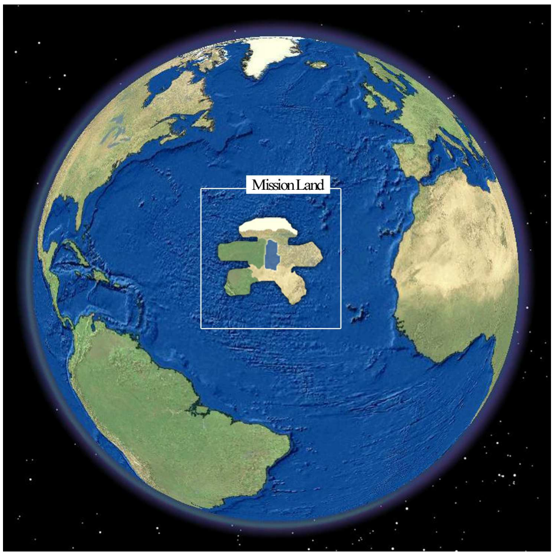

Figure 1: Imagine a new continent: Missionland. (shown geography is random, not final)

The name of this new continent is *Missionland* and its creation was initiated in 2008 by the NATO task group MSG-071. The task group is currently in an early phase of development. Thus, this paper outlines the plans and expected results for Missionland as they are in this initial stage.

The aim of the Missionland task group is to create a common dataset of the static environment that can be used for simulation exercises. The focus is on the content itself, not on the way to store or represent it, as for example SEDRIS addresses.

The paper starts with the rationale and the operational context for Missionland. Then the objectives of Missionland and its task group are outlined. The approach of the work group will be explained and the different phases in the Missionland development process will be described. The creation of the data sets is discussed and the products and services that Missionland will deliver are outlined. Finally it will be explained how the simulation developers or users can use the Missionland data sets to generate databases for use in their simulators.

2. Rationale and Operational Context

A simulation environment is a virtual representation of the real-world natural and cultural environment. Such an environment contains dynamic elements, for example weather, time of day and moving vehicles, as well as static elements, for example vegetation, buildings and infrastructure. When performing distributed (joint) simulations a number of problems exist concerning the selection and use of a simulation environment. These problems can either be caused by the different requirements of the participating users or by different technical capabilities.

An example of such a problem, are the different requirements on the level of detail for different forces, while the databases these forces use should still be correlated for the joint simulation. But even if the requirements on the environment database are the same, the difference between the technical implementation in two simulators might still make the reuse of the same simulation environment impossible. Creating different environments for each simulator has its own problems, as it is then required that these databases are correctly correlated with each other. Other limitations arise from a political point of view. For example the distribution of high resolution geographical data of a specific real world area to other countries is often subject to export restrictions due to national security issues.

The NATO RTO Task Group SAS-034/MSG-001 demonstrated with the Exercise First WAVE that training via distributed mission simulation has the potential to enhance force readiness and operational effectiveness in coalition operations [1]. The Task Group created a distributed training environment in which flight simulators and other crew stations in the nations were linked across a secure wide area network. For four days, operational crews planned and briefed daily coalition air missions then flew them in a common synthetic battle space and debriefed the outcome. Many challenges were encountered and addressed, providing a rich source of experience and lessons, with many deficiencies identified and consequential lessons learned.

To ensure that the correlation issues between the simulator databases were minimised the First WAVE Technical Task Team decided to use a common terrain database source for all facilities. Normally, this is the best way to ensure the correlation of environment databases, but it is costly, both in effort and in money. In First WAVE the Canadian organisation Defence Geomatics undertook preparation of the common database, supported by a specialist database working group from the Technical Team. This group addressed issues including the selection of projections and imagery resolution, though this was in fact limited by the availability of source data at the resolution required [1].

These problems with the environment representation should be solved as must the limited availability of source data due to security and political limitations be addressed. Therefore it is preferable to create a generic and geo-unspecific simulation environment, Missionland. Being a geo-unspecific environment, would also overcome the objections that result from using a real world area as basis for the simulation environment. And besides that, it also offers the advantage that geologically different environments can all be combined in the same simulation environment. This makes a generic environment much more flexible in performing different types of missions within the same simulation environment.

3. Objectives for Missionland

The prime objective of Missionland is to make available a shared coherent dataset from which environment databases can be constructed for a wide scope of simulators. These environment databases are generally needed for visual out-of-the-window and sensor views, but also terrain servers and computer generated forces applications often make use of such databases. An open source development model will be used to ensure that participating nations and industries have full access to the dataset and can feedback changes and improvements made to Missionland.

Only static parts of the simulation environment will be addressed by Missionland, i.e. terrain, buildings, infrastructure (roads, railroads, power lines, etc.) and vegetation. Besides including information for creation of visual simulation environments, Missionland will support multi-spectral use, for example for infrared or synthetic aperture radar sensors.

To reduce problems with intellectual property rights or with political background, Missionland will be a fictitious environment. Missionland will cover multiple climate zones, various elevation settings, coastal areas and ‘large’ continuous land masses. This ensures a suitable environment for a large variety of applications, including: training, tactics development, simulation based acquisition, and concept development and experimentation. One application that is not supported by Missionland is mission rehearsal, due to the fact that Missionland cannot be specific to the operational area of interest.

In support of the prime objective, there is the need to implement a deployment and continuation process to ensure proper use and continuation after the creation of Missionland. This includes guidelines and support in using Missionland.

To reach this objective the Missionland activities are divided into three phases:

1. **Investigation phase:** In this phase the needs of potential end-users are investigated and captured in a user needs statement containing the user requirements and a prioritisation thereof. Investigation of standards and formats will take place with appropriate recommendations. A preliminary Missionland development model and design will be made and the objectives for the creation phase will be formulated and prioritised.
2. **Creation phase:** In this phase the envisioned Missionland development model is implemented and the creation of the dataset is initiated. An incremental and iterative process refines both design and dataset until the objectives for version 1 are completed.
3. **Refinement phase:** It is critical to the continued value of Missionland to put in place the means for continuous refinement of Missionland after the Missionland dataset version 1 has been developed.

4. Missionland Task Group

In 2008 the NATO RTO Task Group MSG-071 ‘Missionland’ started. An RTO Task Group (RTG) technical team activity aims at allowing researchers in different nations to work together in order to solve a particular research and technology problem [2]. In the MSG-071 Missionland activity the following countries and NATO bodies are participating: The Netherlands (chair), Belarus, Canada, Germany, Norway, Sweden, Turkey, United Kingdom and the NATO Joint Warfare Centre. The foreseen duration of the task group is 3 years.

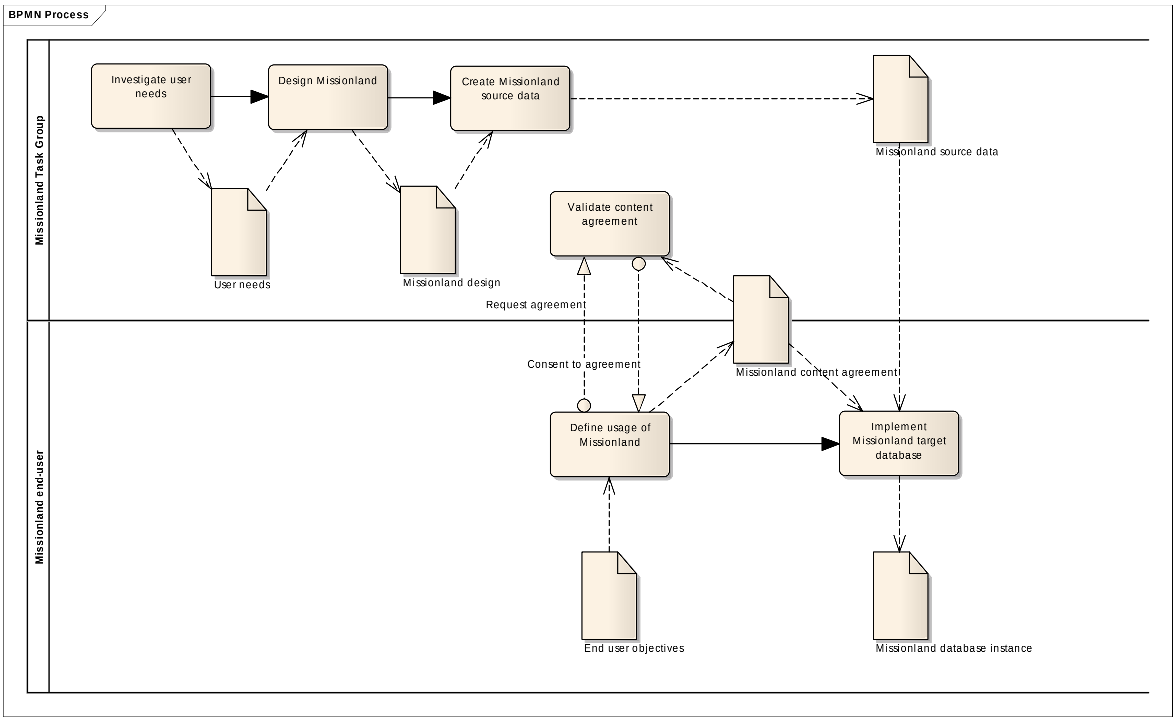

Figure 2 - Scope of Missionland

4.1. Description of work

The objective of Missionland is to construct a dataset from which simulation environment runtime databases can be constructed. To produce a ready made runtime database is not feasible since there are too many different systems and formats. Figure 2 depicts the process of creating and using Missionland; it also scopes the work that falls under the Task Group and what work can only be performed by each of the end-users. Missionland has to facilitate the process of configuration and conversion into a target database. It is proposed to support the concept of 'Content Agreement' to ensure that conversion into a target database is properly performed. The 'Content Agreement' concept is developed in the UK and they offered to work with the Missionland Task Group.

4.2. Investigate user needs

The Missionland Task Group will start with the identification of potential users of Missionland. The Task Group will investigate the needs these users would have for Missionland, what requirements and constraints must be imposed for Missionland to be usable to these end-users. The instrument the Task Group will use for this investigation is a questionnaire. Aspects covered in the questionnaire include: who are the stakeholders, who will be end-user of Missionland, requirements for Missionland, intended use, etc. The availability of Missionland may well affect future concepts on distributed mission simulation or joint mission simulation, both internationally and nationally. Therefore it is important to obtain information not only from simulation end-users but also for instance from policymakers. Apart from the research institutes involved in Missionland the defence audience the Netherlands identified for providing information through the questionnaire consists of policymakers on central staff level, policymakers on training, simulation experts, simulation end-users and milgeo experts, originating form the land, sea and air domain. A first set of requirements for Missionland will be derived from the thus gathered information. All participating countries will perform a resembling action. The results of this activity will drive the further development of Missionland.
Since Missionland will be developed in an iterative and incremental process, feedback from the next development activities will provide the opportunity to refine the user needs.

4.3. Design Missionland

Following the investigation into the user requirements for Missionland, the design will start. The design will merge the objectives and user requirements and result in concrete plans from which the creation of the actual dataset can be started. As the user requirements are not completely defined yet at this moment, the actual design process has not started. But some of the general principles and constraints that will be applied during the Missionland design process are known already and these will be discussed in this section.

To be able to easily use Missionland in simulators it is required that it is designed using real world coordinates. In order to prevent conflicts with the already existing terrain of the world it was decided that Missionland should become an island in one of the oceans. Given the fact that Missionland is created by a NATO RTO taskgroup, using the northern Atlantic Ocean as the location for this new fictitious island seems quite logical.

One of the objectives for Missionland is to be able to provide different geographical zones. The island shall contain polar and tropical, flat and mountainous or urban and rural areas. As each of these zones should allow joint operations of armed forces within the zone, including the air force, it is obvious that each of them should be relatively big. This also implies that the total Missionland island will be of considerable size.

The different kind of forces operating on the Missionland island all have their own requirements on the amount of detail that should be included. A company of soldiers manoeuvring through a town require more details to be present than a naval vessel observing the same town from the seas. Given the vast amount of space available on the Missionland island, filling it all with the amount of detail required for the deployment of ground troops will be an enormous task. Therefore the first version will only contain that level of detail in a number of defined locations, while the rest of the island will be filled with less detail. The detail provided in those other areas will still be sufficient for the units that have to operate there, so that it is possible to perform a joint scenario. With future revisions of Missionland more areas can be upgraded to a higher level of detail.

Combining the need for different geographical zones, the different requirements on the amount of detail needed for different areas and the fact that Missionland will not be created by one single organisation; it becomes clear that extendibility and modularity are important aspects in its design. Another reason for this is that Missionland has the potential to become much more complex than the initial taskgroup will be capable of realizing in the first version. Therefore the possibility of future growth should already be accounted for in the design.

It is envisioned that each nation or organisation interested in Missionland can claim a certain area in one of the Missionland zones and than fill it with content. So for example an organisation interested in urban warfare might claim a spot to create a town, while an organisation interested in air warfare might claim the surrounding countryside and fill it with the necessary content to be able to perform aerial operations.

Whether all geographical zones will be located on one big island or each of them will have a separate island in the Missionland archipelago is still under discussion. On one hand no unrealistic borders should be present between two zones, but on the other hand it should also be possible to create scenarios that span different zones. A solution for this might be to define a certain number of fixed connections that have to be present between zones. This also fits well with the modular character as it would define the constraints at the edges that ensure that the different pieces fit together in the end. And from the operational point of view these might provide some interesting logistical bottlenecks as well.

4.4 Create Missionland dataset

After making the Missionland design, the next step will be the creation of the actual dataset. Using this dataset to end users will be able to create their runtime database for usage in a specific simulator. This section will describe the initial ideas and constraints of the Missionland dataset and the way the dataset will be constructed.

Before the dataset can be filled with content, agreement has first to be reached on the data model that is going to be used for it. The aim of Missionland is the creation of the dataset itself, so it is not intended that a completely new data model or file format is developed. Existing open and well supported standards will be used where possible. There are some ongoing developments on standards for environmental databases and these are monitored by the Missionland taskgroup.

One of these is Synthetic Environment Data Representation and Interchange Specification (SEDRIS), which provides the means for representation and sharing of environmental data. To do so it offers a data representation model (DRM), spatial reference model (SRM and an environmental data coding specification (EDCS) [3]. Another development is the Common Database (CDB) standard developed by CAE and now maintained by Presagis [4].

Another issue with standards is that the simulation and the GIS world do not always follow the same standards. For example for data classification the GIS world favours the FACC coding more, while in the simulation world the EDCS seems more popular. As the field of environment databases is bridging both of these worlds, these differences have to be considered.

The scope of Missionland is to provide the static environment for a simulated mission. This means it will not include dynamic effects such as weather or 3D models of entities. These elements are important for the final scenario, but they are assumed to not be provided by the environment database. The organisation setting up the scenario is responsible for providing them. The environment dataset will contain some meta data that supports the organisation defining the scenario though. For example for weather this could be climatological data.

The dataset will contain all data at the highest level of detail possible. When a certain application does not require this high level of detail, it can be down sampled when creating the runtime database. Guidelines will be provided for this process, so that the correlation between different runtime databases generated from the Missionland dataset is optimal. For convenience these down sampled sources might be stored in the Missionland data repository as well for the benefit of other end users.

How the data for the dataset is going to be generated or constructed is still a point of discussion. Being a fictitious island, it is clear that no ready made data for the area exists.

One option is to use pieces of GIS data from the real world and combine them to form Missionland. A possible limitation for this approach is the licensing of the data. The aim is that the Missionland dataset can be used freely for distributed simulations by all NATO and PfP nations. When inserting data with wide ranges of licenses it is a real risk that, when taking the common factor of all individual licenses, the final dataset gets a very restrictive usage. Another challenge when using patches of real world data is that they have to be integrated seamlessly into the final Missionland world.

Another option is to generate all data for Missionland from scratch. This could be a manual process, but that would be very labour intensive. Another option would be to automate it where possible, by using algorithms to generate the data. An example of this is the creation of elevation data using a fractal terrain algorithm. When generating all data from scratch the challenge is to make the data so that it looks realistic [5][6].

It is expected that in the end the Missionland dataset will be created by a combination of the two methods proposed above. For example the elevation data might be generated with an algorithm, while the street layout of a complex city might be based on real world data.

The correlation between the different types of source data in the dataset is an issue that requires attention, no matter which method is used to create the data. For example the slope of the terrain has an influence on how roads are placed on that terrain and vice versa. So there is a relation between the elevation and vector data. When creating a fictitious terrain like Missionland the designer will have to take this kind of relations into account, else the final terrain will not look realistically.

5 Missionland products and services

This section gives an overview of products and services that are considered to be part of the Missionland concept.

Elevation data
Elevation data will be made available, describing the terrain skin without the features (DTM, Digital Terrain Model). To obtain maximum correlation capabilities, it will be considered to provide not only grid post elevation data, but also a more accurate triangulated irregular network (TIN) representation. Besides the DTM that describes the terrain skin, bathymetric data will be provided that describes subsurface terrain. An explicit Digital Surface Model (DSM), describing the terrain height including features like buildings is not foreseen as a Missionland product.

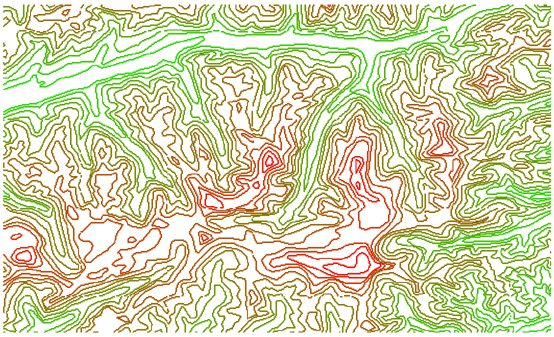
Figure 3: Example of contour elevation data

Imagery
Simulated remote sensing imagery of Missionland will be made available. The primary product will be orthorectified airborne imagery (true orthophotos). It is expected that image resolution that is offered will vary with the database feature density and specific zone depended requirements.

Figure 4: Example of imagery

Vector data

The Missionland vector dataset, consisting of areal, line and point features in the terrain, will obviously provide a description of the topography and geography of Missionland:

- Land use features;
- Infrastructure features;
- Subsurface features.

However, the vector data will provide more than just that. Missionland will strive after a complete description of the simulated continent, including:

- Political data (borders);
- Demographic data (fictitious ethnicity, population numbers);
- Navigation data (beacons, airways);
- Magnetic variance;
- Trafficability.

The vector dataset will be the key to actual database generation, serving all the necessary aspects of simulation: visual, sensor, computer generated forces and scenario development.

Issues to be decided upon in the Missionland project is the data definition standards that are going to be adhered in vector attribute coding.

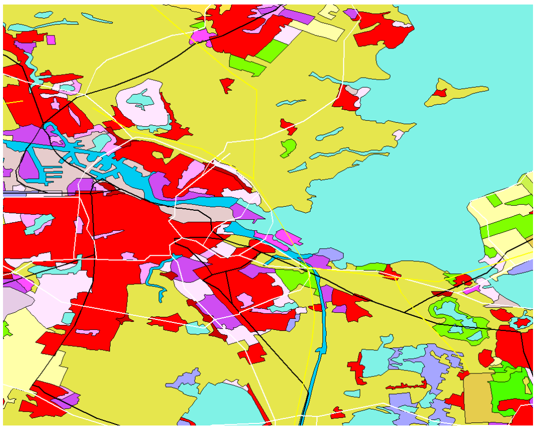

Figure 5: Example of vector data

Feature Model Library

The feature model library will provide a set of all 3D terrain features that are used in the dataset. Objects like landmarks, electricity poles, antennas will be contained in this library.

With respect to buildings, it will be decided how procedural buildings can be incorporated within Missionland in order to achieve correlated runtime databases with a variety of buildings.

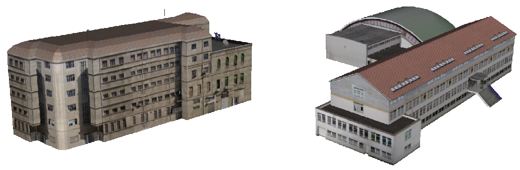

Figure 6: Examples of feature models

Texture Library

The Missionland texture library will contain all geotypical textures that are used in the Missionland dataset.

Figure7: Examples of geotypical textures

Material Library

In order to enable sensor simulation, material coding is required throughout the Missionland dataset. For this purpose, a material library will be defined. Each texture in the texture library will come with material coding according to the material library. A texture can either have a single material code bound to it, or a material texture, containing a per pixel material code.

Services

Apart from supplying just a raw dataset, it will have to be decided which additional services shall be part of the Missionland concept. Services to be considered include:

- Efficient integration and verification of new data into the Missionland dataset;
- Efficient distribution of data;
- Computation of complete terrain database tiles in e.g. OpenFlight format;
- Computation of simulated remote sensing data upon user request;
- Guidelines for the construction of runtime databases from the dataset.

6 Runtime database construction

The actual construction of a runtime database for a specific simulator is not considered to be part of the activities performed by the Missionland taskgroup. This is because this activity is very specific to the target simulator that the database will run on. It will be considered to provide fully computed terrain database tiles in OpenFlight format, but it is recognized that each runtime database has to be tuned to the specifics of the simulator that it will be used on.

To ensure that the different databases constructed from the Missionland dataset maintain correlation with each other, the way the construction phase will be conducted is of interest to the taskgroup. Therefore documentation and guidelines will be provided with the dataset, to enable the end user to build a runtime database in a structured manner and thereby ensure that optimal correlation maintains between different databases build from the Missionland dataset. It is being considered that the end user has to sign an agreement on how to use the Missionland content.

Another point of attention in this phase is how to actually validate the correlation between runtime databases, after they have been constructed from the same dataset. It is expected that guidelines and possibly tools will be provided as part of Missionland to be able to perform this task, as this is an important step in ensuring that the database can be used correctly in a distributed simulation.

7 Conclusions and challenges

It is recognised that training via distributed mission simulation has the potential to enhance force readiness and operational effectiveness in coalition operation. To exploit this potential one of the most challenging efforts is to harmonise the static environment representations across a variety of simulators. These efforts could be simplified when all participating users build their environmental databases using the same datasets. To make this possible the NATO RTO addressed a task group MSG-071 Missionland with the prime objective to construct a coherent dataset from which environment databases can be constructed for a wide scope of simulators.

The task group decided to develop data sets for a fictitious continent. This continent, named Missionland, will consist of several climate zones and will contain flat, urban, mountainous, jungle and desert areas, cultural features, a road network, and specific operational areas of interest. Among the data types available in the Missionland data sets will be elevation data, imagery and textures, vector data, 3D models, material coding and meta data. Aside of creating the data sets Missionland will also develop guidelines on how to use the data and provide a method on how to validate the databases constructed from the data sets.

The main challenges that the Missionland task group is faced with can be summarized in three main issues:

- Finding the right standards that supports wide usage of the dataset is the first key to success;
- The second key to success is getting the right tools and infrastructure in place to support the integration and distribution of the dataset;
- The idea of building a dataset together and share it amongst many nations sounds simple and effective. The challenge is: find a legal and financial concept that makes it work in practice.

8 References

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