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Analysis for the installation of a pellet factory in south of Sonora using Systematic Layout Planning and Scenarios: Case study

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ABSTRACT: This case study was developed during one year in 2017 for the Association of Producers of Vegetables of Yaqui and Mayo in Mexico and Instituto Technologic de Sonora, where the opportunity for the use of waste was presented, in this case lagging potato, that is, potato after the third and fourth production cuts; with the purpose to manufacture bioplastic pellets as row material for 3D printers. The methodology of seven steps for the realization was defined as: 1) Contextualization of the current situation; 2) Identification of the opportunity from lagging potato; 3) Ratification of the factory location, this when obtaining information on the location in which the Association planned to have the new plant; 4) Description of the pellet manufacturing process; 5) Determination of supplies; 6) Layout for the pellet factory; and 7) Simulation of the factory. The main conclusions for the investors are that they have a layout proposal based on a flexible distribution logic and the simulation of the factory to test the capacities according to scenarios. This case study uses Systematic Layout Planning and System Dynamics for scenario analysis as a theoretical contribution in the academic field.

KEYWORDS: Bioplastic, payout, pellet, layout, simulation, scenarios.

I. INTRODUCTION

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper. Bioplastics are a dynamic and innovative part of the plastics industry, playing an important role in the promotion of sustainability; they are penetrating in segments such as food packaging and plastics for agricultural use. They refer to new materials that use vegetable raw materials produced as an alternative to conventional plastic, for various uses, which can range from the construction of a house, a car, make food packaging or, for example, manufacture pots and other plastic elements used in the agriculture [1] According to data from the [2] in cooperation with the Nova Institute of Hürt, Germany (2016); shows that packaging is still the largest field of application of bioplastics with almost 40% (1.6 million tons) of the total market of bioplastics. The data also confirm a decisive increase in the absorption of bioplastic materials in consumer goods, with 22% (0.9 million tons), applications in the automotive and transportation sector with 14% (0.6 million tons)), and construction with 13% (0.5 million tons).

According to a study by [2], it mentions that in 2021 more than 45% of bioplastics will be produced in Asia and about a quarter of the world's bioplastics production capacity will be located in Europe. Although another study of the Nova Institute conducted in 2013, mentions that Europe has established a strong position mainly in the field of starch mixtures (mixtures of polymers of natural starch or thermoplastic starch) and is expected to remain strong in this sector for the next years. In Latin America, emerging markets such as Brazil, Colombia and Mexico share a future in the production of bioplastics, in comparison with the nations of Europe and the United States. In Mexico, around five thousand tons of bioplastic are sold per year; however, most of it is imported mainly from China, but also from the United States and Europe.

The data collected in cooperation with the Institute of Bioplastics and Biocomposites and the Nova Institute show that the production capacity of global bioplastic will increase from 1.7 million tons in 2014 to approximately 6.8 million tons in 2018. Production capacities of biodegradable plastics, such as PLA, PHA and starch mixtures, are also growing stably, almost doubling until 2018. One of the most used bioplastics is the polyacid lactic (PLA), obtained by polymerization of lactic acid resulting from the fermentation of sugar. Its applications are varied: stuffing of pillows and quilts (Nature Works), coating of films and paper (BASF) and disposable packaging material (Ingeo) of various companies (Coca-Cola, McDonald's). It is also being used by the automotive

(Hyundai) and electronics (Samsung) industries. Other bioplastics are polymers synthesized directly by microorganisms, such as polyhydroxyalkanoates (PHAs) and polyhydroxybutyrate (PHB). They are used in the food industry (packaging) and in the medical area, because they are biocompatible (Biopol) [3] Considering this project is aimed for the 3D printer market, you must know some of the types of printers that exist and the material they use. To distinguish the different ranges or types of 3D printers, it is done according to the technology used to carry out the printing. One of it uses an ultraviolet beam to a liquid resin (contained in a cube) sensitive to light that solidifies the resin layer by layer. They are called stereolithographic printers, this method produces pieces of high quality, but a certain amount of material is wasted depending on the support that is necessary to manufacture.

Another is the Selective Laser Sintering (SLS); this technology is powered by laser to print objects in 3D. This allows to use a large number of powder materials (ceramic, glass, nylon, polystyrene, etc.). The laser impacts the powder, melts the material and solidifies. All the material that is not used is stored in the same place where the printing started, so nothing is wasted. There are also the printers by Deposition of molten material (FDM), which consists of depositing molten polymer on a flat base layer by layer. The material in solid state is stored in rolls, melts and is expelled by the nozzle in tiny threads that are solidified as they take the shape of each layer, allows to get parts using ABS plastic or PLA. Now, the material that uses the printers by FDM are called pellets; which are made of agglomerated or compressed material of different materials. They are the result of the process that consists in the production of polymer granules. Pellets or "noodles", as they are also called in English, are pre-production plastic resin pellets. Using the biodegradable polymer based on natural, which can be modified thermo-mechanically, keeping the native chemical composition intact and its physicochemical properties can be produced bioplastics from starch. The following table shows the properties of different types of starch, considering their morphology, granule diameter, gelatinization and gelling temperature, and their cooking properties (See Table 1).

Table 1. Characteristics of starch granules

Starch	**Type**	**Morphology**	**Diameter (µm)**	**Gelatinization temperature (ºC)**	**Gelling temperature (ºC)**	**Cooking properties**
Corn	Cereal	Rounded polygonal	5-30	62-72	80	Opaque gel
Yucca	Root	Truncated oval	4-35	62-73	63	Clear cohesive tendency to gel
Potato	Tuber	Spherical oval	5-100	59-68	64	Clear cohesive tendency to gel
Wheat	Cereal	Round lenticular	1-45	58-64	77	Opaque gel
Rice	Cereal	Spherical polygonal	3-8	68-78	81	Opaque gel

Source: Own elaboration adapted from Starch in Food [4]

It can be observed that the potato has a diameter in microns greater than the other starch granules, it is the second best in needing lower temperature, both gelatinization (wheat) and gelling (cassava), which makes it stand out for the production of bioplastic. The global production of potatoes is about 350 million tons per year, while the United States produces 19 million tons corresponding to 5.42%, however, in Mexico about 54,500 hectares are cultivated with an average yield of 27 tons / Ha, obtaining up to 1.5 million tons nationwide. Of these, 56% is distributed to the fresh market, 29% to the industrial market and 15% to seed production [4]. However, the consumption of fresh potatoes is decreasing at a level of 1.1% per year, due to the fact that consumers increasingly prefer pre-processed foods [5] There are more than 500 potato varieties of which about 150 varieties are grown for commercial purposes, where 50 of these are used for the production of starch. These potato starch varieties contain from 60% up to a maximum of 80% starch (in matters of dry matter) compared to other organic materials (See Table 2).

Table 2. Starch percentage of organic materials

Material Organic	Porcentaje de almidón (en materia seca)
Potato	60-80%
Corn	72-73%
Avocado seed	60%
Banana peel	50%
Yucca (root)	27%

Source: Personal elaboration

A study carried out in 2009 for the ECOEMBES Cathedral of the Environment in Spain entitled "Bioplastics Analysis Project" mentions that in that year the estimated global productive capacity was 300,000 tons, which meant allocating areas for the cultivation of raw materials from which bioplastics are produced. The following table shows the cultivated area for different types of plant species, as well as their yield in tons to reach annual production tons (See Table 3).

Table 3. Required area to achieve annual production of bioplastics.

Specie	Performance (t dry plant / t BPL)	Agricultural productivity (t/ha)	Unit surface (t BPL/ha)	Required area (300,000 t)
Wheat	1,6	4,35	2,71	110,700
Barley	1,6	4	2,5	120,000
Corn	1,29	6,88	5,33	56,285
Potato	1,97	27	13,7	21,900
Soy	7,11	2,4	0,33	909,000

Source: Personal elaboration

It can be seen that potato has a higher yield in bioplastic production and better agricultural productivity, so it requires less surface area compared to other species. This project was developed for the Association of Vegetable Producers of Yaqui and Mayo, which was founded in June 1984 by a group of farmers who saw the need to form an organization to help them compete in the national and international markets. Currently has about 75 partners and 7,500 hectares of horticultural crops of the association's producers. The Association's fields are located in Ciudad Obregon, Sonora in the Yaqui Valley, which is located in the south of the state of Sonora and has 220,000 hectares of irrigation supplied from 3 interconnected dams, with a storage capacity of 7,200 million cubic meters. In the case of the Yaqui Valley region, 12,389 hectares were planted for the cultivation of potatoes in the 2014-2015 cycle, producing close to 432 thousand tons of 25% of the national production [7] this would amount to a starch production of approximately 62 thousand tons to generate around 455 thousand tons of pellet with a market value of approximately $ 1.65 billion. [Considering a market value of 3 thousand dollars per ton (Price taken from Alibaba.com)]. However, due to the high supply of the tuber in the region, it causes its price to be lower, this causes it to sell to local and industrial supply centers and it is not even found where to place the product, so in Sometimes it gets to be discarded.

II. LITERATURE REVIEW

The Systematic Layout Planning (SLP)

The SLP is defined as the organized way to carry out the planning of a distribution. It consists of a skeleton of steps, a pattern of procedures and a set of conveniences [8]

The Systematic Layout Planning (SLP) is a set of six procedures to follow.

1. Record of relationships. The first step is to relate each activity, area, function or building involved in the desired distribution with all other activities by ordering the desired closeness. This is an evaluation step to determine the relative closeness between each pair of activities or areas.
2. Establish space requirements. Establish for each activity the required area, the physical elements, the services and any restriction of the configuration.
3. Diagram of relationships. In this step, the activities are related visually and geographically to form the basic pattern for the distribution.
4. Draw distribution space relationships. Here the space required for all activities will be arranged visually and geographically. Any adjustment or re-arrangement necessary to integrate all the considerations that modify the distribution will be made.
5. Evaluate the alternatives. The most appropriate distribution for the situation is selected. To do this, we must evaluate the alternatives generated in the previous step.
6. Detail the selected distribution. In this final step, the selected distribution is drawn, marking the individual areas significantly. Already complete can serve to guide the installation.

Empirical studies in the production of bioplastics : Soomaree Keshav in 2016, which is titled "Production of Bioplastics" that took place in the Republic of Mauritius, a small volcanic island east of Madagascar in order to investigate the potential of bioplastic production with potato starch produced in the Republic of Mauritius. The result obtained from this project was the production of bioplastic bags with potato starch, where 0.00979 cubic meters of water were used for 890 grams of cut potato that was then liquefied three times and two were filtered for the extraction of starch. To convert it into bioplastic, 15 grams of pre-dried starch diluted in 150 milliliters of distilled water was used in a 500-milliliter container, where 18 milliliters of 0.1 mol of hydrochloric acid and 0.1 mol of sodium hydroxide were added for neutralization. In addition, 12 milliliters of 1% glycerol were added and heated for 15 minutes at a temperature of 100 degrees centigrade, which took one hour to gel [9]. In 2015, Jhon Fernández and Andrea Vargas also produced a thesis entitled "Elaboration of a business plan to determine the feasibility of producing bioplastics from potato against pollution in Colombia" and as its name implies. indicates, it was carried out in Colombia in the city of Bogotá in order to offer an alternative of environmentally friendly raw material. As a result, a market and technical study was carried out to elaborate plastic bags with potato starch bioplastic, using 0.7125 grams of starch where 0.7125 ml of water, 0.3206 grams of PVA plastic, 0.07125 grams of Hydroxyethyl cellulose and 0.01068 grams were mixed. of boric acid. Afterwards, the same amount of water and 0.1613 ml of glycerin were added again for its polymerization, which took an hour, as did the Keshav study; however, it was filtered for 15 minutes and dried in 300 minutes with a temperature of 50 degrees Celsius [10].

Simulation with system dynamics and scenarios: The systems can be analyzed using different mathematical tools, such as systems dynamics, which is defined as a methodology for the study and management of complex feedback systems. Additionally, it provides a single structure to integrate the functional areas of management. It is a quantitative approach that aims to link the organizational structure and the company policy with industrial growth and stability with the purpose of presenting them, itemizing them, studying them, and analyzing them in diverse scenarios [11, 12, 13, 14, 15, 16, 17].

III. METHODOLOGY

Contextualization of the current situation of the organization. In this first step began the phase of clear approach to the problem where an internal and external analysis of the organization was carried out, in order to know its current situation. Through several meetings with the interested partners for the development of this project, data were obtained from the organization and empirical studies that showed an area of opportunity in the production of bioplastic from potato starch, which was taken exclusively for the lagged potato within the organization. As a result, a PEST analysis (Political, Economic, Sociocultural and Technological) of Opportunities and Threats, and a SWOT matrix was developed.

Identification of area of opportunity from lagging potato.: To carry out this part of the method, a bibliographic research was carried out based on data from empirical studies related to the production of bioplastic from potato starch. The above implied studies related to the present, taken as success stories to serve as a reference in terms of the way in which they were developed. As a result of this phase, a table with the synthesis of eight empirical studies applied in the world was obtained.

Ratification of the location of the new factory: For this step of the procedure, the management of the Vegetable Producers Association of Yaqui Mayo (APHYM) provided information on the location in which it plans to have the new pellet processing plant. In addition, an analysis of the critical factors of the location was made. Due to the confidentiality of location data, the exact information of the premises where the pellet factory will be installed is omitted.

Description of the pellet manufacturing process: After having cleared the area of opportunity presented by the information of the facts supported in success cases and the location of the project, we proceeded to the description of the process. Based on the empirical studies and the information provided by the supplier of potato starch processing machinery, a process flow diagram was prepared covering the total number of operations, delays, inspections, warehouses, transportation and information flow. that exist in the process of manufacturing pellet from lagged potato.

Determination of supplies: With the result of the process flow diagram, the supplies that lead to the manufacture of pellets from the post-harvest potato were determined by means of an input determination table. This table describes the activity of the flow diagram, as well as the quantities and units of the input or raw material that is required for the process. In addition, a team determination table was drawn up describing the characteristics and physical size of the equipment required for each activity that will be of support for the next step.

Layout for pellet factory: The last step of this method consisted in the development of the plant distribution proposal with the information obtained from the machinery supplier Nanyang Goodway Machinery & Equipment Co. Ltd.; and the thesis "Production of Bioplastics" by [9] As a result, with the help of AutoCAD software, the layout of the pellet processing plant was obtained, which gave us a detailed view of the production process. By having the first version of the proposal, we proceeded to solve the observations made at the meeting with stakeholders, where the distribution of the plant was updated by moving the input area to the Northeast side giving more space to the truck for the potato unloading activity. Afterwards, the detailed distribution of the production area was carried out, where the change of position of the input side tanks of the plant was considered to be closer to the hydrolysis process, since only in this activity are used the chemical inputs. In addition, the position of the restrooms was modified, so that personnel access was closer to the entrance to production. Finally, it was recommended to place arrows that indicate the flow of the input of the machines for a better visualization

Scenarios of the Bioplastic factory: The methodology of system dynamics was used; using Stella Arquitect Software ®, the factory was simulated throughout the process of potato delivery and pellet production to observe the amount of pellet that would be able to manufacture the factory in optimistic and pessimistic conditions from the current capacity. The result of this last stage was to show investors the three scenarios under which the bioplastic factory could operate with the proposed equipment.

III. MAIN RESULTS

Layout of Pellet Factory: the proposal for the distribution of the plant was developed with the help of AutoCAD software to prepare the sketch of the production area. The proposal was presented to the interested parties in two phases, that of progress and attention to improvements, which are presented below. In the presentation of the advances for the distribution of the plant, a meeting was held with some of the APHYM on October 10 of this year, where an introduction of the project was presented. The application of the PSSD tool was first shown by the work team in what was considered in the plant distribution. In the presentation of the first advance of the plant distribution, some of the partners made their comments known to improve the initial proposal, where they stressed with greater emphasis that there was a very narrow space for the raw material truck to carry out its maneuvers for the potato unloading activity. Having said that, the solution was proceeded. Afterwards, the detailed plant distribution of the pellet production process was developed, where the change of position of the East side input tanks of the plant was considered to be closer to the Hydrolysis process, since only in this activity, these inputs are used. In addition, the position of the restrooms was modified, so that personnel access was closer to the entrance to production. Figure 1 shows the final layout proposal.

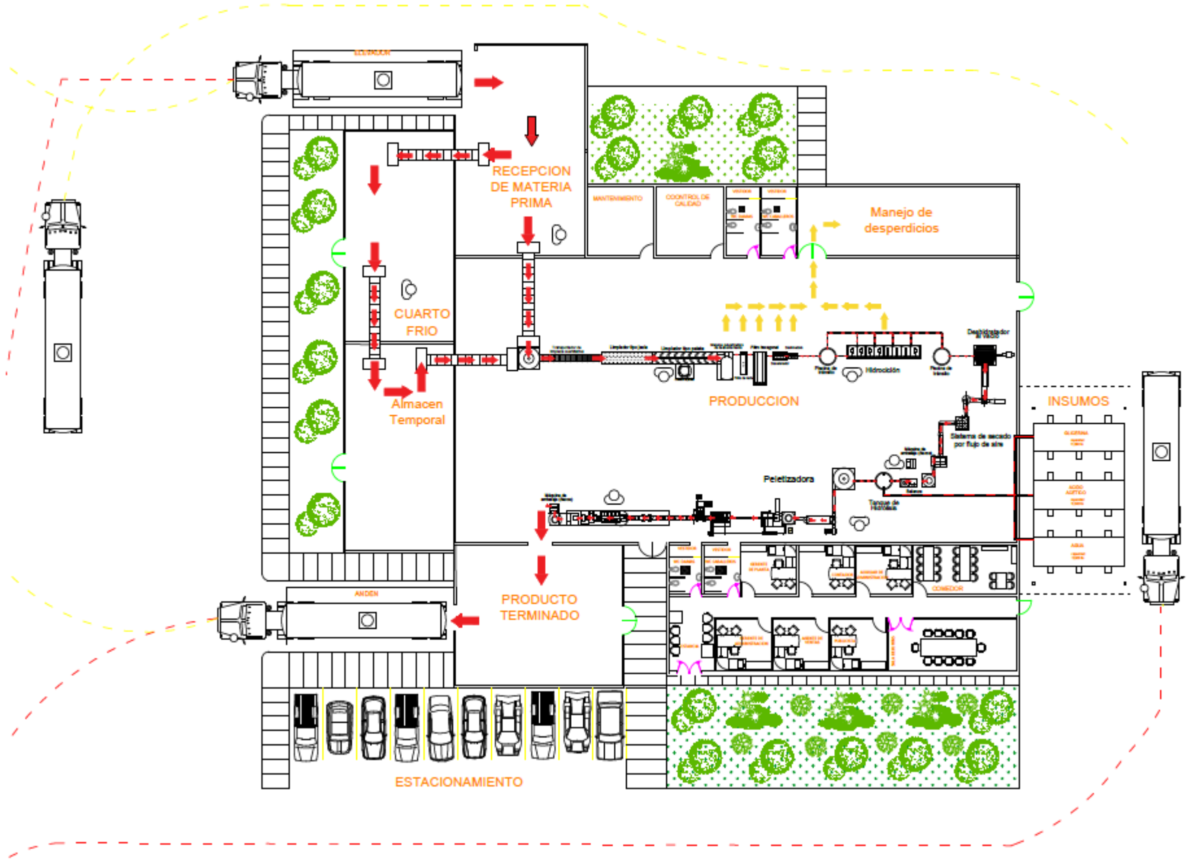

Figure 1. Sketch of the proposed distribution of the process (final version)

Possible scenarios of the Factory: The results obtained in each of the scenarios in which the behavior of critical variables is contemplated, previously selected, harvest, percentage of lag, amount of potato purchased, percentage of starch as finished product, finished product warehouse, starch warehouse and total revenue.

Table 4. Summarized report of scenarios

Variable	**Pessimistic Scenario**		**Actual Scenario**		**Optimistic Scenario**	
Harvest	6000 ton/month	6000 ton/month	6000 ton/month	6000 ton/month	6000 ton/month	6000 ton/month
% of lagging potato	5	5	10	10	20	20
purchased potato	0	0	0	0	10	10
% starch as a finished product	0	15	0	15	0	15
Finished product warehouse	680	640	920	880	1200	1040
Starch warehouse	0	0.54	0	0.405	0	2.43
Total revenue (USD)	**$28,755.5**	**26,246**	**38,904.5**	**39,136.75**	**50,745**	**55,521.5**

With the data previously described, it can be concluded that the scenario in which generate more revenue is in the optimist, which considers that the harvest is 6,000 tons per month, 20% of this is a product of lag, in addition the purchase of 10 is considered as tons of extra potato, and of the total of starch obtained 15% will be destined as a product finished.

IV. CONCLUSION

In the realization of this project it was known that the main purpose of the project was to distribute the plant of a pellet processing factory from potato, however the method to produce said product was unknown. After conducting research on the impact of bioplastics in the world and the trend in the use of technologies such as 3D printers, as well as an internal and external analysis of the organization, it was detected that there was an area of opportunity regarding the use of the waste of lagging potatoes that are generated in the production of the same.
In view of the above, the objective was to design the distribution of the plant for the physical arrangement of the installation based on the process of manufacturing pellets from potato starch. For this, it was necessary to carry out a bibliographic research on the basis of data from empirical studies related to the production of bioplastic from potato starch, taken as success cases to serve as a reference as to the form in which they were developed.

On the other hand, in the evaluation of the scenarios, the optimistic scenario was where obtained the highest profit, however, it was allocating 15% of starch for packaging as a finished product, so it is recommended that interested parties investigate thoroughly about the variables that would be added to the model when handling starch for sale, such as necessary packaging, warehouse conditions, as well as the expenses that this would generate.

Besides the fulfillment of the main objective of this project, which was basically the design of the distribution of a new plant, there is an added value for the client of the project, which will have in its hands the first research project carried out to produce bioplastic pellets type PLA based on potato starch in Southern Sonora.

REFERENCES

[1] International Starch Institute (2015). *Sweet Potato Starch Production*. Recuperado de: http://www.starch.dk/isi/papers/TM22-3e%20sweet%20potato.pdf

[2] European Bioplastics. (2015, Noviembre 5). *La producción global de bioplástico continua creciendo a pesar del bajo precio del petróleo.* PR Newswire. Recuperado de: http://www.prnewswire.com/es/comunicados-de-prensa/la-produccion-global-de-bioplastico-continua-creciendo-a-pesar-del-bajo-precio-del-petroleo-540722051.html

[3] Malajovich (2012). *M.A.M. de Biotecnología*, 2ª edición actualizada. Bernal, Editorial de la Universidad Nacional de Quilmes.

[4] Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO) (2008) *Las papas, la nutrición y la alimentación.* Recuperado de: http://www.fao.org/potato-2008/es/lapapa/hojas.html

[5] Ochoa, Miguel G. (2012, Octubre 3). El cultivo de papa en México. *El Economista*. Recuperado de: http://eleconomista.com.mx/columnas/agro-negocios/2012/10/03/cultivo-papa-mexico

[6] Sispropapa A. C. (2015, Febrero) *"Bioproductos: Bioplásticos a partir de papa".*

[7] Situación actual del cultivo de papa en Sonora. Recuperado de: http://sagarhpa.sonora.gob.mx/portal_sagarhpa/noticias/93-agricultura/181-cultivo-papa-sonora.html
[8] Muther, R. (1981). *Distribución en Planta*. Cuarta edición. España: McGrawHill.
[9] Keshav, Soomare (2016) *Production of Bioplastics.* University of Mauritius.
[10] Fernández Morales, José J.; Vargas Romero, Paola A. (2015). *Elaboración de un plan de negocios para determinar la factibilidad de la producción de bioplásticos a partir de papa en contra de la contaminación en Colombia*. Bogotá. D. C. Universidad Militar de Nueva granada
[11] Forrester, J. W. (1981). *Dinámica Industrial.* Buenos Aires: Ateneo.
[12] Richardson, G., & Pugh, A. (1999). *Introduction to system dinamics modeling.* USA: PEGASUS.
[13] Ogilvy, J. (2006). *Education in the information age:scenarios, equality and equaly.* Barkeley, CA, USA: GBN.
[14] Schwartz, P. (1991). *The art of the long view, planning for the future in an uncertain world.* New York, NY, USA: Currency Doubleday.
[15] Sterman, J. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. Irwin McGraw-Hill.
[16] Ogilvy, J. (2006). *Education in the information age:scenarios, equality and equaly.* Barkeley, CA, USA: GBN.