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Stakeholders Analysis in the Space Sector. A Deep Learning Value Flow Model Simulation.

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Abstract

Artificial Intelligence (AI) is currently being applied nowadays in a variety of business models with considerable success. We propose a new software architecture based on the stakeholder analysis of a space endeavour. The information system architectures currently in consideration in the space area are mostly atomized and do not take into account the relevant role of the stakeholders that create value and momentum to the space activities. We first propose that the value chain vector should be considered in order to identify which stakeholders are most relevant to any space endeavor. We state that from a strategic point of view, the identification and analysis of stakeholders adding value to the process should be the core of the design process. Exploration missions require that people involved in these areas make ow the benefit, tangible or intangible that emerges from the space activity. In the process of creating a value ow model framework, a number of decisions have to be made in order to simplify the value loops, and make the model easily understood. Value loops are defined as value chains that return to the starting stakeholder. Some metrics can be defined and characterized within the model: individuals, companies, Gross Domestic Product created, public awareness, capital ow, etc. The software is able then to simulate the process of industry development and growth, providing clues on which are the optimal stakeholders' architecture for maximizing the overall benefits for all partners. .The implementation of such simulation is done via a deep neural network that is integrated in the software, with an easy user- friendly interface. Our previous work focused in space mission scenearios. We have updated the core network with a deep learning multi-layer network for enhanced results. We hereby provide simulations for different space mission scenarios, private and public ones, with conclusions and recommendations, regarding the optimal organization of the di_erent stakeholders involved. Compared to previous work, the deep learning core network is faster and allows for more accuracy of the different scenarios, providing the possibility of comparing different strategies with a fast classiffcation in therms of optimal characterization. In conclusion, our system is capable of finding the optimal path for efficiently processing knowledge through a complex information system. Specifically, this is the first deep learning core network including stakeholders' diversity, specifically applied to a public-private space endeavour.

Keywords: Deep learning, machine learning, stakeholders, value flow, numerical simulation.

Acronyms/Abbreviations

Adaptive Neural Networks (ANN)
Artificial Intelligence (AI)
Deep Learning Network (DLN).
Knowledge Efficacy Throughput (KET)
International Astronautical Congres (IAC)
National Aeronautics and Space Administration (NASA)
Private Specialized Companies (PSC)
Stochastic Gradient Descent (SGD)
United States of America (USA)

1. Introduction

The field of stakeholder analysis has gained importance as a key methodology to perform corporate analysis. However, its implementation in large companies, and in, particular, large public enterprises has proven to be difficult, not to mention a combination of both. Requirements analysis is a well-known technique, which is widely used in many management project routines. Usual requirements analysis tend to select a particular set of architectures based on technical merit, rather than on any other topic. Stakeholders' analysis is only taken into account in a later step of the design process, with only minor consideration to its importance.

However, space exploration is, basically, a human endeavour. Rationale to venture into space is not based on technical reasons, but on to the will of the human mind to get further and explore the unknown. Space journalist Walter Cronkite defined during the 2002 IAC Opening Ceremony the arrival of men to the Moon as 'the most important moment in human history'. He was not quoting this enterprise just because of its difficulty in technical terms. Indeed, he was referring to it as its value to mankind, as an accomplished that produced enormous value to a wide range of human beings. Not without the social and political support of those times for putting a step on the moon would it had been possible to begin thinking in economic and technical terms.

Therefore, it is obvious that stakeholders are not only important for any space endeavour, but a fundamental one. Without a wide and public support from a number of space actors it is impossible to even think in a large investment for a space activity. Space is a particular field in which stakeholders are key vectors of the full enterprise.

It has been difficult in large government space projects, to identify and analyse the role of every stakeholder. The involvement of the private sector is a growing trend in space activities, with large public funded projects being cancelled, and private companies incoming into the development of new space technologies. The private sector involves a bigger role for a group of space stakeholders, with starring characters that were unthinkable decades ago.

In spite of these considerations, the information system architectures currently in consideration in the space area are mostly atomized and do not take into account the relevant role of the stakeholders that create value and momentum to the space activities.

We first propose that the value chain vector should be considered in order to identify which stakeholders are most relevant to the space endeavours. We state that from a strategic point of view, the identification and analysis of stakeholders adding value to the process should be the core of the design process, and not a secondary addition to technical considerations.

Those design solutions with a proper understanding of the system's stakeholders will be those with early and clearly defined roles. That involves later decisions in accordance of their presence in the value chain of the project. The fundamental aim of this paper is to provide a general framework that reduces the gap between the stakeholders' identification process and their technical considerations.

We start in Section 2 by considering stakeholders, their needs and the relationships between them. In Section 3 we address the value chain, as a vector to reengineer space activities, when private business take a major role. In Section 4 we provide with a basic tool with metrics to optimize the process of an organizational change. Accuracy optimitzation of the results is achieved through the implementation of a Deep Learning Network. Details of the results obtained by using different algorithms with this implementation are shown in Section 5.

2. Space sector stakeholders

Stakeholders are defined as those individuals, entities or organizations that have a role in a definite process. The stakeholders' analysis is usually aimed at finding which the best organization design is that optimizes its effectiveness. The work is performed by focusing in the stakeholders that take a substantial role on the value chain of the company. Basic needs and identification of the main relationships are most relevant for the public sector, where the concept of 'added value' is more difficult to identify.

If we would like to identify the key stakeholders at the space area, the question should be: Who are the stakeholders of space exploration that will make value grow? A review of the literature [1-5] will show us that the major characters had already been identified.

Science, Security, International Partners, Economic Area, Executive & Congress, People, Educators and Media are the main groups of people and organizations that typically add value in the United States, according to the latter references. Some of them, like Educators and Media are mainly intermediaries with the People. Finally, the major public space agency in the US, NASA is noted, to which the private sector should be added in an emerging growing role.

The recent appreciation of value co-creation lying multiple stakeholders has led to studies [6] that explore which motives and resources generate value in multinational case studies. In the building sector, for example, Herazo and Lizarralde [7] have studied different approaches to sustainability from the stakeholders' point of view.

Exploration missions require that people involved in these areas make flow the benefit, tangible or intangible that emerges from the space activity. The overall process of identifying stakeholders and assigning them a proper role and interrelationships among the different systems involved, are known to be the design of the stakeholders model.

3. The Value Chain as a vector to reingeneer the process

Once the basic process of modeling is done, we will have a detailed map of the connections between the different stakeholders involved. The process model is a dynamic one, although only a steady-state photograph of the whole system is considered.

At this point of time, we introduce the concept of value chain coming from the industry and information systems architecture. Value chain is a collection of value flows which are connected by stakeholders, relevant to the process. Major white papers and requirements standards [6] refer to these concepts in the space area as well as others.

The chain has the responsibility to change and add a definite value onto the system. Only stakeholders that form part of input-output flows are the ones relevant to the reengineering process.

By "Reengineering" we understand a major organizational change that aims to optimize the creation of value within the system. A reengineering process based on the value chain, should follow the next steps: 1- Defining value for our system 2-Modeling the stakeholders' matrix, 3-Identifying the key stakeholders which contribute to the value chain, and 4-Rearrenging the value flows in the organization to reinsert key stakeholders into the value chain (Figure 1).

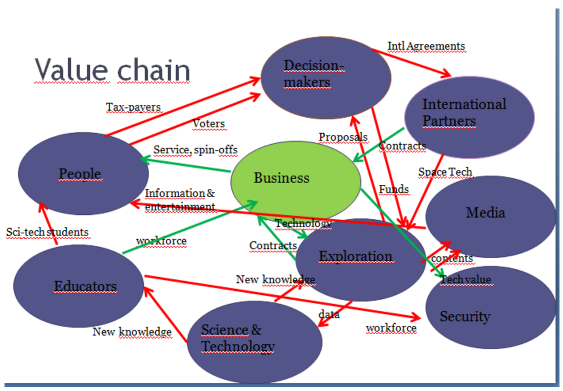

Fig. 1. Value Chain Model

According to Cameron et al. [5], individual flows are categorized into six groups: Policy, Money, Workforce, Technology, Knowledge and Goods and Services. In the process of creating a value flow model framework, a number of decisions have to be made in order to simplify the value loops, and make the model easily understood. Value loops are defined as value chains that return to the starting stakeholder. Simplification of this map has no standard procedure, and depends on the level of detail needed in the reengineering system.

The overall system is then redesigned in order to help the value chain grow, and to lessen interferences and expenditure of resources on to areas that do not really add value in the system.

4. Quantification and Metrics. Results.

The process of reengineering an organization is often regarded as holistic. Different levels of detailed among authors are observed, but it is somewhat difficult to quantify what are the required changes in a process of optimization.

A framework to help reorganize and optimize the value chain should be composed of:

- Stakeholders' matrix.
- Value flow model.
- Metrics.
- Optimization application tool.
- A feedback process
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The stakeholders' matrix and the value flow model have been described in previous section. Metrics are a part of the reengineering design process. Qualitative variables can be quantified in ordinal terms. The exact number of individual people, little institutions (like schools) has to be estimated and the number of people involved in the space activity driven from it. The output-input flow is then derived from the value map.

It is difficult to assess science or education results in terms of 'what space exploration inspires'. Usual quality terms in education or science evaluation can be used, such us number of degrees attained in the space area, number of papers published in peer-reviewed journal, etc.

An important design decision is the weight that is associated with every single indicator in the model. The optimization algorithm should be one of easy implementation, and classic effectiveness.

In our particular example we decided to parametrize the influence of the emerging private sector. We added to the model introduced in [8] a group of private companies as a block interconnected as the pubic space agency was. The number of people involved in these activities was estimated to be a fraction of the overall workforce. We then constructed a flow map duplicating the input-output chain of the public sector, keeping the rest of stakeholders like the public or science intact. We included a restriction that every increased step for the variables in the private sector should be accompanied by a decreased step for the public ones.

For our particular study we chose as value the overall public understanding of space science, including space exploration outcomes, space science, and the increase of education and public understanding outreach.

An Adaptive Neural Network (ANN) was chosen as the optimizing algorithm, and a process of iteration was conducted until value loops reflected a nearly steady-state.

The system evolved to a significant part of the private sector taking over, and a pruning of the number of public organizations interconnections. The independent variable was optimized, and in doing so a number of connexions had their values decreased nearly to zero, which suggest they should disappear were others began to grow. The overall results suggest that a significant part of the value chain could be taken over for the private sector, gaining value for the system, while reducing the overall costs.

A significant result was that the risk of downgrading the benefits was higher while keeping the public funding low, or decreasing the public workforce under a certain deadline.

After these considerations, we studied the importance of having a number of Private Specialized Companies (PSC) in the area. These companies are defined as technological medium-sized private companies that produce new knowledge and added value to the existing one, thus producing a significant change in the existing flow.

Results show in the following table suggest that the ideal minimum number of those companies is three, as the connexions produced are a turning point from what is achieved with only one or two companies put together. The figure of merit associated with this optimization is the Knowledge Efficiency Throughput (KET), defined as the percentage of new flow of knowledge added in the system on average when all stakeholders considered.

#PSC	KET
0	0
1	1.4
2	3.8
3	34.5
4	28.8
5	29.2
10	29.7

Table 1: Results from optimization when including Private tech specialized companies.

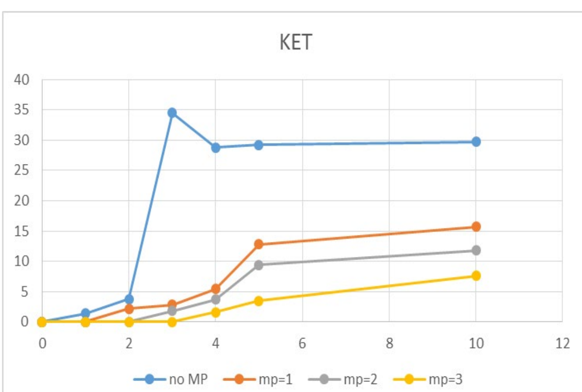

Fig. 2. Knowledge Efficacy Througput (KET) as a function of the number of PSC in different scenarios.

When one or more from these companies enlarge and reach more than 33% of the market in its specific area, then the interactions within the value chained are modified. In Figure 2 data from Table 1 are compared to that in which 1, 2 or 3 of these companies become major players in the market.

The presence of one major player reduces significantly the knowledge exchange, and further inclusion of more major players slightly decreases that figure. From the point of view of knowledge and data flow efficacy it seems reasonable that the high-tech companies involved in the scenario are of comparable size.

5. Deep Learning Network Simulation

Deep Learning allows the computer to generalize input datasets without relying on a fixed governing law using highly complex forms of Artificial Neural Networks [9].

Feeding input datasets allow the computer to train relevant parameters to find the features common among the datasets. With enough input data, the machine learning algorithms are able to create accurate generalizations in a short amount of time, providing more accuracy than shallow neural networks like those explained in the previous section.

5.1. Convolutional Neural Networks

Our Deep Learning Network (DLN) model is based on a Convolutional Neural Network (CNN). It was biologically inspired by the human visual cortex, where the cortical neurons partially overlap with each other to form receptive fields that cover the entire visual field. CNNs are usually applied in the area of image recognition, but can also be applied to other classification problems.

The central idea of a convolutional neural network is to extract the pattern features of the input data. A crucial problem with the classic, fully-connected neural network is that it does not take the spatial position of the data into account. On the contrary, a convolutional neural network takes the position of the input data into account and runs multiple convolution and pooling operations before implementing the fully-connected neural network on the data.

Before the network is implemented to calculate the prediction, the weights and biases of the convolution layers, pooling layers and the fully connected layers are initialized between values of 0 to 1 in a Gaussian distribution. The input value flow structure image is fed into the convolutional neural network, and the convolution operation is applied to the input.

The convolution layer of the network consists of multiple kernels. The presence of multiple filters allows the network to extract various features. After performing multiple convolution operations on the input, the dataset is reshaped to be fed into the neural network.

The backpropagation of a convolutional neural network is more complicated than a neural network, but the idea of passing backwards through the network and calculating the partial derivatives of the cost function with respect to the parameters is the same. The Gradient Descent algorithm is used in the network optimization process as well. The CNN allows the computer to perform autonomous learning. Using these concepts, a deep network structure which reads from the model of our stakeholders value chain was designed.

5.2. Training algorithms

Besides the network structure, another crucial feature of the methodology is training the network. To optimize the parameters for training, several variations of the Gradient Descent algorithm were implemented: Stochastic Gradient Descent (SGD), Momentum, Adadelta, Adagrad and Adam. The accuracy of the network for each optimization algorithm is presented in Figure 8 and Table 5. The number of hidden nodes in this experiment was set as 3.

Gradient Descent Algorithm	**Final Accuracy (to nearest hundreths)**
Stochastic Gradient Descent (SGD)	0.47
Momentum	0.70
Adadelta	0.42
Adagrad	0.53
Adam	0.71

Table 2. Accuracies for varios optimization methods.

Then, the number of hidden nodes in the PredNet was varied. The Adam Optimizer was used as the Gradient Descent algorithm. The overall accuracy of the network was calculated after all the epochs were iterated for each number of hidden nodes. Results are shown in Table 3.

Number of Hidden Nodes	**Final Accuracy (to nearest hundreths)**
3	0.72
5	0.68
7	0.64
10	0.76

Table 3. Accuracies for different number of hidden nodes.

The number of hidden nodes should be maintained at a low value, because a larger number of nodes require more network parameters to optimize. With a limited amount of training data, a large number of parameters cause gradient loss, which can deter the performance of the network. Momentum or Adam Optimizer with a minimum number of hidden nodes of three are the optimal values for our simulation.

6. Conclusions

We have presented the concept of stakeholders' analysis, in relation with the value chain. We have considered the reengineering process, as a vector for organizational change that allows to focus workforce and economic efforts into the process that add value to the system. Based on space stakeholders' models, we have added a more relevant private sector into the system, and thought of what implications may it have on the effectiveness of the variables involved.

Quantization of the variables involved in the value map allows to implement an optimizing method that visualizes possible changes that may arise from the new involvement of the private sector into the stakeholders' matrix. Preliminary results show consistent findings with what is expected by new directions in the major components of the USA space program.

The process of quantifying and optimizing the map has proven to be successful in order to propose long-term organizational changes in the space arena, that will make space exploration more plausible and cost-effective in human and economic terms.

Deep Learning Networks methods such as the Convolutional Neural Network have proven to be useful for providing better accuracy in the predictions at a reasonable computing cost.

Finally, these optimization tools are capable of predicting the optimal way to efficiently process knowledge through a complex information system with a variety of stakeholders, like what we find in a multinational private-public space endeavour.

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