

# APPLICATION OF THE MULTICRITERIA DECISION AID (MCDA) TO THE INDUSTRIAL AIRPORT PROJECT OF VIRACOPOS

Authors' Names: ANTONIO CARLOS FERREIRA MARQUES and MARIA  
LUCIA GALVES

Affiliation: UNIVERSIDADE ESTADUAL DE CAMPINAS  
Faculdade de Engenharia Civil, Arquitetura e Urbanismo  
Departamento de Geotecnia e Transportes

Contact: Phone and Fax: 55-19 35212307

Emails: [admin.marques@uol.com.br](mailto:admin.marques@uol.com.br)  
[mlgalves@fec.unicamp.br](mailto:mlgalves@fec.unicamp.br)

## ABSTRACT

The purpose of this paper is to present the results of a case study on the application of the Multicriteria Decision Aid (MCDA) to the decision of implementing an industrial airport park within the site of Viracopos International Airport in Campinas – São Paulo – Brazil. This is a huge project that aims at transforming Viracopos into the biggest and busiest airport in Latin America, considering both cargo and passengers, and as such, will conceivably bring up significant environmental, social and economic impacts to the affected area. The decision has arisen resistance and controversy among the many stakeholders. MCDA was chosen to simulate the decision because of its logic of structuring and of evaluating complex and conflicting problems, and of dealing with objective as well as subjective aspects in a decision context. The outcomes of the MCDA application to this project revealed interesting convergence of opinions towards a more attractive alternative, as well as significant behavioral changes on the part of stakeholders. It is expected that one of the major contributions of this study is that specialists and decision makers consider using the MCDA methodology to support their analysis of alternatives involving the role of airports and their impacts on urban lives, as well as the assessment of possible future problems involving urban environmental and transport planning and decision making.

**Key words:** airport, industrial airport, multicriteria decision aid, Viracopos

## 1. INTRODUCTION

Studies led by Dr. John Kasarda of the Kenan Institute of Private Enterprise, University of North Carolina have attributed a new wave of regional development to the development of major airports, in the same way that railways led development in the 19th century and roads did in the 20th century. Kasarda *et al.* (2004) state that substantial evidence is accumulating that major airports are generating concentrations of commercial activities that are leading to a new, aviationlinked form – the aerotropolis. Just as towns first grew around seaports, then out of canals and waterways and later railroads and the highways, so it is argued now that airports represent the “fifth wave” of development with clusters of residential and business developments beginning to grow out of airport linkages.

According to Kasarda *et al.*(2004) it is well documented that evolving transportation technology and accessibility have guided the location and the growth of firms. The world’s first great commercial centers grew up around seaports. The next wave of major economic development occurred at river- and canal-based cities that formed the backbone of the industrial revolutions in Asia, Europe and the United States.

Railroads sparked the third wave of commercial development, opening up land-locked interiors to manufacturing and trade. Major processing and distribution industries emerged at rail hubs and terminal points. The fourth wave of economic development was fostered by the shift to cars and trucks to move people and goods. Freeways, expressways, and other major highways generated substantial de-concentration of firms from cities outlying areas. Large suburban commercial centers, industrial parks and office complexes sprouted as far as 50 kilometers from major city centers.

We are now entering the fifth and most opportune economic era – the Fifth Wave – where aviation, international markets and time-based competition predominate (KASARDA *et al.*, 2004). This new era has been ushered in by large, high-speed jet airplanes, advanced telecommunications technologies, and three irreversible forces of immense significance, namely:

- The globalization of business transactions,
- The shift to just-in-time manufacturing and inventory control methods, and, as a result of the first two,
- The growing requirement of industries of all types to ship products quickly by air to distant customers.

The combined thrust of these interacting forces is creating new economic growth nodes around the world with airport supplanting seaports, rail and highway systems as primary wealth and job generators.

According to Gardiner (2006), while air freight carries less than two percent of world trade by weight, it carries approximately 40 percent of the world value of trade, a percentage that is likely to rise given the nature of products in the new economy (small, light, compact and high value-to-weight). World air cargo traffic is expected to triple from 2000 to 2020, with international air express growing three times faster still (Airbus, 2004). There seems little question that in the 21<sup>st</sup> century, time-based competition will compel companies exporting higher value commodities to use air cargo express in order to remain competitive. Much of the freight will continue to be shipped in the bellies of passenger planes, with some Boeing 747s carrying as much as 35 tons of cargo along with shipped their passenger loads and the new Airbus A389 much more.

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Today, essentially anything that can be loaded onto a large aircraft is routinely shipped internationally by air: heavy machinery, automobiles, high-technology equipment, textiles, footwear and fashion clothing, furniture, pharmaceuticals, seafood, live animals, fruits and vegetables, aerospace components and seasonal toys.

As a result of those forces mentioned above, the role and development impact of major airports are changing dramatically. Planners and developers have been challenged to fully leverage airports' new role as multimodal, multifunctional commercial centers attracting businesses and shaping land use miles away.

Airports are no longer just airports (GULLER AND GULLER, 2003). To varying degrees, airports have become not only nodes of a new intermodal transport system for both people and goods, but also new cities with shopping, hotels, conferences and host of ancillary activities more or less loosely linked to aviation. In addition to incorporating shopping mall concepts into passenger terminals and developing logistics facilities near runways, airports are working with developers to place hotels, office and retail complexes, conference and exhibition centers, free-trade zones, and time-sensitive manufacturing facilities on their property.

Aviation-oriented commercial development is occurring beyond airport perimeters (GARDINER, 2006). With the airport itself serving as a regional multimodal transportation and commercial nexus (analogous to the central business districts of the 20<sup>th</sup>-century metropolis), strings and clusters of airport-linked business parks, information and communications technology complexes, retail, hotel and entertainment centers, industrial parks, logistics parks, wholesale merchandise marts, and residential developments are forming along airport arteries up to 20 kilometers outward. The evolution of these new functions and commercial land use has transformed many city airports into airport cities, a new urban form referred to by Kasarda as the aerotropolis.

The studies of Mathis and Michael Guller (GULLER and GULLER, 2003) pointed out that on one side airports are huge generators of economic activity and growth, but on the other side they have become important sources of environmental problems. "*Much of this just happened without a clear planning framework, and these multifunctional airports have often been poorly integrated into regional and local transport plans, resulting in ongoing disputes with local authorities and residents and increasingly difficult access problems*" (GULLER and GULLER, 2003, p. 111).

The purpose of this paper is to present the results of a case study on the application of the Multicriteria Decision Aid (MCDA) to the decision of implementing an industrial airport park within the site of Viracopos International Airport in Campinas – São Paulo – Brazil. This is a huge project that aims at transforming Viracopos into the biggest and busiest airport in Latin America, considering both cargo and passengers, and as such, will conceivably bring up significant environmental, social and economic impacts to the affected area. The decision has arisen resistance and controversy among the many stakeholders.

## 2. LITERATURE REVIEW

Viracopos International Airport was founded in the 1930's but obtained official permission to operate only on October 19<sup>th</sup>, 1960. Therefore, in 2010 the airport will celebrate its 50<sup>th</sup> anniversary. During those beginning 30 years operations at the airport were not done on a regular basis, and only after extensive improvements and the

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construction of a 2,700 x 45 meters runway in 1957 Viracopos became an important option for international jet airplane flights.

Since 1978, Viracopos has been under the administration of a federal government agency named INFRAERO which stands for Brazilian Enterprise for Airport Infrastructure.

Viracopos is located 14 kilometers away from downtown in the outskirts of the city of Campinas in the State of São Paulo the most developed state of Brazil (Figure 2.1). Campinas is 99 kilometers away from the city of São Paulo, the State Capital and the biggest city in Brazil, and 190 kilometers away from Santos Seaport one of the largest seaports in the country.

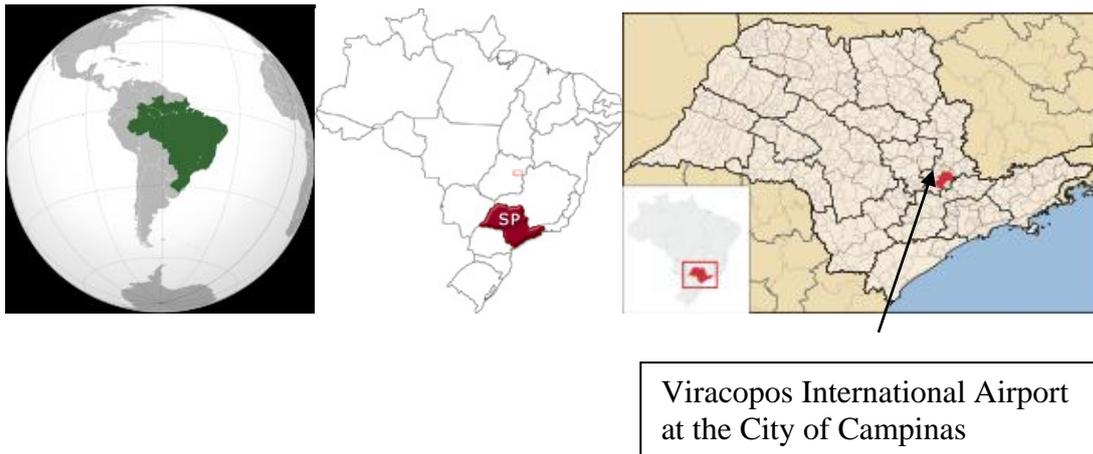


Figure 2.1- Overview of Viracopos International Airport Location

Campinas is a 4 million-inhabitant regional metropolis encompassing 23 other cities (Figure 2.2) which plays a major role in the economic scenario not only in the state of São Paulo but also in Latin America as a whole. The city is host for six big universities, including Campinas State University (UNICAMP) and above forty colleges which offer more than 200 different graduation courses.



Figure 2.2 – Campinas Metropolitan Region

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The city is linked to the rest of the State of São Paulo and to other States in Brazil by a complex system of highways and railways.

Sine early in the 1990's, Viracopos has become a hub of increasing importance for cargo airliners. Development plans and streamlining of cargo and passengers flow processes have been implemented by INFRAERO to make the airport a national reference for air transport.

It is said that the development of Viracopos has been made possible and has been in line with the development of Campinas Metropolitan Region where more than 4,000 manufacturing companies industrialize an expressive range of products, from micro electronics to automobiles, from computers to telecommunications. More than 600 of these companies export their products to all regions of the world (CAPPA, 2006). The airport connects Campinas with many Brazilian cities and also operates international flights for more about twenty airliners.

Viracopos operations have had a substantial growth in the past three years. The number of flights, take-offs and landings, grew 71% in 2009 over 2008 whereas the number of passengers has more than doubled with a growth in 2009 of 210% over 2008. On the other hand, the cargo volume has slowed down in 2009 which was 19% below 2008 (Table 2.1).

The substantial growth of flights and passengers in 2009 is directly related to the choice of Viracopos as the hub for two baby new Brazilian airline companies, whereas the cargo volume reduction in 2009 is related to the world economic crisis which started late 2008 and provoked a sudden reversal of the airport foreign trade operations which were showing an upward trend since 2007 (Table 2.1).

Table 2.1 – Viracopos Operations Evolution

Viracopos Operations Evolution					
Airplanes		Cargo		Passengers	
Year	Nr. Flights	Year	Tons	Year	Quantity
2002	40.551	2002	173.158	2002	787.161
2003	26.997	2003	169.635	2003	654.768
2004	24.584	2004	235.896	2004	717.362
2005	25.716	2005	179.483	2005	816.599
2006	25.107	2006	178.797	2006	826.246
2007	29.226	2007	238.044	2007	1.006.059
2008	32.399	2008	233.699	2008	1.083.878
2009	55.261	2009	189.707	2009	3.364.245

Source: INFRAERO, 2007

## 2.1 VIRACOPOS EXPANSION PLAN PROJECT – 2007 REVISION

The expansion plan which was revised in 2007 for Viracopos takes into consideration not only the growing demand trend for cargo and passengers, but also government authorities' strategic decisions regarding the impossibilities of greater expansions for Guarulhos International Airport and Congonhas Domestic Airport, the two main central airports in the state capital. Congonhas has reached full capacity in 2009 and Guarulhos will conceivably achieve its full operational capacity by 2014. For those reasons, transfers from passengers and cargo flights from those two central airports to Viracopos have already started since 2009 and will reach full speed in 2015.

Table 2.2 – Viracopos Expansion Plan

Viracopos Operations Evolution - Expansion Plan					
Airplanes		Cargo		Passengers	
Year	Nr. Flights	Year	Tons	Year	Quantity
2007	29.226	2007	238.044	2007	1.006.059
2008	32.399	2008	233.699	2008	1.083.878
2009	55.261	2009	189.707	2010	3.364.245
2010	74.600	2010	277.722	2010	4.541.731
2015	113.238	2015	576.443	2015	6.131.337
2020	326.140	2020	1.316.599	2020	28.381.459
2025	732.673	2025	2.366.922	2025	71.655.091

Source: INFRAERO, 2007

The 2007 expansion plan for Viracopos is divided into three phases, the first one to be completed in 2015, the second in 2020 and the third in 2025 when the airport operations are expected to be around ten times bigger as far as cargo is concerned and more than twenty times as big concerning the number of passengers per year (Table 2.2).

The total land area will be increased from 6,8 million m<sup>2</sup> to 27,5 million m<sup>2</sup> and will bring substantial environmental impacts to the south and the south east of Campinas and the neighbor city of Indaiatuba.

Major constructions will be carried out within the next five years, from 2010 through 2015 (Figure 2.3).

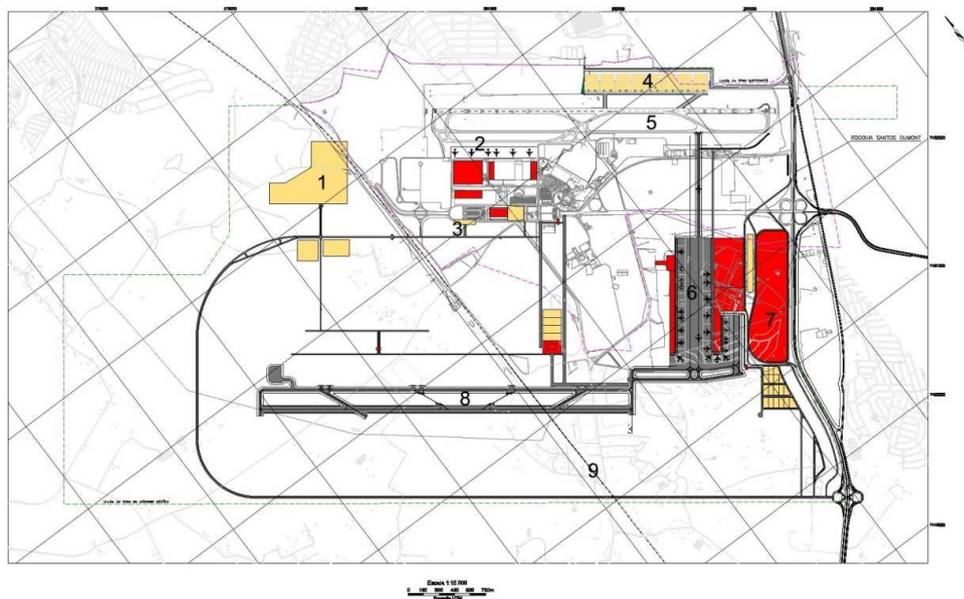


Figure 2.3 – Viracopos Expansion Project and the Major Constructions

Source: INFRAERO, 2007

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Figure 2.3 shows the major constructions which are numbered under the following descriptions:

1. The industrial park lot
2. The expanded cargo terminal
3. Railway station lot
4. Airplane maintenance hangars
5. Runway system 1
6. Passengers terminal
7. Garage and parking lot building
8. Runway system 2
9. Present railway to be relocated

The airport expansion project as seen in Figure 2.3 gives rise to the idea of a hybrid big airport encompassing three types of economic agglomeration such as a passenger's terminal, a cargo terminal and an industrial park.

## **2.2 VIRACOPOS INDUSTRIAL PARK PROJECT**

Firstly, let us define what an industrial airpark is and what it stands for. An industrial airpark is defined as a free trade zone where only smokeless industries are allowed to be installed for the manufacturing of products to be exported to other countries via the air transport. The advantages for those industries are namely tax exemption, financial incentives, security, low cost logistics and just in time operations.

Expectations around the settlement of an industrial airpark within the site of an international airport would be pointed out as follows:

- Generation of new job posts
- Higher income at the site and around it
- Economic development
- Greater regional attractiveness for new investments
- Improvement of the international image of the airport
- Possibilities of airlines' choice of the airport as a hub for their continental operations
- Settlement of schools, colleges and universities to train and specialize labor for industries and services firms
- Settlement of service firms like law firms, logistics firms, consulting and even churches and hospitals

Brazilian government authorities included the industrial park project in the 2007 Expansion Plan revision allegedly due to three main reasons, which are (1) studies preceding the 2007 revision which pointed out the economic feasibility of such an industrial park within the site of the airport, (2) the industrial park projects approval for Confins International Airport in Minas Gerais and for Galeão International Airport in Rio de Janeiro as a result of the newly enacted legislation by the Brazilian Congress in 2002 and 2003, and (3) the prosperous technological and socioeconomic environment in the Metropolitan Region of Campinas.

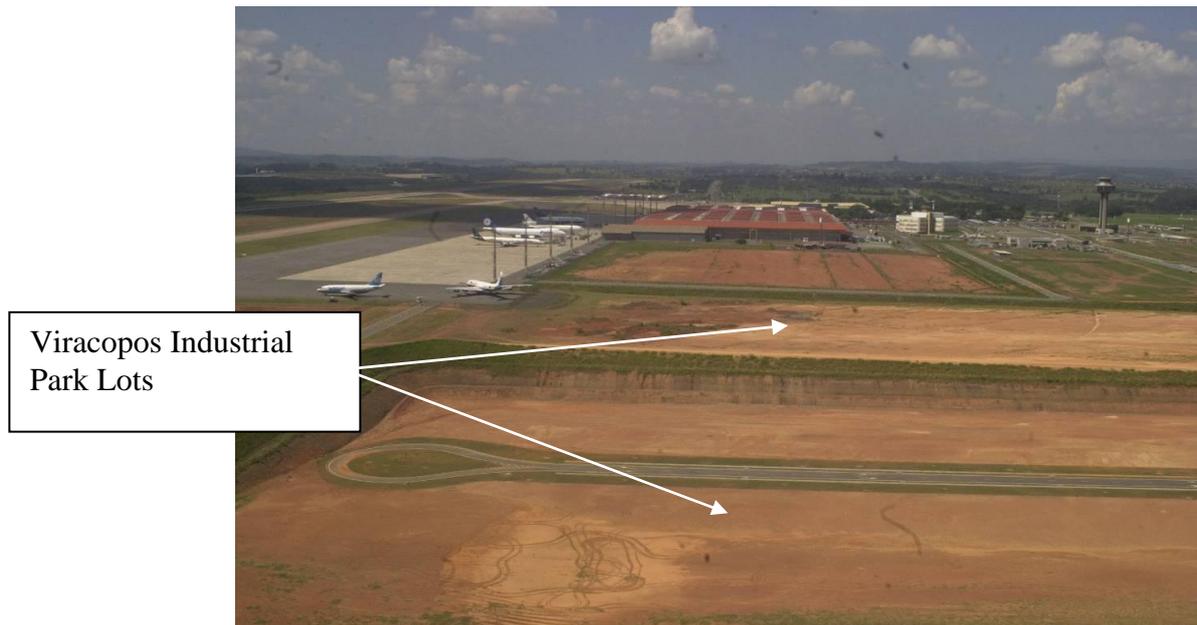


Figure 2.4 – Industrial Park Lots at Viracopos Airport Site

Source: INFRAERO (2007)

Two lots of land which are close to the runway and are at the side of the main cargo terminal have been reserved for the industrial airpark (Figure 2.4). The smaller one is 42,8 thousand m<sup>2</sup> and the other one is 50,0 thousand m<sup>2</sup> both amounting to 92,8 thousand m<sup>2</sup>. Manufacturing firms will be entitled to occupy from 2,0 thousand m<sup>2</sup> to 10,0 thousand m<sup>2</sup> to construct their plants. It thus expected that around 40 manufacturing firms will settle down and operate at the park mainly in the export business.

### 2.3 VIRACOPOS EXPANSION PLAN IMPACTS AND IMPLICATIONS

Viracopos expansion plan is a huge project that clearly aims at transforming it into an airport city with great environmental, economic and social impacts.

According to Guller and Guller (2003), airports that grow beyond 20 million passengers become major regional work centers with long work cycles (often 24-hour service economies). Their survey has also aimed at pinpointing and deciphering two current trends within airport development: the growth of an **airport city** and the evolution of a landside interchange node.

An airport city is, above all, a business strategy on the part of the airport operator, aimed at cashing in on the business opportunities created by its operations and the important function it provides in landside transport networks, commercial services and employment (GULLER AND GULLER, 2003). As these academics point out, in terms of territorial definition, the airport city is, in principle, the more or less dense cluster of operational, airport-related activities, plus other commercial and business concerns, on and around the airport platform.

The term “aerotropolis” is an even further advanced macro system in comparison with the “airport city” (KASARDA *et al*, 2004). While the latter embodies the city contour it is next to and is characterized as a “piece of city”, the former becomes a regional

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interchange node serving millions of commuters who sometimes have nothing to do with the airport platform activities.

Viracopos expansion project covers a wide range of territory partly belonging to a big piece of Campinas county and partly devastating a big area into the territory of Indaiatuba county (Figure 2.5).

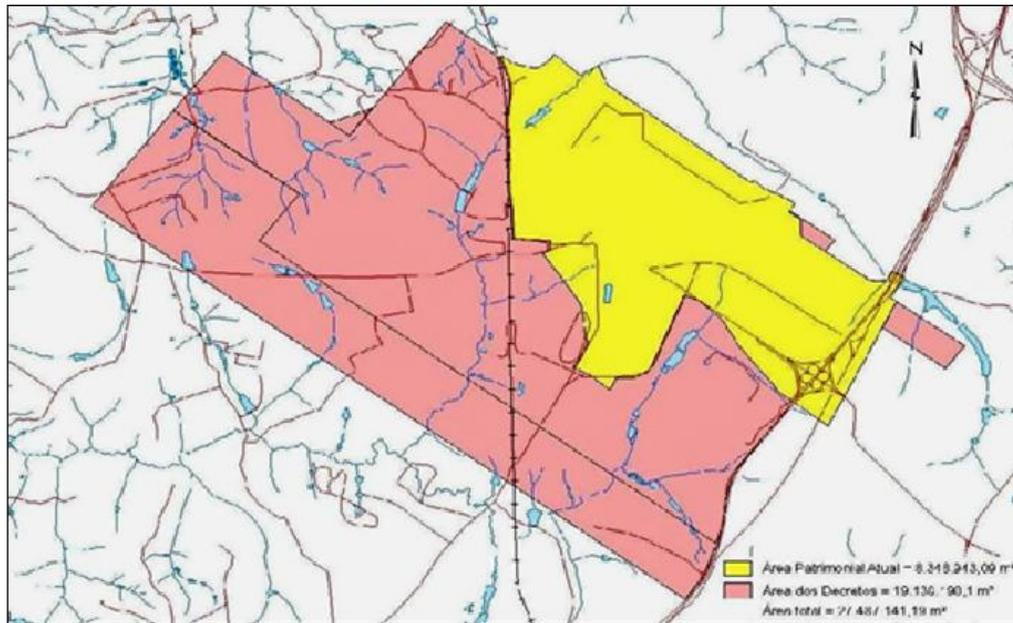


Figure 2.5 – Final configuration of Viracopos Expansion Project site

Source: INFRAERO (2007)

The environmental impacts of the project have brought about controversy and different concerns on the part of many stakeholders. The Environmental Impact Report pointed out thirty-seven impacts, eight of which were categorized as positive, and twenty-eight were categorized as negative. Among those negative impacts that can not be mitigated are the noise level increase, the disappearance of over 32 streamlets and creeks, unemployment of workers in more than 250 small farms, much greater volume of solid waste, water and atmosphere pollution, and the devastation of fauna and vegetation in the affected area.

Viracopos expansion project has divided the opinion of many stakeholders, from business men to environmentalists, from government authorities and politicians to non governmental organizations, from academics to clergymen. The Environmental Impact Report has not been approved yet and continues to be a matter of heavy discussions among stakeholders.

The decision context has grown in complexity and poses questions for which no clear answers have been brought about. Should the airport expansion project be so huge? Aren't there better alternatives? Will the city of Campinas benefit from such a huge project as far as quality of urban life is concerned after its third phase is completed? Have all the aspects and variables been taken into consideration by the decision makers? Should it really have to become an airport city or an aerotropolis the size it is projected?

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This brief literature review aimed at setting the stage for the application of the MCDA methodology to revisit the decision and bring about potentially more attractive alternative to Viracopos expansion project. The MCDA was chosen for this decision simulation due to its logic of structuring and of evaluating complex and conflicting problems, and of dealing with objective as well as subjective aspects in a decision context.

### **3. MULTICRITERIA DECISION AID**

The MCDA is a methodology which is based on the identification of a decision situation in which there are conflicting criteria among stakeholders and decision makers related to a problem solving. The multicriteria methods have been developed with the purpose of supporting decision making and decision makers to create and to assess the alternatives for a problem solution and reach the most attractive choice within a range of decision variables. Those decision variables are the detailed actions that are to be analyzed, decided upon and communicated. The group decision is thus a consequence of the exchange of decisions among the members of a group where collaborative negotiation may take place. If the compromise is reached, the proposals are automatically agreed upon (GOMES & MOREIRA, 1998).

The main distinction among MCDA and the traditional methods of evaluation is the degree to which the values of the individual decision maker are incorporated in the evaluation models. The MCDA assumes that it is necessary to accept that the subjective aspects should always be taken into consideration in a decision process. Thus it should be expected and understandable that there will be found different value judgments among the stakeholders and decision makers. The MCDA approach aims at construing decision models that allow for the expression of value judgments based on multiple criteria to evaluate and, if possible, prioritize chosen alternatives (YU, 1985).

Taking as reference the decision model proposed by Simon (1960) – intelligence, design and choice – the MCDA is a process made up of three interacting phases:

1. Problem structuring
2. Evaluation of alternatives
3. Recommendation

For the purpose of this paper, the problem structuring involves defining the decision context, determining the fundamental objectives, identifying an attribute for each fundamental objective, and creating alternatives.

The achievement of objectives is the sole reason for being interested in any decision. Keeney (1992) distinguishes between fundamental and means objectives. A fundamental objective expresses an essential reason for interest in a decision situation while a means objective is important for the achievement of a fundamental objective. The process of identifying objectives requires significant creativity and hard thinking about a decision situation. Therefore, it is often helpful to enlist a facilitator to guide the process (KEENEY, 1992).

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Objectives can be structured in a fundamental objectives hierarchy and a means-ends objectives network. An attribute, which is a measure of the degree to which an objective is met by the various alternatives, should be specified for each of the lowest-level fundamental objectives of the hierarchy (KEENEY, 1992).

Once the problem has been structured by a set of fundamental objectives and their respective attributes, the next step is to evaluate the alternatives by using a multicriteria aggregation method. For the purpose of this paper, we have used the multi-attribute value function method in the additive form, as shown in Equation 1.

$$V(a) = w_1.v_1(a) + w_2.v_2(a) + w_3.v_3(a) + \dots + w_n.v_n(a) \quad \text{Equation 1}$$

where:

$V(a)$  is the global value of alternative  $a$ .

$v_1(a), v_2(a), \dots, v_n(a)$  are the values of alternative  $a$  for attributes 1, 2, ...,  $n$ .

$w_1, w_2, \dots, w_n$  are the scaling constants for attributes 1, 2, ...,  $n$ .

$n$  is the number of attributes in the model

A value function can be considered as a tool that aids the decision maker to express his preferences. The scaling constants transform local values in global values. In the additive aggregation function, the sum of the scaling constants is equal to one.

There can be found various methods of constructing a value function. We point out three of them as presented by Ensslin et al (2001):

#### 1. Direct Rating Method

This method implies the determination of a best and worst level of the attributes. The decision makers are then asked to express numerically the attractiveness or value of the other impacts in between those extremes.

#### 2. Bisection method

This method is especially useful when dealing with a decision problem with continuous quantitative attributes. The decision maker identifies a fictitious potential action which is halfway between the extremes, the best and the worst levels of the attributes. Subsequent divisions may bring refinements to the value function.

#### 3. Semantics judgment method

The value function in this method is obtained by comparing the attractiveness of pairs of potential actions. The decision makers are asked to express qualitatively their level of preferences from one potential action to another. An ordinal semantic scale is provided to help the decision makers express their preferences.

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There can be found at least three methods to determine the scaling constants (ENSSLIN et al, 2001):

1. The trade-off method

This method consists of comparing two alternatives with different performances only in two attributes, and equal performance in all other attributes. For those two compared attributes, an alternative has the best impact level for the first attribute and the worst for the second, whereas the second alternative has the worst level for the first attribute and the best level for the second. The stakeholder will decide which attribute is preferable by choosing which alternative is most attractive.

2. The swing weights method

This method begins with a fictitious alternative with worst impact level for all attributes in the model. The stakeholders are asked to choose an attribute that makes the fictitious alternative performance “swings” to the best impact level. It is then assigned 100 points to this swing. The same questioning is done for the other attributes in order to obtain the second swing. And so forth until all attribute levels have passed from the worst to the best level. The numbers so obtained should be adjusted to a zero-100 scale.

3. The pairs comparison method

This method is similar to the Semantics Judgment Method used to determine the value function. This method is done by comparing the attractiveness of pairs of potential actions. The decision makers are asked to express qualitatively their level of preferences from one potential action to another. An ordinal semantic scale is provided to help the decision makers express their preferences.

After evaluating the alternatives, additional analysis like sensitivity analysis and robustness analysis may be done in order to better specify the recommendations for a final decision concerning the problem solution.

## **4. APPLICATION OF MCDA TO VIRACOPOS INDUSTRIAL AIRPARK PROJECT**

### **4.1 Problem structuring**

#### **The decision context**

The decision to implement an industrial airpark within the site of Viracopos was taken by INFRAERO management and government authorities early 2007 and as such became an integral part of Viracopos Expansion Plan revised and approved in November, 2007, hereby referred to from now on as PDIR/2007.

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It should be pointed out that the PDIR/98 for Viracopos did not include an industrial airpark. The 1998 plan contemplated expansion for the increase of cargo and passengers capacity at a much smaller scale than the 2007 plan.

The inclusion of an industrial airpark within Viracopos site is part of the strategic objective of INFRAERO to transform Viracopos into the biggest airport both as cargo and passenger capacity is concerned in Latin America. The decision matches the need to respond to a fast growing movement of cargo and passengers to and from the city of São Paulo whose central airports – Guarulhos and Congonhas – offer no possibility of expansion and will have their capacity overfilled within the next three years. Government authorities have decided not to build a fourth central airport to attend the needs of a huge meso region encompassing São Paulo and the cities in a radius of 100 kilometers including the Metropolitan Region of Campinas.

Viracopos, therefore, became the natural solution for this huge problem mostly due to the vast area and very good meteorological conditions in its surroundings. This decision, on the other hand, brought in substantial controversial conflicts yet to be resolved among the many stakeholders. Though the Viracopos PDIR/07 is expected to promote a huge regional economic development in the next thirty years, the price to be paid has been appraised as too high, especially due to the high number of environmental negative impacts. The decision context has become complex and full of conflicting interests.

The question this case study proposed to the stakeholders was “Should the MCDA methodology be used to aid such a complex decision problem, what would the final decision have been?”

### **The Stakeholders**

The authors, acting as facilitators in this decision problem, made the choice of INFRAERO to be and act as the decision maker, and chose two other stakeholders:

1. Stakeholder 1: the decision maker – INFRAERO
2. Stakeholder 2: COMDEMA (The Environmental Committee Authority)
3. Stakeholder 3: CIESP (The State Confederation of Industries)

### **Specifying values: the fundamental objectives and the attributes**

The authors held individual meetings with the stakeholders to brainstorm about their objectives and after two rounds of meetings and over 40 means and ends objectives discussed came up with the following fundamentals objectives:

1. Maximize the airport overall income
2. Mitigate environmental negative impacts
3. Achieve the expected return on investment
4. Increase the gross income in the region
5. Transform Viracopos Industrial Airpark into a hemispheric hub for cargo
6. Promote overall economic regional development

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7. Fill the gap of air transport infra-structure in the region

The fundamental objectives # 1, # 2 and # 4 had to be further specified into sub-level categories as shown in the fundamental objectives hierarchy.

The next step was to discuss with the stakeholders and some knowledgeable people the attributes with which each objective should be measured. All attributes discussed and approved were the direct quantitative continuous type which are also shown in the fundamental objectives hierarchy below:

The overall fundamental objective: ***Implement Viracopos Industrial Airpark***

The fundamental objectives hierarchy specifications<sup>1</sup>:

1. Maximize the airport overall income
  - 1.1 Foreign trade income → *Customs income (R\$/year)*
  - 1.2 Business concessions → *Rent income (R\$/year)*
2. Mitigate environmental negative impacts
  - 2.1 Noise → *Noise level (dB(A))*
  - 2.2 Vegetation suppression → *Vegetation area (m<sup>2</sup>)*
  - 2.3 Creeks and water affluent suppression → *Number of creeks*
  - 2.4 Suppression of archaeological relics → *Affected area (m<sup>2</sup>)*
  - 2.5 Loss of agricultural production and services → *Agricultural Production Units (APU's)*
  - 2.6 Agricultural labor unemployment → *Number of unemployed workers*
  - 2.7 Atmospheric pollution → *CO<sub>2</sub> (ton/year)*
  - 2.8 Water contamination → *Coliform (Total coliform/100 ml)*
  - 2.9 Solid waste → *Daily volume per capita (gram/day/inhabitant)*
3. Achieve the expected return on investment → *ROI %*
4. Increase the gross income in the region
  - 4.1 Direct jobs → *Number of direct job posts*
  - 4.2 Indirect jobs → *Number of indirect job posts*
5. Transform Viracopos Industrial Airpark into a hemispheric hub for cargo → *Cargo airplanes takeoffs and landings per year*
6. Promote overall economic regional development → *Air cargo (R\$/year)*

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<sup>1</sup> The sign → indicates the attribute for the specified fundamental objective

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7. Fill the gap of air transport infra-structure in the region → *Air cargo (t/year)*

## The alternatives

The discussion and brainstorming sessions brought about three alternatives:

1. **Status Quo** – expansion rate to keep up with vegetative growth and build a 4<sup>th</sup> central airport in the meso region
2. **PDIR/07** – implement the approved and revised huge plan
3. **CIESP Plan** – moderate expansion plan for passengers, implement industrial airpark with all tax and other incentives outside the airport site, like a free zone port.

The next step was consumed with elaborating on the impact level of each attribute for each alternative within the time range between 2008 and 2015 which covers the first phase of PDIR/07. The year 2015 is the target date for the impact levels indicated on Table 4.1 which shows the resulting estimated figures. The basis for estimating the figures for each alternative was the different scenarios adopted by INFRAERO, as well as the statistics published by the Environmental Impact Report, and data published by the CIESP PLAN.

Table 4.1- Attributes and impact levels for each alternative

Attributes and Impact Level per Alternative			
Attributes	Status Quo	PDIR/07	CIESP PLAN
1.1 Customs income (R\$/year)	3,7 billions	6,1 billions	4,5 billions
1.2 Rent income (R\$/year)	1,7 billion	2,4 billions	1,7 billions
2.1 Noise level (d/B(A))	49	55	55
2.2 Vegetation area (m <sup>2</sup> )	1,700,000	8,600,000	3,870,000
2.3 Number of creeks	0	32	13
2.4 Affected area (m <sup>2</sup> )	0	3,636,000	1,636,000
2.5 Agricultural Production Units (APU's)	0	215	97
2.6 Number of unemployed workers	0	300	135
2.7 CO <sub>2</sub> (ton/year)	390	756	756
2.8 Coliform (total coliform/100 mil)	1,625	5,000	2,250
2.9 Solid waste (gram/day/inhabitant)	680	1,000	800
3. ROI (%)	12%	15%	15%
4.1 Number of direct job posts	23,000	25,000	25,000
4.2 Number of indirect job posts	63,000	75,000	75,000
5. Cargo planes takeoffs and landing/year	56,800	73,000	73,000
6. Air cargo (R\$/year)	6,4 billion	10,2 billions	10,2 billions
7. Air cargo (t/year)	369,000	720,000	720,000

## 4.2 Evaluation of Alternatives

Once the levels of impact for each attribute for each alternative have been established, it is time to construct the value functions for each stakeholder taking into consideration his preferences regarding the levels of impact for each attribute.

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The authors chose the **Bisection Method** to construct all resulting 51 value functions. The Bisection Method, as argued before in this paper, is the most appropriate for the cases where the attributes are direct continuous quantitative. In this method, it is necessary to define the best and the worst levels of each attribute to which are associated the values 100 and 0, respectively.

To exemplify the application of the Bisection Method, let us take a look at the first fundamental objective – Customs Income per year – as constructed by the decision maker – INFRAERO. Table 4.2 indicates the impact levels for 0 and 100 points for this attribute and Table 4.3 shows the resulting levels of preference of INFRAERO.

The decision maker was asked to identify the potential fictitious action whose impact level would be equivalent to 50 points in the Value column. The figure that came out from INFRAERO representative perception of preference was R\$ 5,6 billions.

Table 4.2 – Impact levels for attribute Customs Income

Value	Customs Income levels
100	R\$ 6,1 billions
50	
0	R\$ 3,7 billions

The same procedure was done to figure out the levels of 75 points and 25 points.

Table 4.3 – Value Function for attribute Customs Income

Value	Customs Income levels
100	R\$ 6,1 billions
<b>75</b>	<b>R\$ 5,9 billions</b>
<b>50</b>	<b>R\$ 5,6 billions</b>
<b>25</b>	<b>R\$ 4,8 billions</b>
0	R \$ 3,7 billions

After figuring out the impact levels by using the Bisection Method, we linked the points in a graph so that the stakeholder could have a better view of the value function worked out by him for the attribute Customs Income (Figure 4.1). The same was done for all other attributes by each stakeholder.

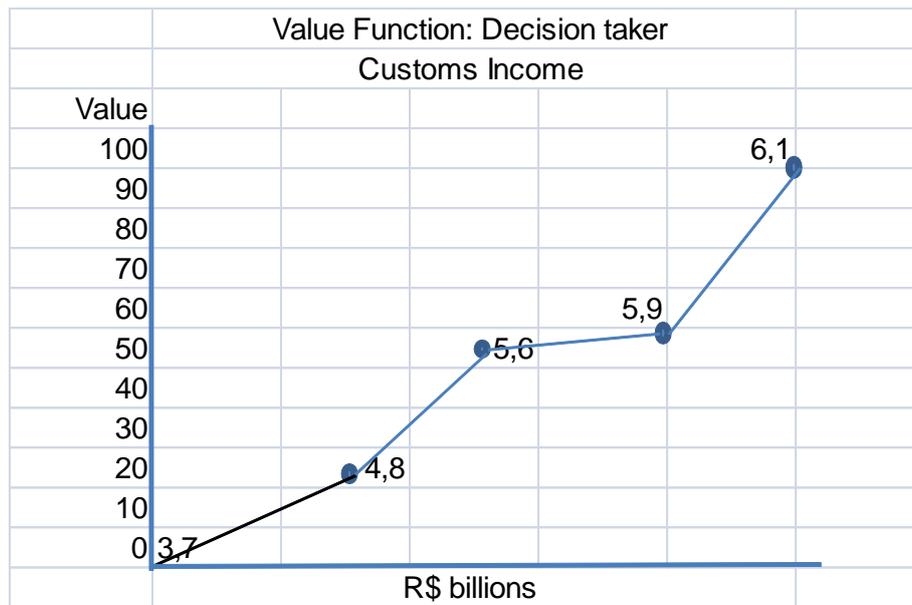


Figure 4.1 – Value Function for Attribute Customs Income

Source: Decision maker (INFRAERO)

Once the value functions have been constructed, the next stage is to obtain the scaling constants in order that the stakeholders express numerically the relative importance of each objective as perceived by his subjective judgments concerning the decision problem.

The method used was the Swing Weights for practical reasons. Tables 4.4 and 4.5 show each stakeholder's preferences and the relative importance of each objective.

Table 4.4 – Scaling constants: Second level objectives

Swing Weights and Scaling Constants Second Level Objectives						
Objective	INFRAERO		CONDEMA		CIESP	
	Swings	Scaling Constants	Swings	Scaling Constants	Swings	Scaling Constants
1.1 Maximize foreign trade income	100	0,95	100	0,91	100	0,91
1.2 Maximize rental income	5	0,05	10	0,09	10	0,09
Total	105	1,00	110	1,00	110	1,00
2.1 Noise level	15	0,04	90	0,12	60	0,09
2.2 Vegetation suppression	100	0,26	92	0,12	65	0,10
2.3 Creeks and water affluents suppression	70	0,18	100	0,13	70	0,10
2.4 Archaeological relics suppression	10	0,03	75	0,10	50	0,07
2.5 Loss of agricultural products and services	5	0,01	91	0,12	100	0,15
2.6 Agricultural labor unemployment	30	0,08	50	0,07	90	0,13
2.7 Atmospheric pollution	35	0,09	88	0,12	80	0,12
2.8 Water contamination	40	0,10	80	0,11	85	0,13
2.9 Solid waste	80	0,21	85	0,11	75	0,11
Total	385	1,00	751	1,00	675	1,00
4.1 Direct jobs	90	0,53	100	0,53	100	0,53
4.2 Indirect jobs	80	0,47	90	0,47	90	0,17
Total	170	1,00	190	1,00	190	0,70

Table 4.4 – Scaling constants: First level objectives

Swing Weights and Scaling Constants First Level Objectives						
Objective	INFRAERO		CONDEMA		CIESP	
	Swings	Scaling Constants	Swings	Scaling Constants	Swings	Scaling Constants
1.0 Maximize the airport overall income	95	0,22	30	0,10	40	0,08
2.0 Mitigate environmental negative impacts	35	0,08	100	0,33	90	0,18
3.0 Achieve the expected return on investment	20	0,05	25	0,08	30	0,05
4.0 Increase regional gross income	30	0,07	35	0,12	70	0,14
5.0 Viracopos to be a hemispheric cargo hub	100	0,23	20	0,07	80	0,16
6.0 Promote overall regional economic development	60	0,14	50	0,17	100	0,20
7.0 Fill air transport infra-structure regional gap	94	0,21	40	0,13	95	0,19
Total	434	1,00	300	1,00	505	1,00

The scaling constants were used to figure out the global value for each alternative in accordance with each stakeholder's preference. This is done by multiplying the scaling constants for each attribute for the values found in the value functions as shown in the example on Table 4.5 and Figure 4.2.

Table 4.5 – Evaluation of alternative Status Quo for Increase Regional Income

Evaluation of Alternative Status Quo By INFRAERO						
Objective /Attribute				Alternative		
First Level		Second Level		STATUS QUO		
Description	Scaling Constants	Description	Scaling Constants	Impact Level	Value	$w * v$
4. Increase regional income	0,07	4.1 Direct job posts	0,53	23,000	67	35,51
		4.1 Indirect job posts	0,47	63,000	63	29,61
		Local evaluation	1,00			65,12
Global evaluation						4,56
$w * v = \text{weights times value}$						
global evaluation = local evaluation (65,12) times first level weights (0,07)						

Source: INFRAERO

Figure 4.2 shows how the value of 67 was figured out for the objective "Direct Job Posts" for the alternative Status Quo according to INFRAERO's value specification.

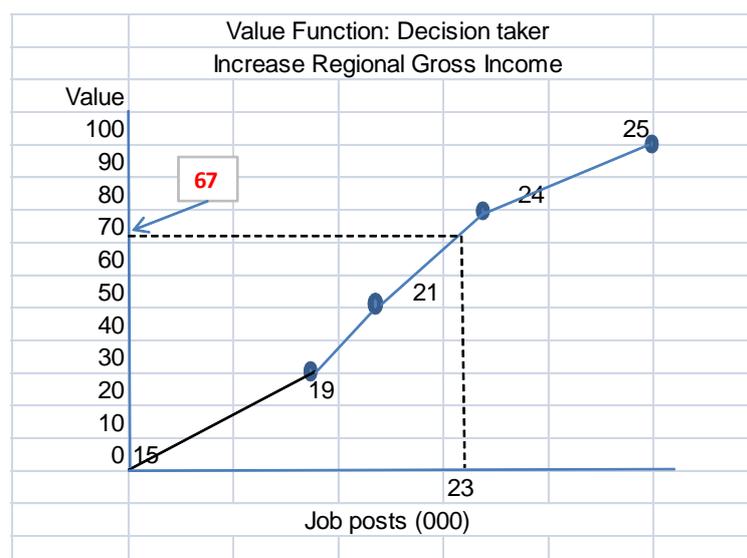


Figure 4.2 – Value Function for Attribute "Direct Job Posts" – Alternative Status Quo

Source: INFRAERO

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Table 4.6 shows the overall global results figured out by the application of MCDA methodology to a complex decision context like implementing an industrial airpark within the site of Viracopos International Airport.

INFRAERO finds PDIR/07 the most attractive solution, but for COMDEMA and CIESP the most attractive solution turned out to be CIESP Plan which contemplates the implementation a moderate expansion plan for passengers and cargo, the construction of a fourth airport in the meso region of São Paulo and the implementation of an industrial airpark in the outskirts of Viracopos like a free zone industry condominium focused on foreign trade.

Table 4.6 – Global Evaluation of Alternatives

Global Evaluation of Alternative			
Based on each Stakeholder's preferences			
Stakeholders	Alternatives		
	STATUS QUO	PDIR/07	CIESP PLAN
INFRAERO	18,89	90,75	73,94
COMDEMA	43,47	63,00	69,06
CIESP	27,51	77,50	79,25

### 4.3 Analysis and Recommendation

It is noticeable that the Status Quo Alternative is the least attractive. As to the two other alternatives there have been found a great number of converging points which opens and widens space for negotiations in search of new and more attractive alternatives.

As yet the PDIR/07 has not been approved or released for implementation mainly due to the hard arguments against it alleged by the Environmental Authority.

It should be pointed that the authors of this paper who acted as facilitators could observe noticeable changes in the behavior of the stakeholders' representatives, as they were compelled to take into consideration the other stakeholders' points of view.

The application of the MCDA to this case brought up the following noticeable advantages:

1. Better understanding and more profound knowledge of the decision context;
2. Stakeholders were compelled to take into consideration the others' points of view and to widen their knowledge about the decision problem;
3. The stakeholders had the opportunity to specify values through the choice and ranking of fundamental objectives before delving into the analysis and evaluation of the alternatives.

On the other hand, we have found some shortcomings and restraints in the application of the MCDA to this case, such as:

1. Stakeholders found it difficult to construct the value functions;
2. It is necessary that stakeholders dedicate more time to the process of structuring the decision problem and evaluating alternatives;
3. There should be group discussions for better understanding and collaborative acquisition of knowledge about the decision problem and of the MCDA methodology.

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Last but not least, the MCDA model developed for this case should not be applied to any other case as attributes and measures, as well as the value functions are pertinent only to Viracopos Expansion Plan which includes the implementation of the case study – The Industrial Airport Park.

#### 4.4 Conclusions

The application of the MCDA to simulate the decision making process to this project brought up interesting converging points and noticeable behavioral changes on the part of stakeholders. Had the process gone further including group discussions it should be expected the enhancement of the alternatives discussed, as well as the creation of new and more attractive alternatives to all stakeholders.

A major aspect of the application of the MCDA to this case was to make the stakeholders express their opinions taking into consideration the others stakeholders' points of view and perceptions of the decision problem. One issue that was worthy of the attention of non-environmentalist stakeholders was the environmental impacts expected to be caused by the implementation of Viracopos expansion project. The discussions enhanced their knowledge about this issue.

The Environmental Impact Report has not been approved yet. In spite of the noticeable negative environmental impacts of Viracopos expansion project, the application of the MCDA revealed that the alternative advocated by the environmentalists was the least attractive to all stakeholders. The overall converging point, though, is that the drawback caused by the hard arguments against the project as previously approved by the INFRAERO shall bring about a new and more attractive alternative for the expansion of Viracopos Airport which has proven to be necessary in the short and long range.

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