Aerial Cable Car in the City Centre of Makassar: The Potential Routes, Technology and Station Locations

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Abstract. Aerial cable car is one of unique and efficient transportation modes that the world has today. This research aimed to explore the potential application of this mode in the urban areas of Makassar City, specifically in its city centre. It is designed to answer preliminary planning questions with regard to the best potential routes, technology, and station locations for the implementation of this mode in the near future. The research was conducted in 5 months (from April to August 2019). The data was collected through literature study and field survey including a traffic counting. The spatial analysis utilized satellite image map of Google Pro Earth, mapping, illustration and descriptive explanation. The research identified at least three trip purposes that the aerial cable car could potentially serve the city: for daily transportation, tourism, and shopping/business centres trips. It was concluded that trips to Lae-lae and Kayangan Resort Islands, the Losari City Tour, and trips from shopping mall to mall, are among potential routes that deserve for further comprehensive researches and feasibility studies. Monocable Detachable Gondola (MDG) is considered the best choice as a starting point in introducing this type of mode to the city and its people. The locational analysis based on defined criteria resulted five to nine potential station locations.

1. Introduction
Makassar is the capital city of South East Sulawesi Province and among the biggest cities in Indonesia. Its city center holds important role not only for the city but also regionally. It is where the city government, central business district, and national and international ports are located; the place of historical sites, traditional buildings and villages; a prominent coastal zone that connects the scatter small islands the city has to the mainland. It becomes the biggest attraction internally and externally that creates problems of heavy traffic during days and nights. Having a very compact and dense urban structure, it gives little flexibility for the government and planners for road widening project. Innovative ideas therefore are vitally needed not only for traffic management but also for a new efficient transportation mode to be proposed that consumes less land and environmentally friendlier.

In Europe, mass rapid transit, such as bus and train system, has a very long history as an effective solution for public transportation in urban areas. Creatively though, in the city center, the size and width of the bus may be modified in order to fit its very narrow streets. Building rails and roads above and under the ground have also proved efficient in expanding and improving the transport services without compromising the wellbeing of the existing on the ground traffic. Implementing aerial transportation such as cable car that requires very less amount of space for the towers and stations building without the need to drastically change the urban landscape is also a favorite choice in many European cities.
This research aimed to elaborate one of the above concepts, i.e., the aerial cable car, as one of potential solutions in Makassar City Center for better traffic management and to improve public transportation service quality. The research was designed to answer preliminary planning questions with regard to the best potential routes, technology, and station locations for the implementation of this mode in the near future. The result would hopefully be beneficial for the local urban and transport planners as well as the city government and to encourage further studies related to its application in other Indonesian cities.

2. Methodology

This research was conducted in 5 months (April to August 2019). The selected case study is the City Center of Makassar. The data was collected through literature study and field surveys including a traffic counting on daily passengers travelling by existing sea transportation mode to Lae-lae Resort Island. The traffic counting was conducted in August within 7 days comprises all working and weekend days (Wednesday/14th to Thursday/15th, continued on Saturday/17th to Tuesday/20th, and ended on Friday/23rd) effectively during 6 hours per day (from 8 am to 4 pm). The spatial analysis was accomplished with the help of satellite image map obtained from Google Earth Pro and using the method of mapping, drawing and descriptive explanation.

3. Result and Discussion

The aerial cable car is a transportation system that relies on cables to pull a motorless vehicle (cabin) on a steady speed along cable that spans meters away between tower to tower connecting station to station where an off-board motor is located. Its operation requires routes, vehicles (cabins), towers, simple stations, supporting cables, motors, information and ticketing system, and a reliable schedule, safety and evacuation system. It runs exclusively, neither undisturbed nor creates disturbance to existing road traffic, thus it could stay consistent and dependable in its service and time schedule regardless the severity of road traffic congestion. These traits make aerial cable a popular choice in big cities with traffic problems and especially with a strong tourism sector.

Table 1. Comparison between technologies of aerial lifts (ropeways) [1]

| Illustration | Photo | Tramways | Gondolas |
|--------------|-------|---------|---------|
|              |       | Single-Haul Aerial Tramways | Dual-Haul Aerial Tramways | MDG | BDG | TDG |
| Cabin capacity |       | Large 20-200 passengers | Large Up to 100 passengers | Small-medium 4-15 passengers | Small-medium 4-15 passengers | Small-medium Up to 35 passengers |
| Line capacity |       | 500-2800 passengers per hour per direction | Up to 2000 passengers per hour per direction | Up to 300 passengers per hour per direction | Up to 3600 passengers per hour per direction | Up to 6000 passengers per hour per direction |
| Grips |       | Fixed grips | Fixed grips | Detachable grips | Detachable grips | Detachable grips |
| Operating speed |       | Up to 43.2 (km/h) | Up to 27 (km/h) | Up to 21.6 (km/h) | Up to 21.6 (km/h) | Up to 30.6 (km/h) |
The aerial cable car system consists of two types of technology: tramway and gondola lifts. The technology of aerial tramway consists of a single- and a dual-haul. The technology of gondola lifts consists of Monocable Detachable Gondola (MDG), Bicable Detachable Gondola (BDG) and Tricable Detachable Gondolas (3S). The main differences between tramway and gondola, especially related to cabin and line capacity, operating speed and distance spans can be seen in Table 1.

3.1. Consideration in Selecting the Best Route and Defining The Planning Purposes
Selecting the best route for public transportation, especially aerial cable car, takes into consideration the following factors: 1) the planning purposes; 2) object of interest; 3) final destination; 4) potential traffic demand; 5) the shortest distance/time; 6) location of transit points; 7) intermodality; 8) complexity of urban structure: the land availability and existing structure flexibility to accommodate the building of infrastructure, i.e., towers and stations; 9) especially for the tourism purpose, it is important to consider routes that passing through as many touristic objects and scenic landscape as possible.

Aerial cable car can be built for a single as well as multiple trip purposes, for example:
- mainly for daily public transportation, such as the Complexo do Alemão Teleférico - Rio de Janeiro in Brazil [2], the Medellin Metrocable in Colombia, and the Caracas Metrocable in Venezuela [3];
- mainly for tourism transportation, such as the Taman Mini Indonesia Indah (TMII) cable car in Jakarta, the Kumala Island Garden Resort Cable Car in East Kalimantan, and the Gondola Timang Beach in Yogjakarta, which was initially built to transport the lobster fisherman from the coast to lobster nests in Timang Island [4] [5];
- (dual purposes), primarily for public transportation and secondary for tourism, such as the Roosevelt Island Tramway in USA [3];
- (dual purposes), primarily for tourism and secondary for public transportation such as the Sentosa Island Gondola in Singapore [2];
- for a temporary construction to support a high-profile event, which later on been made permanently, such the Emirate Air Line in London for the Olympic Game event in 2012 [3] and the Rhine Ropeway Koblenz in Germany for the Hortikultura BUGA event in 2011 [6];
- to serve transportation demand in specific zone, such as the Polinka Cableway in Polandia that connects different parts of the University of Wroclaw separated by the Oder River [7]; and
- for multi-purposes transportation, such as the Mountain Village Gondola – Telluride in Colorado, which does not only serve the public and the tourists, but also the ski players and shopping trips, as well as providing access to reach parking areas [3].

3.2. Planning the Aerial Cable in the City Centre of Makassar
The demand for passenger transportation in the City Centre of Makassar comprises of, at least, three trip purposes: daily transportation, tourism, and shopping business, whereas the aerial cable car, as described above, has the capacity to serve for all these trip purposes.

With regard to the tourism purpose, the aerial cable car is an object of attraction in itself and could potentially induce more attraction to the existing ones. Its planning would encourage a better intermodality of all public transportation that would ease the tourists to reach various destinations from the nearest harbors and ports, from the far away airport, and from the surrounding regions. As Makassar has resort islands, it is a much cheaper solution to connect them to the mainland with aerial cables rather than building concrete bridges or roads. With regard to the business purpose, aerial cable car would enable businessmen and shoppers moving directly and easily from one office building or shopping center to the other. As for daily transportation, its implementation would encourage more utilization of environmental friendlier means of transport such as pedestrian, bicycles, and electrical vehicles, of which would potentially lower the use of private motorized vehicles. This is beneficial especially for a very dense urban structure such as Makassar City Centre. Its user friendliness would help diffable people by giving them more flexibilities and mobilities in travelling to fulfil their daily needs.
The tourism purpose in Makassar City Centre includes trips to resort island, city tours, and shopping centres. Among 12 small islands in Makassar City (table 2), Samalona, Lae-lae and Kayangan are well known as resort destinations that attract local tourists and foreigners due to their nature and recreational facilities. Among them, Lae-lae and Kayangan are the shortest in distance to the mainland and that may lead to higher possibility for the application of aerial cable for less technical challenges that they may cause. Short distance also would make short trips: half day or even couple hours trips, possible.

| No | Makassar Small Island | Administration                        | Characteristic         |
|----|----------------------|---------------------------------------|------------------------|
| 1  | Lae-lae              | Tourism                               |                        |
| 2  | Kayangan             | Tourism                               |                        |
| 3  | Samalona             | District of Ujung Pandang              | Tourism                |
| 4  | Gusung Tallang       | Tourism                               |                        |
| 5  | Kodingareng Keke     | Tourism                               |                        |
| 6  | Barrang Lombo        | Subdistric of Barrang Lombo, Archipelago | Settlement            |
| 7  | Barrang Caddi        | Subdistric of Barrang Caddi, Archipelago | Settlement            |
| 8  | Lumu-lumu            | Subdistrict of Barrang Caddi, Settlement | Settlement            |
| 9  | Bone Tambung         | District of Sangkarrang                | Settlement            |
| 10 | Langkai              | Archipelago                            | Settlement            |
| 11 | Lanjukang            | Subdistric of Kodingareng, Settlement  | Settlement            |
| 12 | Kodingareng Lombo    | District of Sangkarrang, Archipelago   | Settlement            |

3.3. Trips to the Lae-lae Resort Island

Lae-lae Island is located less than 500 meters above sea level, in the District of Ujung Pandang. It has total area of 0.22 km² which is divided into 10 RW (community units) and 3 RT (neighborhood units) and a home for 1.784 inhabitants (about 8.109 inhabitants/km² density) [8].

Currently, the inhabitants and tourists take journey to this island using the only means of public and private transport available, i.e., traditional fisherman ships and local speed boats. The trips started from Kayu Bangkoa, the local harbor in the mainland, crossing the distance of about 1.08 km. With the speed rate of about 10 knots (±18.52 km/hour) theoretically, the travel would only take less than 5 minutes, however in reality due to frequent detour, wind, and technical problems, it may take 10 minutes or even longer to arrive.

The location of Lae-lae Island and three possible alternative routes to travel to this island from the mainland by means of aerial cable car are shown in Figure 1. The first alternative (about 1.08 km) is a journey started from the Kayu Bangkoa Harbour, exactly from where the current sea transportation services are also started. The intermodality between the land, sea and aerial transportation in this point would be an interesting subject to work on. The second alternative (about 1.40 km) is started from the public open space called the Anjungan Toraja. The third alternative (0.48 km) is the shortest distance that started from the Centre Point of Indonesia, which is a newly built settlement resulted from the still ongoing reclamation project.
Figure 1. Aerial cable car alternative routes from Makassar city mainland to Lae-lae resort island [9]

The selection of the best technology (between aerial tramways or gondola lifts) takes into consideration the following factors: 1) the amount of travel demand, which is highly influenced by the public interests to travel by means of cable car system, especially true when it is a totally new system applied in the city/region; 2) whether it is built for a permanent or temporary use, such as for a project exhibition aimed to assess the public acceptance before being made permanently; and 3) the minimum free span and other technical challenges and requirements that have to be met in the planning field.

Whether to implement aerial tramway or gondola lifts, it depends on, among other things, potential demand and public acceptance. High cabin and line capacity such as tramway seem more suitable for high traffic demand. In new application, it could be an optimistic option to be applied in communities that are used to mass transit and cable kind of transportation as it would be relatively easier to gain public acceptance which may lead to an adequate traffic demand to cover the investment as well as daily operational and maintenance costs.

As for Makassar City where bus transportation does not survive well while rail and cable transportation do not exist, the tramway cabin could be too generous. Gondola, in the other hand, seems a rather perfect mode for a trial implementation by which the community’s interests and rate of utilization could later on be assessed to define the continuity of its services in longer term. Monocable Detachable Gondola (MDG) system that is capable to serve up 15 passengers cabin capacity, 300 passengers per hour per direction line capacity and 21.6 km/h operating speed [1] would be the best choice as a starting point in introducing this type of transportation to the city and its people.

Table 3. The travel time to Lae-lae Island by existing transportation mode and aerial cable Car

| Alternative route for cable car | Distance from mainland to Lae-lae Resort Island (km) | Travel time (minutes) by existing public/rented boat (±10 knot) | Travel time (minutes) by aerial cable car (MDG 21.6 km/h) |
|-------------------------------|-----------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
|                               |                                               | Calculated | Real time | Calculated |                                             |
| 1                             | ±0.48                                         | ±2.00      | -         | 1.33       |                                             |
| 2                             | ±1.40                                         | ±6.00      | -         | 3.89       |                                             |
| 3                             | ±1.08                                         | ±4.60      | ±10.00    | 3.00       |                                             |
Table 4. Capacity comparison between existing public/rented boats with MDG technology

| Survey Days | Capacity by existing public/rented boat | Capacity by aerial cable car with MDG (up to 15 psg/cabin) |
|-------------|----------------------------------------|----------------------------------------------------------|
|             | Number of boats | Number of Passengers per day | Per 6 hours | Per hour | Cabin | Line Capacity |
| Monday      | 21                | 166                           | 28          | 2        |       |               |
| Tuesday     | 25                | 203                           | 34          | 3        |       |               |
| Thursday    | 28                | 325                           | 55          | 4        |       |               |
| Wednesday   | 24                | 254                           | 43          | 3        |       | up to 300 pphpd |
| Friday      | 15                | 120                           | 20          | 2        |       |               |
| Saturday    | 20                | 127                           | 22          | 2        |       |               |
| Sunday      | 19                | 71                            | 12          | 1        |       |               |
| Average     | 22                | 181                           | 31          | 3        |       |               |

Table 5. Aerial cable car built above water body, crossing ships and active harbor [7]

| System                   | Application/ Purpose | Water Body/ Harbour | Length (Km) | City           | Technology | Speed (m/s) | Cabins |
|--------------------------|----------------------|---------------------|-------------|----------------|------------|-------------|--------|
| Singapore Cable Car      | Tourist/Urban        | Keppel Harbour      | 1.7         | Singapore      | MDG        | 5           | 67     |
| Wuhan Cable Car          | Tourist/Urban        | Hanjiang River      | 0.9         | Wuhan          | MDG        | 5           | 18     |
| N Car                    | Tourist/Semi-Urban   | Nha Trang Bay       | 3.3         | Nha Trang      | MDG        | 6           | 65     |
| Novgorod Cable Car       | Transit/Urban        | Bor River           | 3.6         | Nizhny Novgorod| MDG        | 6           | 28 (up to 56) |
| Emirate Air Line         | Tourist/Urban        | Thames River        | 1.0         | London         | MDG        | 6           | 34     |
| Yeosu Cable Car          | Tourist/Urban        | Namhae Sea          | 1.5         | Yeosu          | MDG        | 5           | 50     |
| Ngong Ping 360           | Tourist/Urban        | Tung Chung Bay      | 5.7         | Hongkong       | BDG        | 7           | 112    |
| Kolner Seilbahn Roosevelt Island Tram | Tourist/Urban     | Rhein River         | 0.9         | Cologne        | BDG        | 28          | 44     |
| Koblenz Seilbahn         | Tourist/Urban        | East River          | 1.0         | New York       | Dual Haul  | 7.5         | 2      |
| Roosevelt Island Tram    | Tourist/Urban        | Rhein River         | 0.9         | Koblenz        | 3S         | 7           | 18     |
| Spokane Falls Skyride    | Tourist/Urban        | Spokane Falls River | 0.4         | Spokane        | Pulsed Gondola | 6    |       |
| Yangzte River Cable Car  | Transit/Urban        | Yangzte River       | 1.2         | Chongqing      | Aerial Tram | 10          | 2      |
| Polinka Cableway         | Transit/(University)/Urban | Oder River     | 0.3         | Wroclaw        | Aerial Tram | 5           | 2      |
| Port Vell Aerial Tramway | Tourist/Urban        | Port Vell           | 1.3         | Barcelona      | Aerial Tram | 3           | 2      |
The technical planning challenges in implementing MDG, among other things, is to build towers that span between 100-300m, in Europe spans >400m are possible under a certain condition [7]. It is however much less than Tricable Detachable Gondolas (3S) which have larger spans between 1,000-3,000m with the consequence of larger towers [7]. Other technical planning challenges especially in implementing cable cars that crosses water body, ships and active harbors are: 1) clearance distance; 2) navigation marks and signs; 3) flight paths (in case of interference with airplane and helicopter); 4) maximum length of free span; 5) towers built in water; 6) regulating ships movement around cable car; 7) cable car installation, testing and maintenance; 8) fire, safety precautions and rescue system [7]. The examples of aerial cable car that were built above water body, crossing ships and active harbor can be seen in Table 5.

3.4. Trips to the Kayangan Resort Island

Kayangan Island is part of Bulogading Subdistrict in Ujung Pandang District. It has a total area of about 1 ha, which is much smaller than the size of Lae-lae Island. Considering its limitation in land size to accommodate large visitor and the building of more recreational facilities, applying aerial cable car to serve transportation to this island would be an extravagant plan. However, its natural beauty and aerial views could make the journey a favorable and exclusive one. This is the reason why this research includes it as one of the potential routes for aerial cable car.

Traditional fisherman ships and local speed boats are also the main transportation to reach this island. The trips could be started from the Kayu Bangkoa Harbor or Benteng Pannyua Harbor or Traditional Paotere Port. From Kayu Bangkoa Harbor, the journey crosses the distance of about 2.77 km, about less than 10 minutes theoretically but it could reach to even 15 minutes in reality. Travel route from the Paotere Port is more favorable to people as the distance is shorter and thus faster in travel time (about 2.25 km, about 7 minutes theoretically but 10 minutes or even more in reality).

The following figure shows the location of Kayangan Island in satellite google earth and two alternative routes to travel to this island from the mainland by means of aerial cable car. The first alternative, similar to the previous concept for Lae-lae, is to initiate the aerial journey from the Kayu Bangkoa Harbour (about 2.77 km), exactly from where the current sea transportation services are also started. The intermodality between the land, sea and aerial transportation in this point become an advantage. The second alternative is the shortest distance, about 0.86 km, where the station may be integrated within the PELNI private harbour, or, as other possible concept is, fused to one of the commercial buildings nearby.

![Figure 2. Aerial cable car potential route from Makassar city mainland to Kayangan resort island [9]](image-url)
Table 6. The travel distance and time to Kayangan island

| Routes | Distance from the mainland to Kayangan Resort Island (km) | Travel time (minutes) | by existing public/rented boat (±10 knot) | by aerial cable car (MDG 21.6 km/h) |
|--------|----------------------------------------------------------|-----------------------|------------------------------------------|-----------------------------------|
|        |                                                          |                       | Calculated                               | Real time                         | Calculated                        |
| 1      | ±2.25                                                    | ±7.29                 | 10                                       | -                                 | -                                 |
| 2      | ±2.77                                                    | ±8.97                 | 15                                       | -                                 | -                                 |
| 3      | ±2.93                                                    | ±9.49                 | 15                                       | -                                 | -                                 |
| By Aerial | ±0.86                                                | ±2.79                 | -                                        | ±2.39                             |                                   |

3.5. The Losari City Tour
This type of trip is designed as a recreational and vocational trip aimed to present the historical, traditional mixed with the modern culture, and attraction, as well as the dynamic lives that embedded in the City Centre of Makassar. Currently it is a very common trip offered by many travel agents in Makassar for the incoming visitors and tourists. Currently such short trips are conducted by means of public/private/rented buses/minibuses/vehicles. The use of aerial cable car would offer even better and spectacular view of the city landscape, the urban structure and the coastal panoramic.

Losari is the name of a beach, along the coastal area exactly where Makassar City Center is radially located (from the Penghibur Street to Nusantara Street). This particular area is packed with enormous public facilities (shown in Figure 3), including the mayor and governmental offices, traditional harbors, national and international ports, jetty facilities, museums, business and banking services, radio and television centers, stadium and sport centers, hotels, malls and restaurants. It is indeed the prime zone of Makassar City and Regionally.

Figure 3. Objects of attraction along the Losari beach and Makassar city centre [9]
3.6. Shopping Trip from Mall to Mall

It is nowadays a common and favourite habit especially among the young people and women in Makassar City and also in other Indonesian cities. Mall is a type of shopping centre and today it is intentionally designed to be a one stop shopping place as it provides almost all kinds of goods and services of daily needs. As the number of malls is increasing rapidly, people become not satisfied to only visit one mall at a time, but instead in making decision on what best to buy, they feel the need to go and see other options in other malls. This is one of the reasons why City of Brussel offers a free shopping bus line that transport its people from one shopping centre to another. At least 7 shopping centres served by this line from Saturday to Sunday. Besides as part of traffic demand management program and to ease the journey of the people, it is also a way to support the growing businesses and commercials in a very smart and positive way.

Aerial cable car can even be a better option than bus to serve this kind of trips, especially when the shopping centers are located a line (see figure 4). The MTC Mall in Makassar City, the underground Karebosi Link Mall and the Karebosi Kondotel (condominium/shopping/business center) are all clustered together in a very close distance and even have direct pedestrian way, horizontally and vertically, to one another. Right in direct line 2.3 km to the south, there is Ratu Indah Mall which is also clustered together with the surrounding shops, hotels, restaurants and business center. Connected these two very busy clusters with aerial cable car can reduce the use of motorized transport in between and thus ease off the on the ground traffic congestion.

Figure 4. Route of mall to mall shopping trips [9]

The selection of the best location for aerial cable car station takes into consideration the following factors: 1) Along the selected routes; 2) Points where the potential demand is high or even the highest; 3) Points where the intermodality is high or even the highest; 4) Within standard of maximum distance from one station to the other; 5) The availability of land for its construction or existence of tall building to be integrated.
4. Summary and Conclusion
The research identified at least three purposes that this mode would potentially serve the city: for daily transportation, tourism and shopping/business centres trips. The analysis concluded that trips to Lae-lae and Kayangan Resort Island, tours along the Losari Beach, and journeys between shopping malls are among routes that deserve for further feasibility studied. Monocable Detachable Gondola (MDG) that is capable to serve up 15 passengers cabin capacity, 300 passengers per hour per direction line capacity and 21.6 km/h operating speed is considered the best choice as a starting point in introducing this type of transportation to the city and its people. The locational analysis based on defined criteria resulted in five to nine best potential locations for future stations.

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