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Remote Data Acquisation and QC Tools for Vehicle Navigation Mapping Solution

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Abstract— **Auto navigation assistance equipment (NAVI) have become common accessories for many vehicle these days in Malaysia. Regardless OEM or portable, NAVI has created an epidemic until drivers gave 110% confidence for every turning direction provided. Many did not realize that number of accident cases that involving NAVI units has been piles up in these 5 years either globally or Malaysia itself. Productions of NAVI start from data capturing till data conversion to compact disc navigable format. Remote sensing data with high resolution satellite imagery (HRSI) can provide extensive information on road, building, and landform. Attribute data that can be derive from images are merged with spatial data to built a database. Data feature are road mark, road regulation and road restriction. On site visit by GPS is to collect information that invisible in remote sensing image. These feature known as standing feature and only appear as dot or did not appear at all in the image. Roadsign, signboard and Point of Interest (POI) are amongst feature that best capture by on site visit. Quality check (QC Tools) on data were separate into spatial and logic script. Spatial QC Tools tackle error on shape of the feature and logic QC Tools will detect existence of violation in attribute rules for each feature. Manual guideline on remote data acquisition and development of QC Tools that been design to cater Malaysian road and POI perspective should be able to complement ISO GDF : 14825 that globally adopted as reference by map provider. To move forward, Ministry of Transportation or other authorities body that involved in safety issue for auto industries are propose to set up a clear rules depicting "how and what" must be comply by map provider when producing a map for auto navigation to ensure NAVI will not contribute to higher number of accident in the country.**

Keywords - navigation, GDF, road restriction, safety, QC Tools

I. INTRODUCTION

More and more driver in Malaysia choose car navigation system (NAVI) to be "a must" when buying a car. Either portable or OEM, NAVI has become one of the car component and no longer a car accessories. To support this trend, many local mapping solution company in Malaysia has been approach by key player in NAVI data provider in the world. Currently in market there are hundreds of brand for NAVI devices and most of it sharing the same map. Though it is hard for user to recognize the similarity of these map due to difference function offered by different device. ZENRIN, Tele Atlas and NAVTEQ are among key player in this map vendor industry. Their advantage is they have map conversion tool call Geographical Data Format (GDF) converter. This converter is to convert spatial and attribute data in the database into a format that comply with ISO GDF: 14825 and CEN 287. Why it is necessary to do so? This is to ensure compatibility of the data when it will become navigable CD-ROM. Other than that it is to enable Geographic Information to be shared between different users, applications, systems and locations [1]. GDF is not only about conversion but it also depicting on how the data should be collected and how feature, attribute and relations are defined [2]. Now data has been standardize and converted into a GDF comply format. Then what is the reason for accident to happen? NAVI device should be the safest way to reach destination. All roads have been pre determined and driver just navigates the car to the destination. Follow each instruction given by the NAVI voice , turn right and left when asked and you should reach the destination safely. In most cases, accident happen when turning direction given by NAVI is contradict with road regulation. For example, driver were asked to make a U- turn on one way road. How this can be happen? There are four major contributor to this contradiction. Out of date map, wrong data collection, wrong image interpretation and wrong digitizing.

A. Out of Date Map

Road in urban area can change as fast as every alternate days. Construction of new road and changing of road restriction are part of the development. Every time a new building rise, at least 2 roads nearby will be changing to cater access to the new building. In these case, accident can happen when driver were instructed to make turn based on old road network. Perhaps old traffic flow is allowed in both directions but current traffic flow is closed in positive direction and open in negative direction. This surely guide driver to enter the one way road from the opposite direction. Just imagine if this situation happen to an ambulance.

B. Data Collection

For data that invisible in high resolution satellite imagery (HRSI), GPS on site visit method were used. This method also used to collect data for standing feature that only appear as dot or did not appear at all in the image. Roadsign, signboard and Point of Interest (POI) are feature that mostly collected by on site visit. Roadsign or signboard that display prohibited maneuver are the most crucial here. Since on site GPS visit were done manually, it is very vulnerable to an error. One missing "No Entry" signboard can lead the driver to enter no entry road and cause an accident.

C. Image interpretation

Interpretation of the HRSI can be tedious. Especially for urban area with the congested road network and to make things worse, for urban area a road element can have more than 50 attributes[2]. Take example of sliproad. Sliproad is divided into two categories. First is sliproad to enter and exit highway which definitely traffic flow is one way. On the other hand, another type of sliproad is to connect between two general road. This type of sliproad can allowed traffic flow from both direction. If these two sliproad were misinterpret, imagine yourself driving to enter the highway from an highway exit.

D. Digitizing

The main concepts in the GDF data model are features, attributes and relationships. A feature is a formalized entity that is used to represent a topographical object. The properties and particularities of the objects are represented by means of attributes. Properties involving more than one feature, are described by means of relationships[3]. One of the most important relationship is prohibited maneuver. Figure 1 shows junction with the existence of prohibited maneuver. For this junction, digitizer must create at least eight (8) relationship in the database to link prohibited maneuver in from and to these four roads.

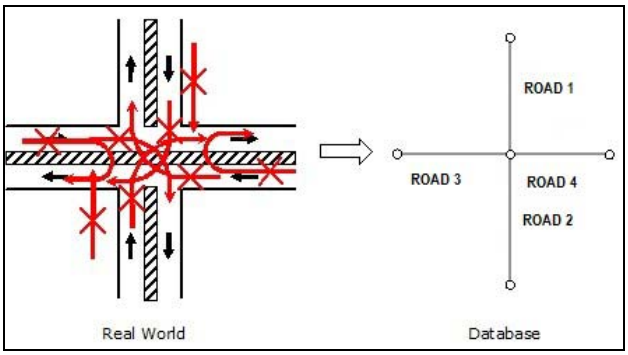

Figure 1. Junction with several prohibited maneuver just because of the existence of divider.

II. DATA ACQUISITION

Collecting, digitizing and relating the feature can be made in many ways. This research concentrates on remote data acquisition while GPS survey as a complimentary data source.

A. HRSI

HRSI capable of feeding vast amount of geoinformation. This suit best for creation of NAVI database. Sharp image though not in 1 meter resolution can give so much information about the road network. The only weakness is when the feature are hiding under another picture. There are discussion to overcome this weakness by getting other image from a different angle. Conclusion is this suggestion is not practical, from the view of cost of image and redundancy of the data. Overall, HRSI is enough for the digitizer and interpreter to extract almost 100% information on the road network. Image in Figure 2 capable of extracting all three level of information in GDF.

Level 0: Topology. This is a common GIS topology description that is widely accepted - i.e. everything has been described by nodes, edges and faces.

Level 1: Features. Level 1 is the most used level of GDF and contains simple features such as road elements, rivers, boundaries, and signposts. Features can have attributes that are specific (i.e. one way, road width, number of lanes) as well as relations that are very important for car navigation systems. Relations can be "forbidden turn from road element 1 to road element 2" or "road element 1 has priority over road element 2".

Level 2: Complex Features. At this level the "simple features" are aggregated to a higher-level feature. For instance, at Level 1 all road elements of an intersection should be represented, but at Level 2, the intersection is only represented with a single point. Level 2 is mostly used when a simplified description of the road network is sufficient. [4]

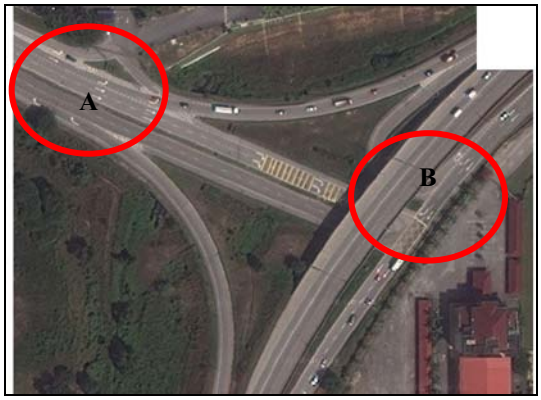

Figure 2. Multi level road HRSI. Shape of the road can easily been trace and digitize. A & B shows arrow been painted on the road and it can be interpret as road regulation.

Figure 3 shows output of digitizing and interpretation is a base map. Base map will contain basic spatial and attribute data regarding the road network.

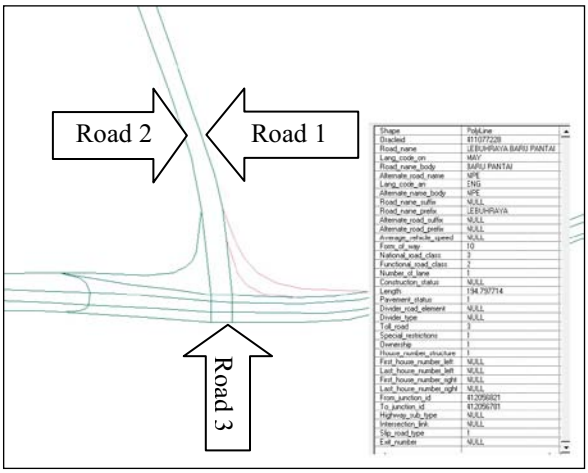

Figure 3. Base Map

B. GPS

GPS site visit is similar to GPS survey except it is much simpler. In GPS site visit, surveyor or data collector referring to base map and make some sort of comparison between real world and database in base map. In figure 2 HRSI, a U turn from road 1 to road 2 are invisible due to flyover. In GPS site visit, surveyor will identify the road and tag it as a U-Turn (Road 3) at identified junction.

III. BUILDING A DATABASE

During data acquisition, base map has is the only place where all data been dumped. Though it contains spatial and attribute data but most of the data either redundant or incomplete. At this stage, base map is more like a storage place instead of database [5]. Building a database from the base map is not easy. Though it is faster since all the data already in digital format but classification process can take up as much time as start the database from the scratch. In this stage, it is important for the developer/digitizer to be fluent in database design. Database in this research had been develop compliant to GDF ISO: 14825 with a few item that not suitable for Malaysia been excluded. There are eight feature themes in the database compared to ten features themes in GDF. Administrative Area, Settlement and Named Area, Road, Railway, Brunnel (Bridge and Tunnel), Waterway, Land Cover and Usage, Services and relationship. Administrative Area is fix from the topographic maps acquire from JUPEM. Settlement and Named Area is based on postal code map by Pos Malaysia with a minimal accuracy. Another source of reference for this theme is road surrounding the settlement area. Every settlement cluster need to be classified and bounded in order to ensure searching function in NAVI run faster. Road is the major challenged in building this database. As NAVI units rely on road to calculate route for every destination enter by the user, road feature take up 60% of the entire task in building the database. The complexity of the road in Malaysia is challenging especially not much of the road design in Malaysia is catered in GDF ISO 14825 or CEN 4.0. In most cases, the solution used is by using logic QC. As long as the attribute defined on the specific road did not violate any of the logic QC then it is acceptable. For cases that somehow did not passed the logic QC but the situation is precisely captured from the site and transferred to database correctly, a recordable exemption will be the solution. There are only 3 cases that been granted exemption for the entire road network inclusive of Klang Valley and all highway in Peninsular Malaysia. As for Railway and Brunnel, not much constraint since data is observed GPS site visit for every railways and road intersection. For bridge and tunnel, start and end of the feature can easily trace from HRSI. Waterway and Land usage are another feature that been trace from HRSI. There are an issue regarding Land Cover that also serve as an sport or recreational facilities that supposed to declare as services but it later been conclude as Land Cover with a services (for sport or recreational facilities) been marked as feature there. Services are another important feature in the database. For commercial purposes, quantity of services available in NAVI units is an indicator of the quality of the NAVI device itself. This simple math is calculate based on how many services available in the device divide by how much the price of the device. If the price can goes down to 10 cent per services, then that NAVI unit is competitive enough in market. Concurrently with database development, feature relationship also been digitize. This relationship consists of 24 subsections. Basic idea of creating a relationship is to tie each road to administrative area, each settlement and named area to road and lastly each service to road, administrative area and settlement and named area. Apart from that, relationship is also a section in database whereby all prohibited maneuver, divided junction (junction with divider) and grade separated (flyover) been digitized.

IV. QC TOOLS

In this research, analysis is in the form of QC Tools. This is to evaluate the data integrity from the data acquisition method previously done.

A. Spatial QC Tools

Most of spatial data were acquire vie HRSI with a complimentary of GPS site visit. Therefore the shapes of the spatial data were identical to feature shape in real world. At certain area this is a violation of the QC rules. Most common case is sharp road curve. Maximum angle between the road that allowed is not more that 15° . This to avoid the NAVI system read this curve as a turn. This type of QC is easy to apply since the topology of the road network is connected to each other. Among the challenging QC tools for spatial data is to guarantee at the part of road intersects with the other road, when grade is same, guarantee road is divided. This is the case where two or more roads are intersecting with each other. This is definitely a violation in any digitizing rules. For this case, the intersection is necessary if the road is a flyover. This situation is known as grade separated crossing. Figure 4 shows an area at Sg.Penchala where Lebuhraya Damansara Puchong(LDP) and Lebuhraya SPRINT (SPRINT) crossing each other in in a massive grade separated crossing. The creation of relationship is compulsory here to distinguish different grades. Though this relationship not only for road but also for situation where a road passes a brunel.

Figure 4. Massive Grade Separated Crossing at LDP and SPRINT. Road been digitized with a line crossing each other in several tier.

B. Logic QC Tools

For logic QC Tools, the development process were conducted in 3 phase. First phase is listing out the relationship of the entire attribute for the entire feature. This task is important to ensure all feature attribute has a connection with at least one feature. Second phase is drawing the entity relationship model (ERM). This model function as a spider web, any constraint or rules that need to apply for each attribute will have to satisfy the entire web. Last stage is enforcing the QC tools to the database. It is important to make sure the correlation between logic QC tools with NAVI program. Case 1: All services must have relationship with road. This is important since NAVI user will key in services as destination and NAVI units supposed to guide user till the front of premises or building at least. Case 2: When divided junction is existing, guarantee all the corresponded prohibited maneuver are exist. In these case, regardless the junction is not crossable due to existence of physical divider or double line mark, a prohibited maneuver relationship need to be created. This to avoid NAVI system calculates routing through this forbidden junction. A mistake here can cause a serious accident since the driver might ramp into another car or road divider. Case 3: If the road is closed for construction then attribute direction of traffic flow must be negative in both directions. This will notify the NAVI system not to take into consideration of this road when doing route calculation. Case 4: Guarantee that direction of traffic flow and prohibited maneuver relationship is not contradict. In these case, the road will become dead end. All these cases are originated during digitizing. It is difficult to check this error manually since the volume of data is high. Batch processes using a program like SQL is the best solution.

V. CONCLUSION AND SUGGESTION

From the data acquisition till the QC process, this research has gone through a lot of bump and obstacle. Though ISO GDF and CEN document has been used as guidelines but when adapting the rules in both documents into the Malaysia road structure, it is almost impossible to finish this research. Though the main research is to identify the integrity of data that been acquire by HRSI and GPS site visit, the conclusion of this research must be simultaneously presented with a manual guideline of how data were captured, how data were digitized and how QC been applied to the data. All these manual is important for the audience to understand the output (result) of this research. Target audience of this research are map provider and map vendor in Malaysia. Here in Malaysia, our map are not accessible freely in the web, even for foreign company to buy the map in Malaysia need to get official release from Jabatan Tanah dan Pemetaan Malaysia. All this due to security reason according to the authority. Because of that, most NAVI data provider need to engage local partner (map provider and map vendor) to produce a database. Here the role of NAVI data provider to give a training on how data were captured, how data were digitized and how QC been applied to the data is very crucial. This training can take up around 3-6 months and this definitely affected the progress of the work. Due to this, some of NAVI data producer only give a data specification to their local partner and it is up to them to interpret ISO GDF document in order to produce the database. Here misinterpret is most likely to happen. There is a huge gap of knowledge between NAVI data provider and their local partner. This is one of the reason map in the NAVI unit become unreliable and can cause an accidents. At least, all the document and QC Tools that been develop in this research can contribute to the government effort in reducing the accident.

REFERENCES

[1] CEN 287

[2] M. Konijn, "GDF – Geographical Data Format", http://www.ertico.com/gdf-geographic-data-files. Access on 12 May 2011.

[3] L.Heres, H. Claussen, "GDF: A Proposed Standard for Digital Road Maps". GDF workshop - February 1995.

[4] GDF ISO – 14825 : 2004

[5] N.Ghazali, M.R. Mahmud, N.Zainal 2009. Automobile Navigation Challenge – Safety. Proceedings of ISG 2009, Kuala Lumpur, August 10-11,2009.