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Spatial and Activities Models of Airport Based on GIS and Dynamic Model

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Abstract. The purpose of research were (1) a conceptual, functional model designed and implementation for spatial airports, (2) a causal, flow diagrams and mathematical equations made for airport activity, (3) obtained information on the conditions of space and activities at airports assessment, (4) the space and activities evaluation at airports based on national and international airport services standards, (5) options provided to improve the spatial and airport activities performance become the international standards airport. Descriptive method is used for the research. Husein Sastranegara Airport in Bandung, West Java, Indonesia was study location. The research was conducted on September 2015 to April 2016. A spatial analysis is used to obtain runway, taxiway and building airport geometric information. A system analysis is used to obtain the relationship between components in airports, dynamic simulation activity at airports and information on the results tables and graphs of dynamic model. Airport national and international standard could not be fulfilled by spatial and activity existing condition of Husein Sastranegara. Idea of re-location program is proposed as problem solving for constructing new airport which could be serving international air transportation.

1. Introduction

Geographical Information Systems (GIS) is used for transport modeling because can significantly contribute to a more efficient modeling process and more reliable model results, namely, geospatial data, disaggregated transport models and the role of geo-vizualitation. This paper is presented to stengthen the spatial perspective in transport modeling and to call for a further integration of GIS in the domain of transport modeling [1].

Many elaborate dynamic model are explored effectively in transport system modeling. We various decision rules that embed distance and direction, density thresholds and transition or mutation probabilities into the model's dynamics, and we then outline the software designed to generate effective transport simulation consistent with GIS data inputs, outputs and related functionality [2].

The modeling of spatial processes is involved as an emerging branch of geo-computing. The most important being traditional regionalized system dynamics approaches were used at large spatial scales [3].

Airport modeling is of highest diversity combining presentation of navigation airspace, sophisticated constructions, buildings, different transportation subsystems, etc. Airports technological and organizational complexity forces the airport planners to collect highly accurate spatial data, develop better and more precise navigation and layout plans, manmade construction models, and employ state-of-the-art geographic information systems for running their business. Several national aviation administrations and the International Civil Aviation Organization (ICAO) have issued

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documents stating two important objectives. First objective instructs the airport planners how to capture and store spatial data and develop an airport database, particularly an electronic airport layout plan (eALP) that will serve for the development an enterprise airport geographic information system (eAGIS). Second objective requires the deployment of avionic equipment that will convert airspace traffic management from being ground-based to satellite-based, which requires highly accurate three-dimensional (3D) airport models. With GIS, Computer Aided Drafting and Design (CADD), and Building Information Modeling (BIM) technologies currently in place, sophisticated airspace and manmade modeling has to be fulfilled by airport planning professionals. As airports move toward the implementation of new traffic management, the airspace and navigation obstruction analyses are of highest priority as these analyses are based on different spatial data models that are simultaneously involved. The most important models are of: navigation data and imaginary protective surfaces; ground and runway surfaces; manmade structures [4].

Geographic information science and technologies are revolutionizing basic and applied science by allowing integrated holistic approaches to the analysis of geographic locations and their attributes. However, the increasing mobility and connectivity of many people in the world means that the relationships between people and place are becoming more subtle and complex, rendering a place-based perspective incomplete [5].

The economic behavior of airports changed dramatically in the last quarter-century, with consequences on the internal management structure, the relationship with other competitive airports, and the way airports interact with their nearby city. Airport commercialization is the transformation from a public transportation utility towards a profit-orientated enterprise. Parking lots, shops and shopping malls, restaurants, entertainment centers, hotels and congress facilities can be found at every bigger airport these days and belong to the non-aviation sector. Revenues created by non-aviation businesses sum up to 50 % and more of the airports income. The new spatial quality in this is that non-aviation activities are also placed outside the airport fence [6].

The Geography of Transport Systems, concerned with movements of freight, people and information, tries to link spatial constraints and attributes with the origin, the destination, the extent, the nature and the purpose of movements. It is divided into nine topics, each covering a specific conceptual dimension, including: Networks, modes and terminals, international transportation, urban transportation dan environmental impacts [7].

Transportation researchers and airport engineers joined hands to explore practical aspects of airport simulation and their utilization to enhance airport planning (both airside and landside) and their implementation for complex airport and airspace capacity studies. The primary objective here was to solve the lingering capacity shortages plaguing busy airports, the NAS airspace, and the airport system at large [8].

2. Research method

The descriptive method was used for spatial analysis. The descriptive method was applied to the analysis of spatial form of presentation of thematic maps that go through stages, namely: (1) user needs identification, (2) data collection (maps and statistics), (3) data groupped by types and levels, (4) input, processing and output of data conceptual modeling, (5) design data structures and database management functional modeling, (6) spatial development system implementation, (7) analog data converted into digital, (8) a model programmed of the interaction between the database management systems with the users, (9) spatial system tested to obtain feedback, (10) the spatial system revision, (11) the use of a spatial system, (12) spatial system maintenance.

The method used is mechanistic explanatory for airport activities model. Methods mechanistic explanatory through stages, namely: (1) a literature study and analysis of real-world system, (2) the components identification that make up the real world system, (3) a causal loop diagram design, (4) flow chart modeling, (5) primary and secondary data collection, (6) data entry into the flow chart model, (7) the flow chart model tested, (8) feedback, (9) the flow chart, (10) the flow chart model revised implementation, (11) tables and charts printed out, (12) mathematical model printed out, (13) the model validity tested, (14) the model sensitivity tested, (15) conclusions and recommendations.

3. Result and discussion

3.1.Spatial information and model

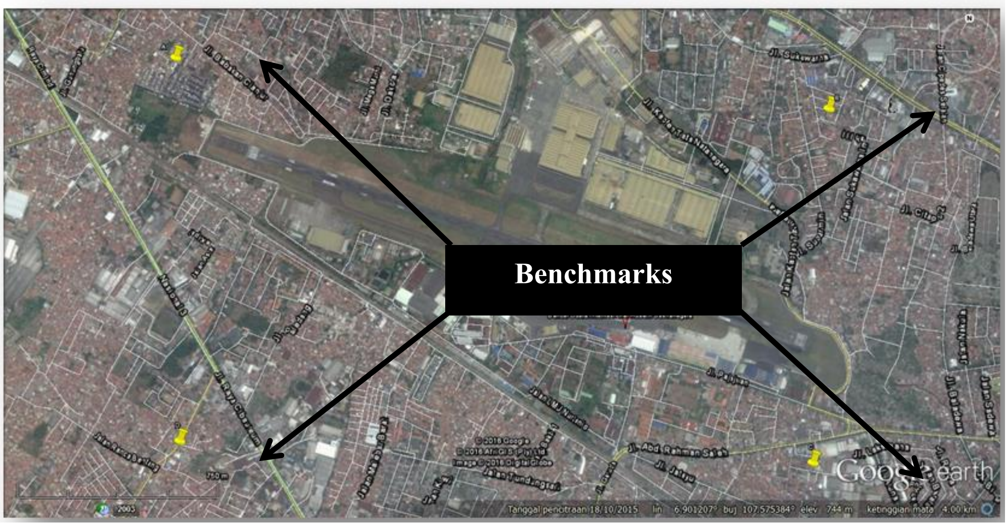

Figure 1. Satellite image benchmarks of Husein Sastranegara Airport from 4 kms height from earth surface (Source : Google Earth, 2016).

Benchmarks was used as reference points for registering and transforming satellite image coordinates to zone 48 UTM (universal transverse mercator) coordinates. Raster data were converted become vector data through on screen digitizing. Affine method was used as registration and transformation process.

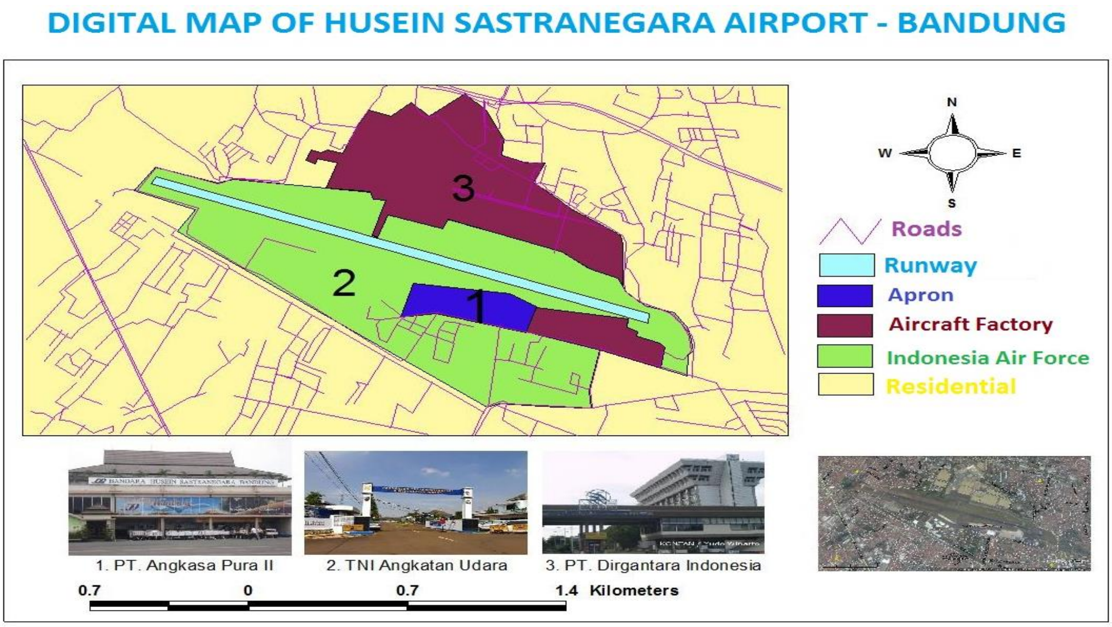

Figure 2. Digital map of Husein Sastranegara Airport (Satellite map digitalization, 2016).

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Digital map was produced from digitizing on screen which was integrating graphical (point, line, polygon) and attributes (numeric, string, boolean, date) data. Spatial analysis could be done on digital map resulted.

Figure 3. Existing activities map of Husein Sastranegara Airport (spatial analysis, 2016).

Airplane was landed on runway from east to west. Airplane was going to change its direction to taxiway then apron from west to east and stopped near of terminal. Only one runway was constructed in Husein Sastranegara Airport.

Table 1. Area calculation of Husein Sastranegara Airport.

No	Owner	Area
1.	Indonesia Air Force	358,000 m^2
2.	Angkasa Pura Company	5,000 m^2
3.	Dirgantara Indonesia Aircraft Factory	150,000 m^2
4.	Runway	99,000 m^2

Area of Indonesia Air Force, Angkasa Pura Company, Dirgantara Indonesia Aircraft Factory and Runway were produced from spatial analysis using GIS software. The largest area was founded on Indonesia Air Force parcel.

3.2. *Dynamic simulation model*

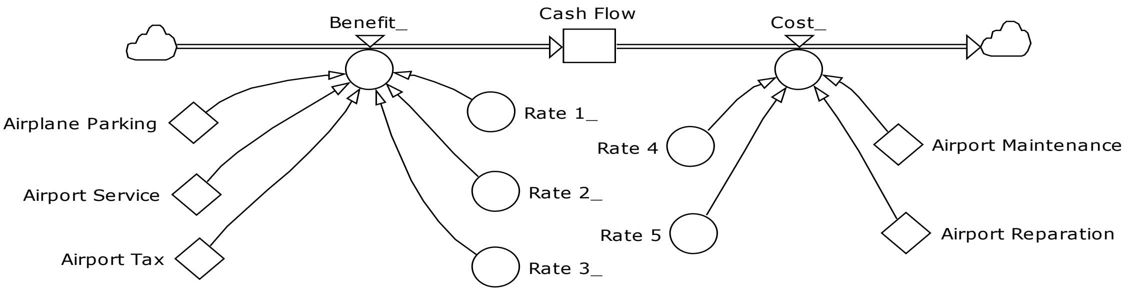

Figure 4. Flow chart diagram of spatial and activities models of airport based on gis and dynamic model.

Airplane parking, airport service, airport tax, airport maintenance and airport reparation were grouped into constant symbols. Rate 1, 2, 3, 4, 5 were grouped into auxiliary symbols. Inflow (benefit) or outflow (cost) is constant time auxiliary. Reservoir (cash flow) is inflow (benefit) minus outflow (cost).

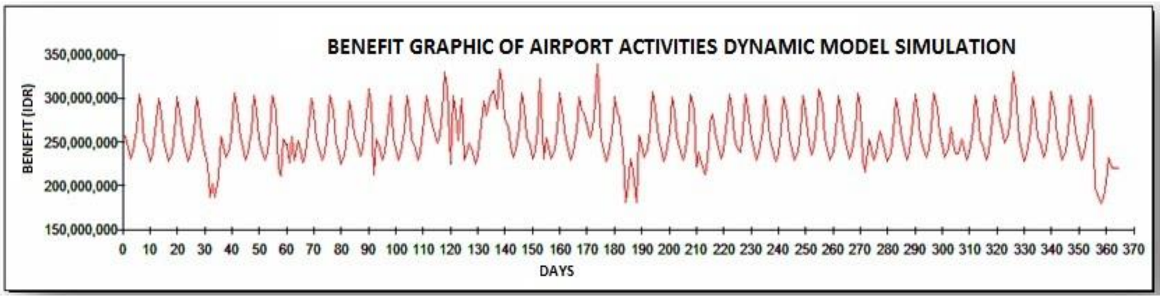

Figure 5. Benefit graphic of spatial and activities models of airport based on gis and dynamic model.

Graph fluctuation for beneficial components were shown from dynamic model simulation. Beneficial prices range were about 150 to 350 millions rupiah for 365 days (one year). Lowest price was happened on day 180 to 190 and highest price on day 170 to 175.

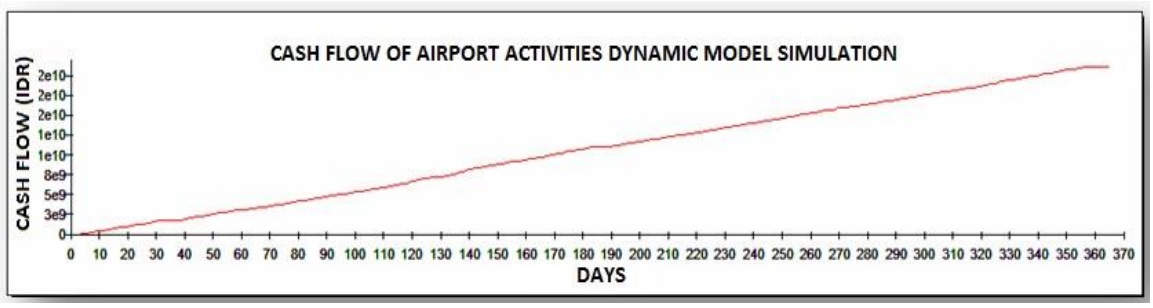

Figure 6. Cash flow graphic of spatial and activities models of airport based on gis and dynamic model.

Graph was continuing up for cash flow were shown from dynamic model simulation. Cash flow price was started from 0 rupiah on day 0 become 2 billion rupiah on day 365. Cash flow was beneficial minus cost components.

4. Conclusion

- Airport parcel area information, take off and landing aircraft movement and properties neighbourhood based on GIS topology (closure, connectivity, conjuguity) were resulted from conceptual and functional model implementation using GIS. Spatial information could be used for accurate decision in airport operation, maintenance and re-location project.
- Beneficial components (airplane parking, airport service, airport tax), cost (airport maintenance and airport reparation) and cash flow informations referenced on dynamic modeling symbols (reservoir, inflow, outflow, constant, auxiliary) were produced from causal loop and flow chart model simulation using dynamic modeling. Tables and graphs information could be contributed to performance evaluation and financial audit.
- Spatial and activity information which were resulted from GIS and dynamic modeling simulation were describing existing spatial condition not feasible for wide body aircraft international flight. Only one runway for airplane landing and take off. New runway construction could not be realized because of land acquisition.

- Airport National Standard still could be fulfilled by Husein Sastranegara but International Standard could not. Passenger increased in the future (5 to 10 years later) could be caused Husein Sastranegara airport performance decreased.
- Existing performance condition of Husein Sastranegara airport was very difficult for being increased in spatial and activity perspective. Airport re-location project is one option for being choiced.

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