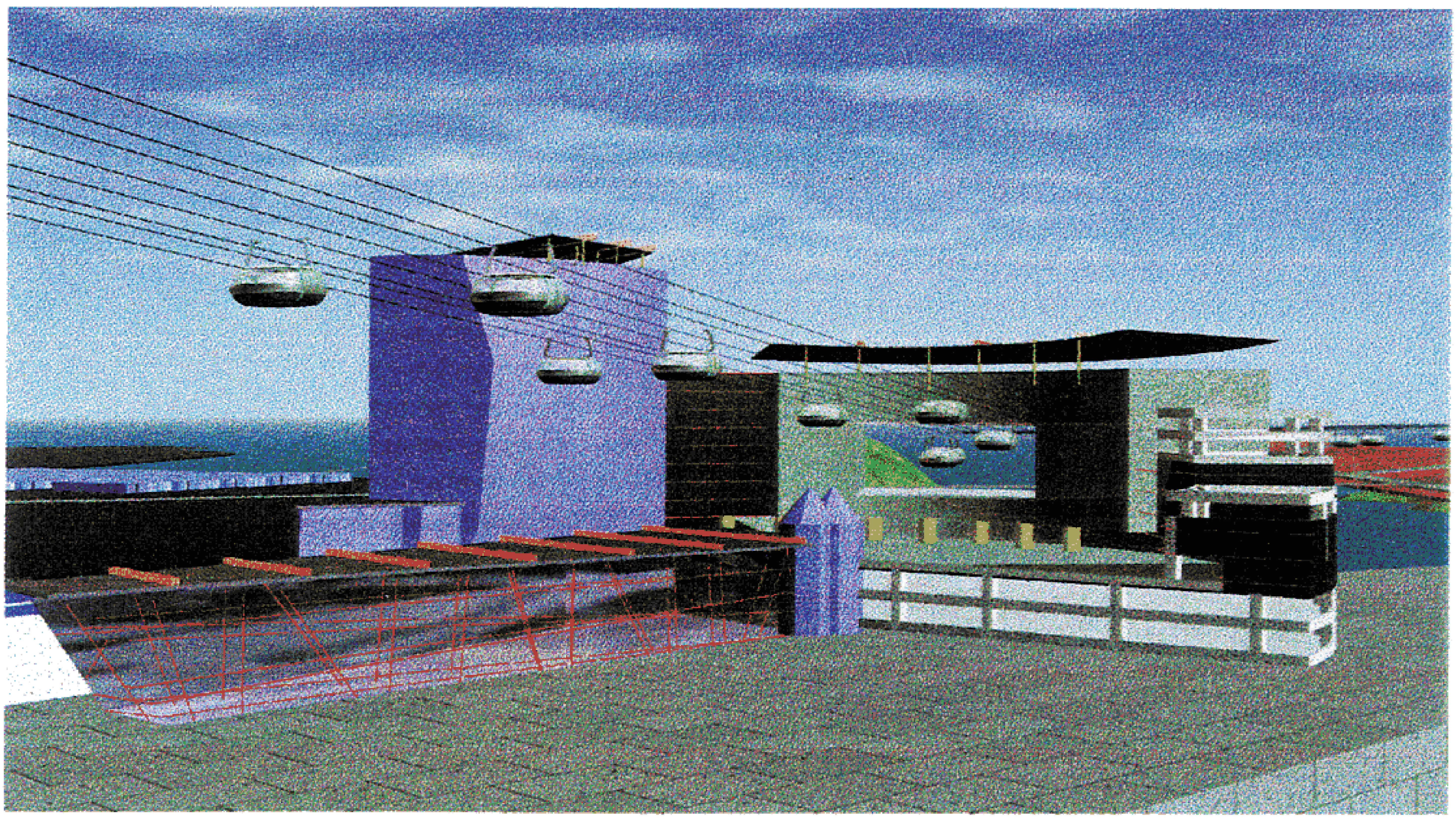
地鐵公司
MTR Corporation

Consultancy Agreement NEX/034
Tung Chung Cable Car
Feasibility Study

Final Feasibility Study Report (Revised)



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In association with

Booz Allen & Hamilton (HK) Ltd
Liang Peddle Thorp Architects and Planners Ltd
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EHS Consultants Ltd
Davis Langdon & Seah HK Ltd
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Consultancy Agreement No. NEX034
Tung Chung Cable Car Feasibility Study

Final Feasibility Study Report

Date	Originator	Checked By	Approved By
26/3/99	Terry Chung	K M Yeung	R M Bradley

FINAL FEASIBILITY STUDY REPORT

CONTENTS

Note : Some of the chapters of this report are withheld by the MTR Corporation because they contain commercially sensitive information.

1.0 INTRODUCTION

1.1 Project Background

1.1.1 The proposal to construct a cable car system between Tung Chung and Ngong Ping for enhancing tourism in the area was first mooted in the North Lantau Development Study 1992. This concept was further developed by the Visitor and Tourism Study for Hong Kong (VISTOUR) prepared for the Hong Kong Tourist Association (HKTA) and Planning Department in 1995.

1.1.2 A preliminary appraisal of the engineering feasibility, ridership, cost and revenue was undertaken by the MTR Corporation (MTRC) in 1996. The proposal was further studied under the "Remaining Development in Tung Chung and Tai Ho Comprehensive Feasibility Study" commissioned by the Territory Development Department in 1997.

1.1.3 The Government formally announced on 29 May 1998 that the MTRC would take the lead in developing a proposal for the cable car project and to mastermind the way forward. It is understood that this project shall be based on a fast track process to enable the operation of the cable car at the earliest possible time as emphasized by the Government.

1.1.4 This Feasibility Study was commissioned by the MTRC on 9 September 1998 with the specific objective of examining the merits of providing such a system and this Report summaries the findings and conclusions of this Study.

1.2 Scope of Study

This Study comprises the following two Stages :

1.2.1 Stage 1 - Interim Review which consists of the following Activities:

(a) Activity 1a - Study Planning; and
(b) Activity 1b - Interim Report.

1.2.2 Stage 2 - Feasibility Study which consists of the following Activities:

(a) Activity 2a - Draft Final Feasibility Study Report; and
(b) Activity 2b - Final Feasibility Study Report.

Results and findings from Stage 1 were used to formulate the requisite design and planning assumptions as required for Stage 2 of this Study.

1.2.3 Activity 1a - Study Planning

All documents from related studies were reviewed, and an Inception Report was submitted to include but not limited to the following:

(a) Methodology to accomplish the Activities of the Study;

(b) A programme detailing the major tasks and key dates for submission of deliverables.

1.2.4 Activity 1b – Draft Interim Report

The following issues were investigated in detail and the requisite findings were reported :

(a) Alignment Options;
(b) Transportation;
(c) Cable Car System Selection;
(d) Engineering;
(e) Buildings and Stations Architecture;
(f) Land Use, Rural Planning and Landscaping;
(g) Commercial Development and Complementary Tourist Attractions;
(h) Initial Environmental Planning Assessment; and
(i) Project Programme Evaluation.

The Draft Interim Report was submitted in the end of November 1998. Comments on the Report were received from various parties. The complete set of comments and responses has been included in Appendix II of the Draft Final Feasibility Study Report prepared in Stage 2 of this Study.

Stage 2 – Feasibility Study

1.2.5 Activity 2a – Draft Final Feasibility Study Report

The Draft Final Feasibility Study Report incorporated all confirmed conclusions and principal findings from the Interim Report.

The Draft Final Feasibility Study Report was issued on 15 February 1999. Comments on the Report were received from various parties. A complete set of comments and responses is included in Appendix II of this Final Feasibility Study Report.

1.2.6 Activity 2b – Final Feasibility Study Report

This Final Feasibility Study Report will be submitted to Government and may also form one of the technical elements of the MTR Corporation's Proposal to Government for design, construction and operation of the Cable Car System.

1.3 Summary of Study

1.3.1 This Study has investigated the feasibility of providing a cable car system to ply between Tung Chung and Ngong Ping, which will improve the transportation capacity of these two places, and in turn facilitate local residents as well as tourist visitors to pay a visit to the Big Buddha. Proven cable car systems have been identified to meet the projected transportation demand and a preferred alignment has been determined to minimise land, environmental, landscape and visual impacts.

1.3.2 Various alignments for this cable car route (refer to Figure 1.1) have been examined. The detail evaluation of these alignments are described in Section 6 of this Report. The cable car system selection process is included in Section 7.

1.3.3 This Study concludes that Alternative Alignment 2 (Modified) with an Intermediate Station located on the Airport Island is the most preferred alignment (refer to Figure 1.2).

2.0 TRANSPORTATION STUDY

2.1 Objectives

2.1.1 The transportation study objectives were to:

- Review the existing demand studies and other relevant reports for the cable car system;
- Identify factors which have changed since the studies were prepared and which may impact on the accuracy of the results;
- Undertake appropriate research to:
  - Establish a patronage model for the proposed cable car;
  - Forecast the annual number of trips that would occur on cable car and the station loadings on which this forecast is based, for the years 2001, 2006, 2011, 2016;
  - Estimate potential revenues under a limited number of fare and operational options and recommend optimum fare strategies;
  - Provide an analysis of the key risks impacting on the achievement of the forecast demand and revenues; and
  - Provide appropriate input to the financial assessment of the proposed cable car.
- Investigate the transportation purpose of the proposed cable car system.

2.1.2 There were also a number of interchange issues that needed to be resolved, namely;

- To establish the planning of transport interchanges between the cable car and other transport modes, including pedestrian linkages – as part of this process assess passenger movements at stations and terminals;
- To assess impact of road traffic and patronage/revenue implications on the MTR Tung Chung Line (TCL);
- To assess the effect on other modes if the cable car was unavailable on certain occasions.

2.2 Methodology

Diagram 2.1 below provides a schematic representation of the approach. Five principal tasks were defined.

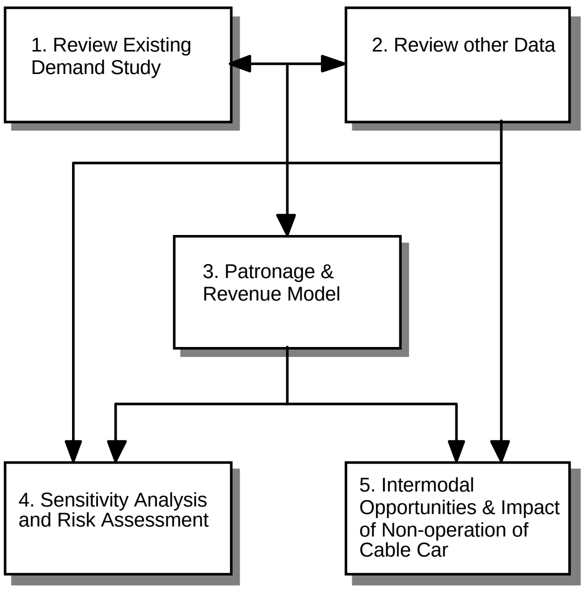

Diagram 2.1 Transportation Study Approach

2.2.1 *Task T1 - Review Existing Demand Study* - The Project Brief identified the previous relevant demand study reported in the Draft Working Paper No. 10 of the Government's "Remaining Development in Tung Chung and Tai Ho Comprehensive Feasibility Study, June1998". The model methodology and results of the Report are used as the baseline for this study.

2.2.2 *Task T2 - Review Other Data* - Task 2 reviewed population trends, ridership levels, tourism growth trends, visitor modal split, tourist penetration rates and travel options from previous studies. Our assessment of forecast changes encompass the period 2001 – 2016 using data from the Territorial Development Strategy Review and the Hong Kong Tourist Association.

2.2.3 *Task T3 - Demand and Revenue Model* - The model was based on the previous demand methodology updated to incorporate the data derived from Task T2. Future cable car patronage forecasts were calculated for 2001, 2006, 2011, 2016. Fare revenue projections were developed for these same milestone years.

2.2.4 *Task T4 - Sensitivity and Risk Analysis* - The sensitivity analysis considered the responsiveness of cable car patronage to fare levels for cable car and competing modes. It examined:

- Fare levels and structure for cable car and competing modes (concessions, discounts, integrated ticketing etc.); and
- Availability of capacity on the cable car system and service levels/design implications for cable car.

2.2.5 Task T5 - Intermodal Opportunities and Impacts – the physical requirements of the interchanges between modes are assessed (refer to Section 11) :

- The required transport interchanges, i.e. requirements for car and coach parking, taxi drop-off and bus and MTR interchanges;
- The impact on road traffic around Tung Chung cable car terminal;
- The pedestrian linkages between MTR Tung Chung Station and the cable car terminal;
- The Passenger Movements at cable car stations.

2.2.6 The intermodal impacts of the cable car also result in ridership and revenue impacts on its feeder and competitive services. As a result of this, the following are examined:

- The patronage and revenue impact on the MTR TCL; and
- The impact on other modes if the cable car system is unavailable on identified occasions.

2.3 Previous Studies and Information Review

2.3.1 The previous demand study undertaken as part of WP10 "Remaining Development in Tung Chung and Tai Ho Comprehensive Feasibility Study", derived the demand forecasts depicted in Tables 2.1 and 2.2.

Table 2.1 - WP10 – Potential Annual Cable Car Ridership (Millions)

Scenario	**2001**	**2011**
Low	0.76	1.38
Medium	1.22	2.26
High	1.69	3.82

Table 2.2 - WP10 - Potential Daily and Hourly Cable Car Ridership (One-Way)

Period	Scenario	2001	2006	2011
Average Day	Low	2,100	2,800	3,800
	Medium	3,300	4,600	6,200
	High	4,600	7,200	10,500
Peak Day	Low	7,400	10,000	13,400
	Medium	11,900	16,500	22,100
	High	16,500	25,500	37,200
Average Day Peak Hour	Low	300	400	600
	Medium	700	900	1,200
	High	1,200	1,800	2,600
Peak Day Peak Hour	Low	1,100	1,500	2,000
	Medium	2,400	3,300	4,400
	High	4,100	6,400	9,300

2.3.2 These forecasts were based on the following critical assumptions:

- Total number of residents in Hong Kong;
- Total number of tourists to Hong Kong;
- Percentage of residents visiting Ngong Ping;
- Percentage of tourists visiting Ngong Ping;
- Percentage of tourists and residents using the cable car to travel to Ngong Ping.

2.3.3 The review of the WP10 forecasting methodology has shown that the model has a clear, logical structure. However, the review of the WP10 model indicated three areas of concern:

- The model required updating with new population and tourism forecasts through to 2016;
- The mode split levels between Mui Wo and Tung Chung were reviewed in the light of the introduction of the TCL;
- The patronage and revenue forecasts did not include patronage from Airport transit passengers.

2.3.4 The scenarios used in the WP10 model have also been adapted to better represent the likely demand to visit Ngong Ping and to use the cable car as follows:

- **Low Scenario:**
  - Continuation of existing trends in terms of an even percentage of visitors to Ngong Ping;
- **Medium Scenario**:
  - More visitation due to better accessibility to Ngong Ping through the development of the cable car;
  - Additional demand derived from attractions planned for Ngong Ping;
  - A station located near the airport to attract transit passengers for trips to Ngong Ping;
- **High Scenario:**
  - Aggressive marketing of Ngong Ping and the cable car;
  - Additional development at Ngong Ping (compared to the Medium scenario).

2.3.5 Of these scenarios the Medium case best represents the expected development at Ngong Ping and future growth in population and tourism. Hence the Medium Scenario is used for further detailed development in this study to derive the demand and revenue forecasts. The Low and High scenarios merely show sensitivity to different growth and planning scenarios.

2.4 Demand Models and Patronage Forecasts

The methodology applied in the WP10 study was used to calculate new forecasts for demand based on updated knowledge of the operating environment, changes in population and tourism figures to Hong Kong, etc. These issues are discussed in the following modelling sections.

2.4.1 Tourists to Hong Kong and Tourists Visiting Ngong Ping

2.4.1.1 Tourist levels to Hong Kong have fallen significantly since the Handover and also due to the economic downturn in Asia. Table 2.3 shows the updated levels and forecasts for tourists to Hong Kong in comparison with those used in WP10.

Table 2.3 Tourist Forecasts to Hong Kong (Millions)

Year	**WP10**	**HKTA Forecasts**		
	Medium	**Low (25% Lower Forecast Growth)**	**Medium**	**High (25% Higher Forecast Growth)**
1998		-	**9.57***	-
1999		-	**9.9**	-
2001	12.2	10.6	**10.8**	11.0
2006	-	12.1	**12.9**	13.7
2011	18.0	13.7	**15.1**	16.6
2016	-	15.2	**17.3**	19.7

***** Actual figures

2.4.1.2 The Medium figures show Hong Kong Tourist Association (HKTA) forecasts. These December 1998 forecasts are based on the following HKTA methodology:

- Regression analysis of historical visitor arrivals to Hong Kong from individual markets was conducted by the Research Department HKTA to form the basis of the forecast;
- Based on the information above, consultations were conducted with all HKTA offices and representatives from various sectors of the Hong Kong travel and tourism industry;
- Results are adjusted taking into account input and feedback from industry members in Hong Kong and overseas. Specifically, the following factors are included:
  - Currency fluctuations, e.g. currency turmoil in regional markets and depreciated currencies;
  - The economic and political situation of visitor generating countries;
  - Competition from regional destinations and the rise of new destinations/hubs;
  - Changes in air seat capacity between Hong Kong/Mainland China and visitor generating countries;
  - Impact of the opening of the new Hong Kong International Airport;
- Forecast figures include visitor arrivals by all modes of transport;
- Unknown factors such as special promotional offers by industry members and changes in prices are not taken into account.

2.4.1.3 The low and high scenarios show +/-25% growth on that forecast by HKTA. The new forecasts show significantly fewer tourists to Hong Kong; 1 to 2 millions less in 2001 and 3 millions less in 2011 than the WP10 forecasts.

2.4.1.4 The assumptions for the percentage of tourists visiting Ngong Ping are based on:

- The previous data from WP10, where 7% of tourists visited Ngong Ping in 1997;
- Updated figures including the impacts of the opening of the MTR TCL, from:

- 1998 New Lantau Bus Co. franchised bus usage on Route 23 (Tung Chung to Ngong Ping) and Route 2 (Mui Wo to Ngong Ping);
- Annual passengers on the non-franchised Kwoon Chung services between Tung Chung and Ngong Ping in 1998.

Table 2.4 Annual Bus Ridership to Ngong Ping 1998

Route	Passenger Volume	Percentage by Entry Point
NLB Route 2 Mui Wo – Ngong Ping	871,534	34% via Mui Wo
NLB Route 23 Tung Chung – Ngong Ping	1,323,827	66% via Tung Chung
Kwoon Chung Tung Chung – Ngong Ping (approx.)	360,000	
Total Bus Passenger Volume	2,555,361	100%

2.4.1.5 Assuming that all bus passengers make a return journey the annual number of visitors to Ngong Ping in 1998 was approximately 1.3 million. The figures are similar to those noted in 1997 in the WP10 study. Assuming a similar split between tourists and residents the approximate percentage of each in 1998 is:

- 6% of tourists visiting Ngong Ping;
- 10% of residents visiting Ngong Ping.

2.4.1.6 The assumed percentages for tourist visitors are shown in Table 2.5. The Medium scenario shows the introduction of the cable car and the increase in accessibility of Ngong Ping as a one off event. The model reflects this in an increase from approximately 7% visitation in 1997 to 11% in 2001. It is believed that in the Medium scenario this percentage can be sustained over time as Ngong Ping and the cable car will be new experiences for most tourists to Hong Kong.

Table 2.5 Estimates of Tourists Visiting Ngong Ping

Year	WP10	Scenario		
	Medium	Low	Medium	High
1997(Actual)	7%	-	**7%**	-
1998 (Observed)			**6%**	
2001	10%	9%	**11%**	11%
2006	-	9%	**11%**	12%
2011	12%	9%	**11%**	13%
2016	-	9%	**11%**	14%

2.4.2 Residents in Hong Kong and Residents Visiting Ngong Ping

2.4.2.1 The WP10 model assumes 6.6 million population in 2001 and 8.1 million in 2006. The population forecasts included in the updated model are from the Territorial Development Strategy Review, Scenario 2 (TDS2) assumptions on population recently announced by the Planning Department. These recent forecasts of population in Hong Kong suggest that growth is more rapid than previously suggested.

Table 2.6 Hong Kong Population Forecasts (Millions)

Year	WP10	TDS2 Forecasts
1997 (Actual)	6.5	-
1998 (Actual)	-	6.7
2001	6.6	7.0
2006	-	7.7
2011	8.1	8.3
2016	-	8.9

2.4.2.2 The estimates of residents visiting Ngong Ping in the WP10 Report have been revised to assume a relatively even spread of visits to Ngong Ping throughout the year. This yields a visitation rate of 11% of the population in 1997. Figures for 1998 based on bus usage suggest an approximate resident visitation of 10% of the population (Para. 2.4.1.5). Table 2.7 shows the forecast percentage for each scenario compared to WP10. In the Medium scenario, a growth in resident visitor numbers in the first years of operation has been assumed, i.e. to 14% in 2001. However, a decline in visitation in future years is considered to allow for a lessening in attractiveness to residents over time.

Table 2.7 Estimates of Residents Visiting Ngong Ping

Year	**WP10**	**Scenario**		
	Medium	**Low**	**Medium**	**High**
1997 (Actual)	11%	-	**11%**	-
1998 (Observed)			**10%**	
2001	13%	11%	**14%**	15%
2006	-	11%	**13%**	15%
2011	13%	11%	**12%**	15%
2016	-	11%	**11%**	15%

2.4.3 Tourists and Residents Using the Cable Car

2.4.3.1 The WP10 model assumptions of entry point to Ngong Ping in 2001 are shown in Table 2.8.

Table 2.8 Entry Point to Ngong Ping – WP10 Assumptions

Year	**Group**	**Arriving Via**	**% Arriving Via**		
			Low	**Medium**	**High**
2001	Tourists	Tung Chung	35%	**40%**	50%
		Mui Wo	65%	**60%**	50%
	Residents	Tung Chung	45%	**50%**	60%
		Mui Wo	55%	**50%**	40%

2.4.3.2 These assumptions were based on data previous to the opening of the MTRC TCL. 1998 patronage levels on the buses between Tung Chung/Mui Wo and Ngong Ping suggest that with the opening of the TCL and the Lantau Fixed Link far more people are travelling to Ngong Ping via Tung Chung – i.e. approximately 66% via Tung Chung and 34% via Mui Wo overall (Table 2.4).

2.4.3.3 This study has therefore made the assumptions in Table 2.9 regarding point of entry. Return trips are assumed to have a similar distribution.

Table 2.9 Point of Entry and Modal Split Assumptions for Cable Car Patronage

Group	**Arriving Via**	**% Arriving Via**	**Of those, % Using Cable Car**		
Years 2001-2016		**Medium**	**Low**	**Med**	**High**
Tourists	Tung Chung	**60%**	75%	**80%**	90%
	Mui Wo	**40%**	50%	**60%**	70%
Residents	Tung Chung	**70%**	75%	**80%**	90%
	Mui Wo	**30%**	50%	**60%**	70%

2.4.3.4 The cable car usage rates are similar to those used in the WP10 study – developed from the original survey of Ngong Ping visitors carried out in 1997. They are also similar to the MTRC cross-harbour market shares of approximately 70%. The cable car is very competitive with the bus routes to Ngong Ping in terms of journey time, comfort and the leisure impact of a good view of the Airport and surrounding area. The cable car market share is forecast at approximately 73% (excluding airport transit passengers) for all the forecast years.

2.4.4 Airport Transit Passengers who may use the cable car

2.4.4.1 A station at the Airport Island will allow air passengers who are in transit to visit the Giant Buddha. There is already one tour running for transit passengers from the airport. Cathay Pacific and HKTA run a tour for transit passengers costing HK$120, including a return trip by the MTRC Airport Express. The trip calls at:

- Wong Tai Sin Temple
- Kowloon City Park
- Tsim Sha Tsui New World Centre

The service runs between 9.15 a.m. and 1.45 p.m., every 45 minutes (7 per day). Users of this service have to exit the airport through immigration and pay the HK$50 Airport Tax on returning to the airport. The patronage for this service is shown in Table 2.10. The demand for this transit tour is approximately 20-50 people per day.

Table 2.10 Hong Kong Transit Tour Usage

Month /1998	**Patronage per Month**
August	488
September	241
October	588
November	681
December	1,539

2.4.4.2 Evidence from Singapore Changi Airport shows that they formerly ran a free "Sightseeing Tour" for transit passengers that had a capacity for 450 passengers per day, or 50 per hour between 10 a.m. and 6 p.m.

2.4.4.3 The Hong Kong Airport Authority (HKAA) state that they have on average 80,000-90,000 passengers per day using the airport, of which approximately 25% (20,000) are believed to be in transit. A survey was then conducted and about 25% of passengers were found to be in transit for 5 hours plus. Approximately half of them were visiting Hong Kong for the first time. If the cable car is priced at HK$50, 65% of the respondents said that they would ride the cable car after considering the time required and the airport tax. It is expected that one fourth of them will actually ride the cable car after deducting factors of over-stating, weather conditions, operating hours and survey error. The cable car patronage made by Airport transit passengers in 2001 is conservatively estimated in Table 2.11 and it is worth noting that the HK$50 airport tax is exempted in the 1999 budget for same day transit passengers which would help to generate more day-tour trips if such exemption is continued.

Table 2.11 Cable Car Usage by Airport Transit Passengers

Scenario	**Medium**	**%**
Total Transit Passengers	20,000	-
Passengers in Transit 5 hours plus	5,400	27%
Passengers in Hong Kong for First Time	2,800	52%
Intention to Ride Cable Car @HK$55	1,700	62%*
Actual Ridership	400	25%

** Interpolated Figure*

2.4.4.4 If it is assumed that the growth in total tourist numbers (Medium scenario Table 2.3) can be applied to both Hong Kong airport arrivals and transit passengers, this provides the forecast as shown in Table 2.12.

Table 2.12 Annual Cable Car Usage by Airport Transit Passengers

Medium Scenario	2001	2006	2011	2016
Daily	400	480	560	640
Annual	146,000	175,000	204,000	234,000

2.4.5 Total Annual Visitors to Ngong Ping and Annual Cable Car Patronage

2.4.5.1 The forecast annual visitors to Ngong Ping from the updated model are shown in Table 2.13.

Table 2.13 Forecast Annual Visitors to Ngong Ping (Millions)

Scenario	2001	2006	2011	2016
Low	1.8	2.1	2.3	2.5
Medium	**2.3**	**2.6**	**2.9**	**3.1**
High	2.5	3.0	3.7	4.4

2.4.5.2 These forecasts compare with approximately 1.3 million visitors to Ngong Ping in 1998. Hence the Medium forecasts represent an approximate doubling of visitors by 2006 but a slower growth in visitors to 2016. This growth in numbers is due to population and tourism growth, increased accessibility and the development of visitor facilities at Ngong Ping. These levels of visitor numbers are comparable with other attractions in Hong Kong, e.g. the Peak Tram carried approximately 3.3 million people in 1998, Ocean Park had approximately 3 million visitors per year (excluding the Water-world). The forecasts will place the Giant Buddha and cable car as a major attraction in Hong Kong, of similar status as the Peak and Ocean Park.

2.4.5.3 The forecast annual cable car patronage based on the assumptions described in the previous sections is shown in Table 2.14.

Table 2.14 Annual Cable Car Patronage Estimates (Millions)

Scenario	2001	2006	2011	2016
Low	1.2	1.4	1.5	1.7
Medium	**1.7**	**1.9**	**2.1**	**2.3**
High	2.1	2.6	3.0	3.5
WP10 Forecast (Medium)	1.22	-	2.26	-

2.4.6 Daily and Hourly Patronage

2.4.6.1 Estimates of daily and hourly trends in patronage follow the previous WP10 methodology. The Peak Day for tourist and resident visitors is assumed to be approximately 3.6 times the average day. Peak arrivals are approximately 15-20% of daily flows. The high patronage forecast on peak days is expected to flatten out the 1997 peak of 25-30% of daily flows in future years. Transit traveller's trips have been added into the average and peak all day flows, but are not expected to significantly affect peak hour flows.

2.4.6.2 The forecast one-way daily and hourly patronage for average and peak days is shown in Table 2.15. As in the WP10 report average day flows represent typical weekdays. Peak day flows represent Sundays and Public Holidays.

Table 2.15 Daily and Hourly Patronage Estimates

Period	Scenario	2001	2006	2011	2016
Average Day	Low	3,300	3,800	4,200	4,600
	Medium	**4,700**	**5,300**	**5,900**	**6,400**
	High	5,700	7,000	8,100	9,600
Peak Day	Low	11,900	13,600	15,100	16,500
	Medium	**17,000**	**19,100**	**21,100**	**23,000**
	High	20,400	25,300	29,200	34,800
Average Day Peak Hour	Low	500	600	600	600
	Medium	**950**	**1,100**	**1,200**	**1,300**
	High	1,400	1,700	2,000	2,400
Peak Day Peak Hour	Low	1,700	1,900	2,100	2,300
	Medium	**3,200**	**3,600**	**3,900**	**4,300**
	High	4,800	5,900	6,800	8,100

2.4.6.3 The Medium forecast is based on the most likely future scenario of:

- Population growth and visitation;
- Tourism growth and visitation;
- Transit passenger growth and visitation;
- Development of the cable car;
- Developments at Tung Chung and Ngong Ping.

Hence, these should be used when planning the capacity of the cable car system and calculating system revenue.

2.4.6.4 The Medium peak day figures show a peak hour requirement for 3,600 cable car passengers in 2006 and 4,300 passengers in 2016. Such high patronage figures will have a major impact on the selection of the cable car system.

2.5 Capacity and Design Implications

2.5.1 The Medium scenario forecasts for the capacity of the system design are based on the peak hour flows, as shown in Table 2.16. The capacity requirements show a need for a system that can carry up to 3,600 passengers per hour on peak days in the first 5 years of the design life of the system and for the following 10 years up to 4,300 passengers per hour. It is not necessary that the system carries all of this peak day peak hour patronage – pricing and some queuing can control it. However, as noted in WP10 if the system has significantly less capacity, ridership and revenue will be affected as there is no capacity to relieve demand. Trips will not be made or will be diverted to other modes.

Table 2.16 Capacity Requirements for cable car

Period	2001	2006	2011	2016
Average Day Peak Hour	950	1,100	1,200	1,300
Peak Day Peak Hour	3,200	3,600	3,900	4,300

2.5.2 To cater for the arrival of passengers in groups and to make provision for the fluctuation of arrivals within the peak hour, 15% additional capacity (equivalent of 5,000 passengers per hour) is allowed for the design capacity of the cable car in 2016.

2.6 Impact On Other Modes during Service Suspension

2.6.1 The preferred cable car system (either '3S' or 'Funitel') has good proven records of reliability under hard weather conditions even uphill in alps region. The assessment for impacts on the other modes during service suspension at rare occasions is only for contingency purpose. Its requirement of emergency buses is in anyway not necessarily a pre-requisite of the cable car operation. The impact of unavailability is much less critical for the non-peak days.

2.6.2 Table 2.17 shows the patronage expected on average and peak days, and the bus departures required to deal with this level of traffic should the cable car be non-operational. The assessment is based on the following assumptions:

- Capacity of buses is limited to 60 per bus;
- If the system is closed for a full day warning will be given via the media, therefore only 50% of passengers would attempt the trip;
- If the system is closed due to bad weather or emergency during operation – all visitors to Ngong Ping will have to return by bus. The average number at Ngong Ping at any one time is assumed to be 40% of daily patronage.

Table 2.17 Bus Departures Required if Cable Car Non-Operating

Year	Average Day Cable Car Patronage	Peak Day Cable Car Patronage	Average Day - Whole Day Suspension	Average Day – Bad Weather/ Emergency	Peak Day – Whole Day Suspension	Peak Day – Bad Weather/ Emergency
2006	5,300 (Peak Hour 1,100)	19,100 (Peak Hour 3,600)	44 buses per day (9 buses in the peak hour)	35 bus loads of Cable Car passengers at Ngong Ping at any one time	159 buses per day (30 buses in the peak hour)	128 bus loads of Cable Car passengers at Ngong Ping at any one time
2016	6,400 (Peak Hour 1,300)	23,000 (Peak Hour 4,300)	53 buses per day (11 buses in the peak hour)	43 bus loads of Cable Car passengers at Ngong Ping at any one time	192 buses per day (36 buses in the peak hour)	154 bus loads of Cable Car passengers at Ngong Ping at any one time

2.6.3 HKTA, travel agents, the media and the Transport Department Information Service, etc. should be informed early of any planned closure of the cable car to allow agencies and individuals to make alternative arrangements. Buildings and temples at Ngong Ping can also serve as safe shelters for the passengers to stay.

3.0 INITIAL ENVIRONMENTAL IMPACT ASSESSMENT

3.1 Construction Phase Impact Assessment

An environmental assessment has been undertaken to define the nature and scale of potential environmental impacts associated with implementing the Project. Both construction and operational phase impacts have been assessed and mitigation measures recommended to reduce residual impacts to acceptable levels.

Fugitive Dust Emission

Assessment Criteria

3.1.1 The principal legislation which is relevant to air pollution from construction sites is the Air Pollution Control Ordinance (APCO) (Cap. 311). Relevant Air Quality Objectives for Total Suspended Particulates (TSP) and Respirable Suspended Particulates (RSP) extracted from Chapter 9 of the Hong Kong Planning Standards and Guidelines (HKPSG) are tabulated below in Table 3.1. For construction dust, EPD also recommends a maximum hourly level of 500µg/m^3 for TSP at nearby Air Sensitive Receivers (ASRs).

Table 3.1 Hong Kong Air Quality Objectives

Averaging Time	Pollution Concentration Level (µg/m^3)	
	TSP	**RSP**
1 hour[1]	500.0*	N.A.
24 hour[2]	260.0	180.0
Annual[3]	80.0	55.0

(1) Not to be exceeded more than three times per year.
(2) Not to be exceeded more than once per year.
(3) Arithmetic means.
N.A. Not Available
* Maximum allowable dust level recommended by EPD.

Potential Air Quality Impact

3.1.2 Construction of the proposed cable car system may cause elevations of dust levels on the surroundings and at the air sensitive receivers (ASR's) at the terminal stations, pylon sites, and the maintenance footpath along the system. To avoid using a haul road which would generate noise, dust and visual impacts, it has been recommended that construction materials should be brought to site by helicopter (see also Section 8.7). This would have a significantly reduced impact on air quality compared to the construction of a haul road, but as a consequence it would increase short-term noise impacts. The major dusty operations during the construction of the cable cars include:

- excavation and earthworks for the site formation of the pylon sites and terminal stations; and
- earthworks for the maintenance path along the cable car alignment.

3.1.3 Potentially affected ASRs during the construction phase would include the Lantau North Country Park and a few nearby village houses scattered around Ngong Ping Terminal. Depending on the timing of developing the residential developments at Tung Chung Areas 4, 71 & 72, these developments may also become ASRs of this project.

Air Quality Protection Measures

3.1.4 Fugitive dust emissions at the ASRs unlikely to be a cause for concern due to the limited extent of construction work to be carried out. Nevertheless, practicable and cost-effective dust mitigation measures are subject for the detailed EIA stage. In addition to the foregoing, the future appointed Contractor shall be required to follow the Air Pollution Control (Construction Dust) Regulation and shall adopt suitable dust suppression methods

Construction Noise Impact

Assessment Criteria

3.1.5 Construction noise within "restricted hours" (i.e. between 19:00 to 07:00 hours from Monday to Saturday and any time on public holidays) is controlled under the Noise Control Ordinance (NCO) (Cap. 400) and the relevant Technical Memoranda (TMs) issued by the Environmental Protection Department (EPD) through a Construction Noise Permit (CNP) system.

3.1.6 If construction works are carried out during the "restricted hours", a CNP must be obtained from EPD. In addition, any percussive piling work can only be carried out with a valid CNP issued by the Authority. The TMs define a variety of uses including domestic premises, hostel and place of public worship as noise sensitive receivers (NSRs).

3.1.7 Although the TMs do not provide any statutory control over construction noise during the "non-restricted hours", a limit of L_{eq}(30min) 75dB(A) is proposed for all domestic premises including temporary housing accommodation in the "Practice Note for Professional Person, PN2/93" issued by the Professional Persons Environmental Consultative Committee in June 1993. For schools, the recommended noise levels during normal school days is L_{eq}(30min) 70 dB(A) and is lowered to L_{eq} 65dB(A) during examination periods. These limit have been applied on major construction projects and is now widely accepted in Hong Kong. The same noise criteria can be found in *Table 1B Noise Standards for Daytime Construction Activities* in the gazetted Technical Memorandum on EIA Process issued under Section 16 of the EIA Ordinance which also specifies the relevant noise standards for hotels and hostels as shown in Table 3.2.

Table 3.2 Noise Standards for Daytime Construction Activities

Uses	**0700 to 1900 hours on any day not being a Sunday or general holiday, L_{eq} (30 mins) dB(A)**	**1900 to 0700 hours or any time on Sundays or general holiday**
All domestic premises including temporary housing accommodation	75	See Note (iii)
Hotels and hostels	75	
Educational institutions including kindergartens, nurseries and all others where unaided voice communication is required	70 65 (during examinations)	

Notes :

(i) The above standards apply to uses which rely on opened windows for ventilation;

(ii) The above standards shall be viewed as the maximum permissible noise levels assessed at 1m from the external facade;

(iii) The criteria laid down in the relevant technical memorandum under the Noise Control Ordinance for designated areas and construction works other than percussive piling may be used for planning purpose. A Construction Noise Permit (CNP) shall be required for the carrying out of the construction work during the period.

Source : Table 1B of Technical Memorandum on EIA Process.

3.1.8 For planning purposes, the noise standards for the control of helicopter noise are provided in Table 1A of TM-EIAO which are tabulated below in Table 3.3. Noise control regulations for helicopter noise are enforced under the Noise Control Ordinance (NCO). Relevant Noise Standards for control of helicopter noise extracted from Chapter 9 of the HKPSG are tabulated below in Table 3.3.

Table 3.3 Noise Standard for Helicopter Operation

Uses	**Helicopter Noise L_{max} dB(A) 0700 to 1900**
All domestic premises including temporary housing accommodation	85
Hotels and hostels	85
Offices	90
Educational institutions including kindergartens, nurseries and all others where unaided voice communication is required	85
Places of public worship and courts of law	85
Hospitals, clinics, convalescences and homes for the aged • diagnostic rooms • wards	85

Notes :
(i) The above standards apply to uses which rely on opened windows for ventilation;
(ii) The above standards shall be viewed as the maximum permissible noise levels assessed at 1m from the external facade.

Potential Construction Noise Impact

3.1.9 Identified noise sensitive receivers (NSRs) for the project include the scattered village houses, the Po Lin Monastery, the Youth Hostel at Ngong Ping, the future residents near the proposed temporary helipad in Area 74 including those in Areas 30/31 and depending on the timing of the population intake, those in Area 34 and Area 37. Given the discrete location for construction works for the proposed cable car system, it is anticipated that compliance with noise criteria will be able to be achieved.

3.1.10 In order to minimize the disturbance to the Country Park, it is recommended that helicopters are used to transport construction materials to most of the pylon sites inside the Country Park (see also Section 8.7). Due to the remoteness of the construction site and the flexibility of the flight path that can be chosen with aircraft safety as a prime consideration, it is not expected that this shall cause any unacceptable increase in noise level.

Noise Mitigation Measures

3.1.11 Noise mitigation measures which may be considered appropriate for this Assignment include:

- Application of properly designed silencers, mufflers, acoustically dampened panels and acoustic sheds or shields, etc. (especially at Ngong Ping);
- Use of electric-powered equipment where applicable instead of diesel-powered or pneumatic-powered equipment;
- Erection of noise enclosures around noisy plants if required;
- Location of noise emitting plants at maximum possible distances from sensitive receivers;
- Inclusion of conditions of Contract for environmental protection during construction;
- Restricting the use of noisy operations during non-restricted hours; and
- Regular maintenance of site plant/ equipment.

3.1.12 With the implementation of appropriate noise mitigation measures, it is envisaged that the potential construction noise impact can be substantially minimised. Details of the noise mitigation measures shall be formulated based on the conclusions of the detailed EIA study to be carried out at the next stage of the project. The effectiveness and continuous implementation of the noise mitigation measures will be checked by a noise monitoring and audit programme which will aim to protect nearby NSRs through the provision of regular feedback to the site contractors.

Construction Water Quality Impact

Relevant Legislation

3.1.13 The Water Pollution Control Ordinance (WPCO) (Cap. 358) enacted in 1980 is the principal legislation controlling water quality in Hong Kong. Under the WPCO, Hong Kong waters are classified into 10 Water Control Zones (WCZs). Statutory Water Quality Objectives (WQOs) are specified for each WCZ. Discharge of effluents within a declared WCZ must be licensed. For inland waters, there are also selected WQOs specified for parameters for various WCZs or sub-zones.

3.1.14 The Technical Memorandum (TM), "Standards for Effluent Discharge into Drainage and Sewerage Systems, Inland and Coastal Waters", issued under Section 21 of the WPCO defines acceptable effluent discharge limits to different types of receiving waters. With regard to inland waters, there is no distinction between different zones and the beneficial use of the inland waters is the only factor governing the quality and quantity of the effluent that should be met. Under the TM, inland waters are classified into four groups. These are given below in Table 3.4.

Table 3.4 Different Groups of Inland Water specified in the TM

Inland water grouping	Beneficial use
Group A	abstraction for potable water supply
Group B	Irrigation
Group C	pond fish culture
Group D	general amenity and secondary contact recreation

As the Ngong Ping Terminal is within the water gathering ground of Shek Pik Reservoir, any effluent discharged from the terminal to the existing stream course must be pre-treated to comply with the relevant discharge standards for Group A inland waters as stipulated in the TM.

Potential Water Quality Impact

3.1.15 Potential impacts on water quality from construction activities include:

(a) excavated spoil and general waste arisings may be temporarily stockpiled which, along with the storage of cement, fuels and other materials on site, could result in erosion during periods of rainfall and contaminated runoff from the site;

(b) contamination of surface water with sediments, organic materials, or bentonite slurries or other grouting materials;

(c) general construction activities including diversion of water courses;

(d) sewage from the construction workers; and

(e) possible construction phase water quality impacts on the San Tau SSSI arising from, for example, marine plant assisting in cable stringing.

Environmental Protection Measures

3.1.16 Good site management practice should ensure that construction impacts on water quality are kept to a minimum. Prevention of surface water contamination during construction involves two basic elements:

(a) minimising the quantity of water which might become contaminated by high levels of suspended solids (silt) off exposed and disturbed ground surfaces; and

(b) collection and treatment of potentially contaminated water to appropriate standards.

3.1.17 The potential for water quality impacts can be mitigated by the following possible means:

(a) use of bunds round any temporary stockpiled material to prevent washout into the water course;

(b) all stock-piled areas over $50m^3$ should be covered e.g. by tarpaulin, and intercepting drains should be provided to prevent storm runoff from washing across exposed soil surface or stockpiled area;

(c) where possible, surface excavation work should be scheduled for the dry season;

(d) areas of excavation should be minimised and exposed surfaces stabilised appropriately by covering with aggregate, hydroseeding, etc;

(e) all appropriate stormwater runoff from the study area during construction should be routed through oil/grit separator and/or sediment basin/trap before discharging to the nearby receiving waters;

(f) compounds in the works area should be designed to take account of contaminated surface water. Oil and fuel bunkers, which should be locked and sited on sealed areas, should be enclosed by bunds capable of holding 110% of the bunker capacity in order to prevent discharges due to accidental spillages or breaching of tanks;

(g) where there is the potential for leakage of oil from construction plant or equipment, sawdust or other absorbent material should be available in the vicinity. These clean up materials should be replaced with fresh material on a regular basis. Any polluted materials should be disposed of in an acceptable manner;

(h) all appropriate measures should be adopted to avoid solid materials, litter or wastes being deposited in surface waters;

(i) all personnel on site should be required to use proper sanitary facilities;

(j) all sewage discharges from the study area have to meet the TM Standards and approval from EPD through their licensing process is required;

(k) use of precast concrete rather than cast in-situ concrete; and

(l) all storm catch basins/inlets, if any, receiving storm runoff from construction areas could be covered with wire mesh filter on top of which should be placed with crushed stone on top in order to prevent sediment from entering the inlet structure and to reduce potential sediment loading to the receiving waters. In addition, the EPD's ProPECC P/N 1/94 Construction Site Drainage will be followed closely during construction and appropriate clauses, such as the EPD's, PPCC, for additional information on best management practices during construction will be included into the construction contract.

A more detailed study of water impacts is a subject for the detailed EIA.

Construction Waste Management

Legislation and Guidelines

3.1.18 The principal legislation controlling waste materials in Hong Kong is the Waste Disposal Ordinance (WDO) (Cap. 354) and its subsidiary regulations.

Waste Management Strategy

3.1.19 The general waste management strategy is to avoid waste generation in the first place. If that is unavoidable, source reduction and segregation should be exercised as far as practicable and at the same time, recycling and reuse should be adopted to salvage as much as possible all the recyclable and reusable materials.

Construction Waste Impact

3.1.20 Construction activities for the proposed cable car development will generate waste material requiring appropriate management and disposal. Likely range of waste types include:

- excavated spoil;
- wood from formwork;
- materials and equipment wrappings;
- cleaning, coating and painting wastes; and
- refuse generated by the workforce.

Environmental Protection Measures

3.1.21 On-site sorting of construction wastes will be recommended. Primary on-site sorting can be achieved by avoiding the generation of “mixed waste” through good site control.

3.1.22 Chemical and oily wastes generated from the construction activities, vehicle and plant maintenance and oil interceptors shall be disposed of as chemical waste in strict compliance with the Waste Disposal (Chemical Waste) (General) Regulations.

3.2 Operation Phase Impact Assessment

Air Quality

Assessment Criteria

3.2.1 The principal air pollution legislation in Hong Kong is the Air Pollution Control Ordinance (APCO) (Cap. 311). There are various subsidiary legislation that are made under the APCO to deal with specific types of air pollution. To safeguard the health and well-being of the population, Air Quality Objectives (AQOs) have been specified for various criteria pollutants in Chapter 9 of the Hong Kong Planning Standards and Guidelines (HKPSG). The AQOs of those air pollutants which are considered relevant to the potential operation phase air quality impact are provided in Table 3.5.

Table 3.5 Hong Kong Air Quality Objectives

Pollutant	Averaging Time Pollutants Concentration (μg/m^3)			
	1 hour (i)	8 hours (ii)	24 hours (ii)	1 year (iii)
SO_2	800	N.A	350	80
CO	30,000	10,000	N.A.	N.A.
NO_2	300	N.A.	150	80
TSP	N.A	N.A	260	80
RSP	N.A.	N.A.	180	55

(i) Not to be exceeded more than 3 times per year
(ii) Not to be exceeded more than once per year
(iii) Arithmetic means
N.B. Concentrations are to be measured at 298 K and 101.325 kPa (one atmospheric pressure)

Potential Air Quality Impact

3.2.2 The cable car system is situated in a rural area with limited sources of air pollution. Although EPD does not operate any routine air quality monitoring stations in the vicinity of the study area, in the absence of any major air pollution sources, the existing air quality within or in the vicinity of the subject site is expected to be good.

3.2.3 During operation of the proposed cable car system, no significant aerial emissions will be produced. It may thus be concluded that following construction, air quality is not expected to be a cause for concern.

Operational Noise Consideration

Assessment Criteria

3.2.4 Noise standards are presented in the Noise Control Ordinance and its subsiding Technical Memorandum for assessment against possible noise impact from industrial operation sources. With no Influencing Factor (IF) in the vicinity of the cable car alignment, any noise sensitive receivers in the vicinity of the cable car system shall be classified as Area Sensitivity Rating “A”. For planning purposes, the noise standards for faxed noise sources are stipulated in Table 1A of TM-EMIO. The planning standards are 5dB(A) below the appropriate Acceptable Noise Levels (ANL) as shown in Table 3.6 or the prevailing background noise levels (for quiet areas with levels 5dB(A) below ANL). The ANL for the NSRs is presented in Table 3.6.

Table 3.6 Acceptable Noise Level at the Noise Sensitive Receivers

Time Period	Acceptable Noise Level*
All days during the evening (1900 to 2300 hours), and general holidays (including Sundays) during the day-time and evening (0700 to 2300 hours)	60 dB(A)
All days during the night-time (2300-0700)	50 dB(A)

Potential Noise Impacts and Mitigation Measures

3.2.5 Designated land uses within the alignment of the cable car system site that are classified as noise sensitive receivers (NSRs) include the residential development in Tung Chung Areas 4, 71& 72, the scattered village houses and Youth Hostel at Ngong Ping and the Po Lin Monastery.

3.2.6 Industrial noise from the cable car will be generated from the following sources:

(a) Mechanical Equipment at the End Terminal Stations

Mechanical equipment will be installed at the end and at the intermediate station of the cable car system. Items of mechanical equipment will be fully enclosed within the building structure. If necessary, noise abatement equipment could be provided at openings for equipment ventilation to reduce noise transmission.

(b) Cable Car passing Through Pylon Sites

Discrete noise impacts, “wheel chatter” or “clamp shock”, will be generated from the cable car runners passing over the pylons. This noise generated by the operation of the cable car system is unavoidable in the Funitel system. However, with the 3S and Bi-cable systems, there will be no such noise as the grips are not required to force through the sheaves on the pylons.

As part of the EIA a detailed noise impact assessment will be carried at the detailed design stage of the project. The EIA shall address the potential noise impact of the cable car system and determine the most practicable mitigation measures to be incorporated into the design to ensure residual noise levels comply with the standards set in NCO.

On-site Measurement and Assessment

3.2.7 A site survey was carried out and noise readings taken at Ocean Park on 30th September 1998. Although the cable car system used for the proposed project will not be the same as that in Ocean Park (which is a monocable system), the data still provide an indicative of noise levels.

3.2.8 Noise measurements for the operation of the cable car system were taken from within and outside the terminal, as well as inside the car compartment. The measurement was taken by using Brüel & Kjær Precision Integration Sound Level Meter Type 2236. The instrument had been calibrated immediately prior to and following each measurement by B&K Sound Level Calibrator Type 4231. Measurements shall only be considered as valid if the calibration levels before and after the noise measurement agree to within 1dB(A).

3.2.9 According to observations, the power motors were identified as the major noise source of the cable car operation. As the motors are only located at the north terminal, the south terminal is not subject to any motor operational noise impact. The measured results are tabulated in Table 3.7.

Table 3.7 Measure noise level at the Ocean Park Cable Car System

Location of measurement	**Noise Level (dB(A))**
10m outside north terminal	67
10m outside south terminal	55
Inside repair house (under terminal)	79
Inside cabin while travelling	53-67
Inside north terminal	85

3.2.10 The cable car terminal in Ocean Park is not located in the vicinity of any identified NSR, and therefore neither the terminal nor motors are enclosed or sound insulated. Measurement results shows that the noise impact from the operation of a cable car system will generate acceptable noise levels (in the order of around 55dB) and further improvement can be made by housing the motors inside concrete buildings.

Water Quality

Relevant Legislation

3.2.11 The legislation given under Section 3.1.13 is also applicable to potential adverse water quality impact during the operation phase of the cable car system.

Potential Water Quality Impact

3.2.12 As the operation of the system per se will not generate liquid wastes it may be surmised that there will be minimal impact on receiving water systems. The wastewater arising associated with the maintenance of the system, the washing of the cabins/gondolas, and the domestic effluent generated by passengers patronising the system will all need to be considered and appropriate collection, treatment and disposal options prepared in accordance with the requirements of the TM.

Solid Waste Management

Legislation and Guidelines and Waste Management Strategy

3.2.13 Relevant legislation and guidelines as well as waste management strategy discussed under Section 8.1.4.1 are also applicable to solid waste management consideration during the operation phase. In addition, *Waste Disposal (Chemical Waste) (General) Regulation*, provides guidance for all aspects of chemical waste disposal including; storage, collection, transport, treatment, and final disposal generated from the cable car system.

Solid Waste Disposal

3.2.14 During the operation of the proposed cable car system, the bulk of waste arising will consist of domestic and commercial refuse. Most of these, such as aluminium, glass, ferrous metals can be recycled or reused which shall be planned and implemented by the management of the cable car system. The remaining waste materials shall be properly delivered by trucks to the Mui Wo RTS which has a capacity of 65 tonnes/ day for municipal solid waste. Based on current practice, the municipal waste is to be containerised and transported to WENT landfill via self-propelled marine vessels from the Mui Wo RTS.

3.2.15 Used lubricating oil and hydraulic oil will be generated from various operational process of the cable car system, and the operator will be registered with the Environmental Protection Department as a chemical waste producer.

Archaeological and Cultural Heritage Impact

3.2.16 If necessary, an historical, archaeological and culture heritage impact study will be carried out during the detailed design stage of the project to address the potential impacts along the alignment of the cable car system.

3.2.17 A desk top study had been conducted at this preliminary stage to identify some potential area of archaeological or cultural interest in the vicinity of the subject site. By searching through the records from the Archaeology and Monument Office (AMO), four declared and listed monuments and two known archaeological site were identified within the study area as indicated in Figure 3.1.

- The Tung Chung Fort, located to the south of the Tung Chung town, is a declared monument. Although it has a date of 1832 on the stone lintel above the entrance, it is mentioned in records as early as 1817. The fort is described in Chinese records as military administrative centre and has strategic significance.

- Tung Chung Battery is another declared monument in the area, which is located to the south west of the proposed Tung Chung cable car terminus. The Battery is believed to be contemporary with Tung Chung Fort, although, not yet excavated, its exact age has not been established. The Battery is the only known surviving structure of its kind.

- The Tung Chung Rock Carving is identified and taken up in AMO's record. The carving found to the south-east of Tung Chung represents a game board, which has been carved on a horizontal rock face. The rock carving probably dates to the historic period.

- A Grade II Listed Building, Hau Wong Temple, sits at the south-western corner of Tung Chung. The Temple was constructed in 1730 and is the community temple of the ancient indigenous community of Tung Chung. The Temple stands at the centre of one of the most complex Fung Shui system of the New Territories.

- Sha Tsui Tau is a known archaeological site in the area. This site has yielded prehistoric coarse and hard geometric ware along with T'ang and Song Dynasty glazed stone ware. The site also contains a historic lime kiln.

- Ma Wan Chung is a recently excavated site, which revealed a large quantities of Song, T'ang and Ming porcelain.

3.2.18 Findings in the Tung Chung valley as a whole have shown that there is a likelihood of prehistoric deposits from the Late Neolithic Period (2900-1500 BC) and from the Song, T'ang, and Q'ing Dynasties. Material from these periods exist in the form of standing Q'ing monuments (Tung Chung Fort and Battery and the Hau Wong Temple) and excavated sites at Ma Wan Chung and Sha Tsui Tau, both of which have deposits from all four periods.

3.2.19 No site with archaeology or cultural interest has been identified in Ngong Ping or along the cable car alignment within the Country Park. It is concluded that these areas are of less archaeological and cultural value than Tung Chung. Upon confirmation of the car alignment, an initial archaeological study shall be conducted for the Tung Chung site. If the selected route option impacts on an area defined as having archaeological potential by the initial assessment, mitigation measures will be recommended including the following:

- Field evaluation of the area; this would consist of systematic field walking, auger testing and test pit excavation.
- If a site is found, the AMO may require it to be fully excavated if it cannot be preserved by alignment alterations.
- Excavation should be carried out by the AMO itself or by the archaeological consultant.

3.3 Ecological Impact Considerations

Review of existing information

3.3.1 Two preliminary ecological impact assessments were prepared by CES Asia Ltd (1996)[1] and Ecosystems Ltd (1997)[2] for proposed resort developments at Ngong Ping on private land lots adjacent to the Po Lin Monastery. These documents summarise existing flora and fauna records available for the Ngong Ping area; predict and evaluate impacts and provide mitigation measures to offset any predicted adverse ecological impacts.

3.3.2 The ecological impacts of the proposed reclaimed island as part of the Tung Chung New Town adjacent to the San Tau Beach Site of Special Scientific Interest (SSSI) have already been investigated as part of the North Lantau Development Study.

3.3.3 The rest of the area traversed by the proposed cable car alignment has not been studied in detail, though some information exists for the Ngong Ping plateau and the area around the San Tau Beach SSSI.

Habitat Survey and Mapping

3.3.4 For the purposes of this initial EPA, a survey area has been defined covering a corridor of approximately 1000 meters wide as shown in Figure 3.2. Recent and historical aerial photographs have been checked and vegetation categories have been mapped in the field. A preliminary habitat map for the whole survey area plus more detailed maps of the two termini have been drawn up as shown in Figure 3.2 to Figure 3.4.

Presence of Rare or Protected Species

3.3.5 Where already known, the locations of rare or protected species, including Romer’s Tree Frogs, have been noted and shown in Figure 3.2. These are all located to the east of Po Lin Monastery at Ngong Ping centred around the unpolluted stream and the mixed habitats surrounding it. The stream on the west of the Monastery is highly polluted and sampling in 1997 proved it to be of very limited ecological importance.

3.3.6 It is possible that rare or protected invertebrate and/or fish species could be present in the rocky stream beds which flow off Nei Lak Shan through a deep valley and out into the sea at San Tau. This supposition is based on preliminary field observations (site inspections) conducted by the Consultant during October 1998 and on the previous findings in adjacent similar rivers in North Lantau and needs to be confirmed during the detailed EIA. The actual impact is not confirmed until the final alignment is established and checked by field survey conducted for the detailed EIA.

Evaluation of Habitats

3.3.7 Ten different habitat types have been identified as occurring within the survey area. Habitat distribution are shown in Figure 3.3. The mangrove habitat located in the intertidal zone near San Tau village is considered to be of the highest ecological importance and is designated as a SSSI. Of the remaining areas, the secondary natural woodland, stream, river valleys and associated riparian habitats, abandoned agricultural land and tall scrub habitats are all considered to be of moderate to high ecological importance. They are generally of good species diversity and a semi-natural character, though none can be considered as ancient,

[1] Stage I Environmental Impact Assessment Report - Ecology Section for Proposed Resort Development at Ngong Ping,Lantau Island by CES (Asia) Limited. (1996)
[2] Project Profile - Ecological Section for Proposed Resort Development at Ngong Ping, Lantau Island by Ecosystem Limited. (1997).

natural, irreplaceable habitats. Most of the woodland is relatively recent in origin. Regular hill fires combined with poor soils, maintain a high proportion of the upland areas as grassland and low scrub. Much of the proposed cable car alignment is likely to pass through this fire-maintained grassland and low scrub which is of limited value to wildlife. The natural habitat at Ngong Ping near location Y supports a large population of Romer's Tree Frogs. Detailed description will be considered the detailed EIA when the cable car alignment is confirmed and ecological survey requirement is established for the EIA.

3.3.8 The residential areas, cultivated land and the planted areas are generally of less importance. These habitats comprise mainly common or planted species with no irreplaceable features.

Areas of Conservation Value

3.3.9 Any chosen alignment for a cable car will fall within the existing Lantau North Country Park and the potential Lantau North Country Park extension. The need to consult the Country and Marine Parks Authority and the Country and Marine Parks Board or its Country Parks Committee and obtain consent from them is noted. An initial consultation to the Committee was carried out in January 1999. The Committee has supported in principle the development of this project although it also expressed concern about possible adverse impacts of the proposed cable car project to the natural environment. Ecological constraints of the system are shown in Figure 3.2.

3.3.10 The cable car routing is likely to pass immediately above or near to the San Tau Beach SSSI. The interest of this SSSI is the small area of mangroves which includes the rare many-petalled mangrove plant (*Bruguiera gymnorrhiza*) and the seagrass bed of *Haliphila ovata* and *Zostera japonica* which supports an interesting assemblage of marine invertebrates in intertidal waters. Experimental transplanting of small populations of the seagrass to other suitable sites has already been undertaken as mentioned on SSSI citation No 58 under section Recommended Protection Measures. As the interest is either static (plants) or water/land based (invertebrates), cable cars running overhead are unlikely to cause any ecological impacts. Constraints for the Tung Chung terminal are shown in Figure 3.3.

3.3.11 The Lantau Peak SSSI and Special Area both fall within the Lantau South Country Park and are located on the eastern margins of the survey area. These areas are not likely to be directly affected by the proposed cable car. Ecological constraints in the Ngong Ping area are shown in Figure 3.4.

3.3.12 Other ecologically significant areas within the survey area such as mature natural woodland, tall scrub, wet abandoned agricultural land and rivers/streams and their associated riparian habitats have been highlighted as potential ecological constraints on the project. Their significance shall be confirmed by further ecological study in the detailed EIA if necessary.

Evaluation of Potential Ecological Impacts

Operational Impacts

3.3.13 Since the cable car system is suspended above ground by pylons and the passengers generally have no access to the country park area, disturbance to the country park ecology during the operational phase should be minimal. Seagrass bed at the San Tau Beach SSSI are highly sensitive to sediment, silt and oil. The cable car which will fly over the seagrass bed should have no direct impact on the SSSI. On the contrary, the Government proposed reclamation of an artificial island in the area would be the primary element causing risk to the seagress. Hikers returning from Ngong Ping to the coastal areas would unlikely cause impact on the seagrass as this is an inundated area and pedestrian access does not exist. The most probable ecological impact will be brought about by pylon maintenance works and visitors in the Ngong Ping area as listed in Table 3.8.

Table 3.8 Checklist of Potential Ecological Impacts during Operation

Potential Ecological Impacts during Operation	Remarks	Likely to occur for the Cable Car Project
Pylon maintenance	Access to the pylon bases is likely to be required for maintenance purposes	EMSD requirement for a trail associated with the cable car alignment would enable routine maintenance access to be easily achieved without further impact.
Increased number of visitors	People visiting Ngong Ping are likely to increase several fold. This could lead to increased disturbance to wildlife and vegetation.	Yes - but the actual impacts would need to be assessed in detail at a later stage of the project. They are likely to prove difficult to quantify.

3.3.14 Maintenance activity at individual pylons has the potential for local impacts but in the nature of cable car systems this is unlikely to be significant or widespread although would need management measures. Besides, maintenance activities required for individual pylons will be very seldom. The movement of the cars and any noise from equipment would be most unlikely to have any ecological impacts. Hence, operation of the cable car is unlikely to have significant, or any, adverse ecological impacts.

Construction Impacts

3.3.15 The possible ecological impacts during the construction phase of the project are identified in Table 3.9. These tables act as checklists of potential ecological impacts. In practice the effect of most of these impacts is likely to be slight.

Table 3.9 Checklist of Potential Ecological Impacts during Construction

Potential Ecological Impact during the construction period	Remarks	Likely to occur on the Cable Car Project?
Habitat loss	The construction of pylon bases and termini could involve the removal of certain habitats.	Yes, in a limited way, a few pylon bases may fall within habitats of moderate ecological value. Careful rehabilitation, for example covering with soil, reseeding and replanting, will be required. Termini are likely to be located in areas of low ecological significance
Habitat fragmentation	Construction could fragment and isolate areas of habitat	Construction unlikely to fragment areas in any significant way
Species removal	Habitat loss could result in local extinction of species	No - no species known to be restricted to survey area
Animal mortality	Increased mortality caused by development e.g. road kills	No - as cable car flies in air space.
Hydrological disturbances	Works could change local water regime	Minimal and localised - through new drainage channels and increased hard surfaces at the termini only
Changes to stream flow patterns	Altered drainage could change run-off rate and pattern	Streams/rivers unlikely to be impacted adversely with appropriate work practices prescribed and monitored

Potential Ecological Impact during the construction period	**Remarks**	**Likely to occur on the Cable Car Project?**
Soil erosion and silt deposition	Soil exposed during construction is more liable to erosion, with subsequent siltation of watercourses	Impacts could be mitigated
Water-bourne pollution	Chemicals, hydrocarbons, sewage and other waste from site could enter watercourses	Impacts could be prevented from occurring
Air-bourne pollution	Gaseous emissions from vehicles or buildings could damage local habitats	Very unlikely to be significant given the type of project
Vegetation damage by hill fires	Burning of vegetation, hindering of natural succession and potential damage to wildlife	Impacts could occur, further work would be required to assess potential impacts and suggest mitigation measures.
Dust depositon	Dust generated during construction could damage local environment	Unlikely to be significant given the type of project

Distribution and Duration of Ecological Effects

3.3.16 Ecological effects during the operation phase of this project will be minimal. During construction, ecological impacts are predicted to exist but, with suitable mitigation measures and careful control of construction work practices, will be localised and for short-term.

History of similar projects in Hong Kong

3.3.17 The only cable car system in Hong Kong is at Ocean Park and was built about 20 years ago. With a length of around 1.5km, it is much shorter than the one proposed in this project and is located within a private lot on Hong Kong Island in different habitats and geology. It is understood that no detailed ecological impact assessment work was carried out on this project at the time of construction although environmental considerations were addressed in general terms.

3.3.18 Other similar projects involving large linear cables and pylons both within and outside Country Park areas are the China Light and Power overhead electricity pylons for their 400KV and 132KV lines. EIAs (including ecological impact assessments) were carried out on these projects prior to the implementation of the EIAO. Presentations of these projects were made to the Country and Marine Parks Board and the consents of the Country and Marine Parks Authority were obtained. Useful experience and information including in particular the siting and rehabilitation of the pylon sites can be gleaned from these projects.

Requirements for Future Surveys

3.3.19 Upon the confirmation of the chosen route of the cable car and its method of construction, a detailed ecological surveys should be required during the detailed design stage of the project, following the assessment criteria as established in Annex 8 in the Technical Memorandum of the EIAO. One of the key habitat likely to require further investigation is the woodland/scrub slope to the southwest of San Tau in the potential Lantau North Country Park extension. This work will mainly aim at reducing the impact by determining the most suitable locations to site the pylons bases within this area and determining specific appropriate working methods.

3.3.20 Although it appears to be possible to eliminate potential impacts to the natural streams and rivers within the study area, further survey works providing sufficient baseline information of streams will be carried out. Further work may need to be carried out to clarify the requirements for densely wooded areas and mature forestry as set out in the clearance section of the Code of Practice (Design, Manufacture and Installation of Aerial Ropeways) issued by EMSD. The exact criteria for further study would rely on the finalized cable car alignment and requirements established by EPD and AFD to be provided in the EIA Study Brief.

Ecological Protection Measures

Retention of Natural Habitats and Species

3.3.21 Natural habitats and species will be retained wherever possible. Pylon bases will be located in the less ecologically sensitive areas. The termini will be located in areas of low ecological significance.

Control of construction work practices

3.3.22 In view of the remoteness of much of the site, road access for construction would be extremely difficult and likely to be damaging. In common with many overhead power lines constructed in recent years, the use of helicopter may be warranted. Ecological guidelines for working in the countryside will be examined and the need for worker's training to work in the countryside reviewed. The following site activities are identified to have potential ecological impacts:

- **dumping of spoil on or off site**

During the construction of foundations, it is likely that excess spoil will be generated. Depending on the habitats, geology and land formation of each pylon site, it may be possible to relocate the excess spoil within or near the pylon site by grading and seeding it to match the local topography and vegetation conditions.

- **soil erosion and silt deposition**

Construction during the wet summer season is likely to cause more erosion and siltation problems. On sensitive sites, where erosion is likely to occur, work should preferably be carried out between October and March. Care should be taken to ensure that eroded soil does not run off into existing natural stream courses. All the stream courses near the cable car route are natural and unpolluted. Active protection from washdown soil generated by pylon construction will be considered.

- **the need for water on site for construction**

For mixing of concrete and other purposes, water is often required for construction works. It is generally the case that, in remote areas, contractors will try and find the nearest source of water (e.g. the local stream course) and use pipes and pumps as appropriate to bring the water to the site. As these sites are of importance to wildlife, this should be reviewed in the detailed EIA.

- **smoking on site during construction**

Smoking by construction workers on site has been shown to be one of the causes of the many hill fires in Hong Kong. If possible, smoking should be banned on site.

- **litter**

Workers should be encouraged not to leave litter on site as it can cause considerable damage to wildlife and is an eyesore.

All surplus materials should be removed from site and daily clearance of general litter is advised. Particular care should be taken over bottles, wire, polystyrene lunch boxes, plastic wrapping, cans and non-degradable materials.

Litter should not be burned on site but should be removed off site.

- **potential to pollute streams/rivers**

Any use of oils, chemicals etc on site should be controlled. No run off should be permitted into natural stream courses. All feasible measures to reduce erosion and run-off into streams during the construction period should be taken. Measures to control erosion might include: phasing the works to avoid the wet season when the site will be most vulnerable to erosion, rapid revegeation or protection of exposed soil and the use of silt traps and fences where appropriate.

- **hydrological disturbances and changes to stream flow patterns**

Any plans to divert local drainage within sites to prevent local flooding have the potential to alter the hydrological characteristics of the site.

- **need for site offices and depots for materials**

Should these be required, they should be sited in urban areas or areas identified as being of minimal ecological importance.

- **need for haul routes**

If materials are to be brought in by helicopter, a haul road is not required.

- **rehabilitation of pylon sites with native planting**

Phased replanting should be carried out on the pylon sites. Replanting should take place as soon after the completion of the works as possible. Plants native to the immediate area should be replanted. Before any construction work takes place on site, each pylon bases should be surveyed and a list of existing plants with their dominance should be noted.

Hill Fires and the Cable Car

3.3.24 It is necessary to review whether the cable car project could be affected by hill fires. The season for fires normally starts in October and ends in April during which period the weather is dry and more people visit the countryside. Fires are more dominant in dry grassland, low scrub and Pine tree covered areas than in dense ravine or mature broadleaved woodland.

3.3.25 Fire is one of the key factors which maintains Hong Kong’s vegetation as grassland and does not allow it to develop naturally into scrub and then woodland, the natural climax vegetation of Hong Kong.

3.3.26 Most hill fires are caused by human carelessness. The major causes are unattended barbecue fires, discarded cigarette ends, fires escaping from burning off rubbish or weeds on farmland near hillsides, fires escaping from burning joss sticks and paper money during the grave-worshipping festivals. Along the cable car route, any of these causes could happen although the cabins will be ‘No Smoking Zones’. A cabin car system with high level windows would discourage discarded cigarettes as well as general litter.

3.3.27 The whole of the route is to some extent vulnerable to hill fires. The majority of the route runs through grassland and low scrub where, should a fire occur, grass cover is likely to burn off rapidly. Pylons in grassland and low scrub should therefore be fireproof at their base. Pylons within dense tall scrub and woodland are likely to be better protected from hill fires. However, it is understood that the ecological impacts on dense tall scrub and woodland are generally higher, hence the route should avoid scrubland and woodland as much as possible.

For unavoidable scrubland and woodland areas, the issue will be to minimise impacts and seek mitigation measures wherever available and practicable.

3.3.28 The height of the cables and the car itself should also be considered in relation to hill fires and the most suitable designs chosen. From this point of view, a cable car system that was higher off the ground and had fewer pylon bases would be likely to be less affected by fire.

3.3.29 In view of the possible outbreak of hill fires which will damage the natural woodland and threatening the cable car system, measures to prevent hill fire and early fire warning systems shall be investigated. Consideration should be given to the need for a Fire Prevention and Fighting Plan for the Cable Car route.

3.3.30 FSD consultation has confirmed that the woodland areas have a low tendency to burn and that they are to a great extent self-extinguishing. This should enable retention, in principle, of woodland along the alignment, subject only to localised impacts for forming trails etc. Detailed discussion of firebreaks is presented in 4.3.11 to 4.3.16.

Access and Safety Trail

3.3.31 It is understood that a trail under or near the cable car route is required for safety and maintenance purposes.

3.3.32 There are a number of existing trails along the route corridor although these are not well used at present. Opportunity therefore seems to exist to base the cable car access track on these existing paths although they would need some upgrading.

3.3.33 It is suggested that the public should be positively encouraged to use these paths. This will keep the path clear of vegetation and will reduce the requirement for maintenance. Concrete surfacing to paths is positively discouraged. Suitable signposting would be required at various points along the route. One way of ensuring effective use of this trail could be to label it Lantau Trail or equivalent.

Ecological Planning Gains

3.3.34 Opportunities present themselves for some ecological and environmental enhancements which could be associated with the cable car project. Potential exists to include the opening up of an existing network of recreational trails to the north of Ngong Ping which are almost impassable at present, to replant with native species and to improve the area for rare butterflies and frogs. When the proposed sewage treatment plant at Ngong Ping is implemented, there will be an opportunity to improve the stream to the west of the monastery for wildlife. The actual improvement shall be estimated and studied at the detailed EIA stage.

3.4 Environmental Monitoring and Audit

3.4.1 This initial Environmental Planning Assessment has outlined the potential environmental impacts which would arise from the construction and operation of the proposed cable car system and has introduced briefly some possible environmental mitigation measures that can be incorporated into the Project. The need to develop an environmental monitoring and audit programme, for example, during the construction phase of the project, would require examination after evaluation of the magnitude of environmental impacts in the detailed EIA report.

3.5 Conclusions

3.5.1 This Initial Environmental Planning Assessment provides an initial appraisal of the potential environmental effects that could arise during the construction and operation of the project. The assessment indicates that the key environmental issues during the construction and operation phases include the following :

(i) Construction Phase

- fugitive dust emission;
- noise impact generated from powered mechanical equipment and helicopter operation during construction works;
- water quality impact due to construction site runoff;
- construction waste impact; and
- ecological impacts.

(ii) Operation Phase

- wastewater collection, treatment and disposal;
- fixed industrial noise from mechanical equipment of the cable car system;
- waste management and disposal;
- ecological impact;
- archaeological constraints; and
- visual impact.

3.5.2 Practicable mitigation measures are required to alleviate the construction phase environmental impacts, though transient, to acceptable levels. The development of an appropriate management strategy for industrial noise, sewage, ecology, archaeology, and solid waste management during the operation phase will be key issues requiring further assessments.

3.5.3 This report has identified all the potential construction and operational phase environmental impacts of the cable car system. However, construction air quality impact can be effectively mitigated by using helicopters for material transport and other site management strategies. Also, the air impact from the construction phase of the project will only be short-term and non-persistent. Hence, the major concern for the construction of the cable car system shall be the construction noise, water quality and possibly ecological impacts.

3.5.4 During the operational phase of the cable car system, impact upon the area along the alignment is predicated to be minimal. The most significant environmental impact is the fixed noise problem from the motor operations in the terminus.

3.5.5 The proposed cable car system may be classified as a Designated Project by the Authority under Section Q - Miscellaneous under Schedule 2 Part I of the Environmental Impact Assessment Ordinance (EIAO). The identified environmental issues would be addressed in an EIA so as to identify practicable, effective and sufficient environmental mitigation measures for implementation during both construction and operation of the Project.

4.0 LANDSCAPE AND VISUAL ISSUES

4.1 Scope of Study

4.1.1 The scope of the landscape and visual study is to predict and judge the significance of the effects the cable car development will have on the landscape character and visual amenity within the alignment corridor for the cable car between Tung Chung and Ngong Ping. However, it should be noted at the outset that visual impact assessments, in particular, involve subjective judgement. Accordingly, regard to community perception of the particular landscape features and visual amenity affected should be taken into account.

4.1.2 In the preparation of this Section of the Report, reference has been made to Annexes 10 and 18 in the Technical Memorandum of the Environmental Impact Assessment Ordinance which set out the approach and methodology for Landscape and Visual Impact Assessments. Whilst this Report is not intended to be a detailed Landscape and Visual Impact Assessment, it has been structured in a similar format for clarity and ease of reference.

4.2 Baseline Conditions

Existing Landform, Vegetation and Landscape Character

4.2.1 Tung Chung is dominated by the dramatic backdrop of the main Lantau ridgeline with Nei Lak Shan and Lantau Peak at the head of the valley. The two major valleys in the Tung Chung area are separated by the steep central spur emanating from Lantau Peak (refer to Figure 4.1). This ridge is a strong landscape element together with the historic fort site and fung shui woodland on the lower slopes at the northern end. The ridge bounding Tung Chung to the east extends to the coastline as a series of three knolls that will be incorporated into the design of the future town park.

4.2.2 The area to the west of Tung Chung is remote, sparsely developed and accessible only by footpaths. It contains three major spurs which come off the main Lantau ridge which fall steeply to the coast forming four highly scenic valleys of San Tau, Sha Lo Wan, San Shek Wan and Sham Wat. The coastline in this area displays granite and sandstone formations of great visual interest and the Fung Shui of the region is significant. The alternative cable car routes being considered in this feasibility study are located along the east and west flank of the major of these ridges separating Tung Chung from San Tau and the smaller valleys to the west.

4.2.3 The upland vegetation cover is predominantly fire-maintained grass and shrubland with a number of natural woodland areas in the more sheltered valleys and ravines (refer Figure 4.2 and Table 4.1). In addition to their ecological value these upland natural woodlands are important elements in the overall landscape character of the area. The grass and shrub vegetation is highly prone to hill fires in the dry season and most of the woodlands are in retreat as a result of recent hill fires. The area north of Ngong Ping is one of the most frequently burned and considered to be an ecological desert supporting relatively few animal species.

4.2.4 Woodland below 300m is apparently all secondary woodland or planted with small pockets of Fung Shui woodland found behind the majority of the village settlements. These woodlands, being more sheltered, contain many mature trees of high visual amenity and landscape value which should be protected as much as possible.

4.2.5 Other habitats of landscape as well as ecological importance include the small areas of mangrove located in the wetland zone near San Tau village and an area of sea grass which has been designated as a SSSI.

Table 4.1 Typical Species Observed Within The Study Area Vegetation

Natural Secondary Woodland Species Mix		Scrubland Species Mix		Grassland Species Mix
Alangium chinensis	*Aleurites montana*	*Aster ageratoides*	*Baeckea frutescens*	*Apluda mutica*
Acronychia pedunculata	*Aporusa chinensis*	*Breynia fruticosa*	*Bambusa spp.*	*Arundinella setosa*
Bridelia monoica	*Brucea javanica*	*Dianella ensifolia*	*Dicranopteris lineraris*	*Cymbopogon nardus*
Callicarpa spp.	*Castanopsis fissa*	*Diospyros vaccinoides*	*Eurya chinensis*	*Eulalia speciosa*
Celtis sinensis	*Cinnamomum camphora*	*Ficus pumila*	*Ficus variolosa*	*Ischaemum spp.*
Cratoxylon ligustrinum	*Diospyros morrisiana*	*Fortunalla hindsii*	*Gordonia axillaris*	*Miscanthus spp.*
Ficus spp.	*Garcinia oblongifolia*	*Ilex asperella*	*Lantana camara*	
Gordonia axillaris	*Ilex spp.*	*Lespedesa formosa*	*Litsea rotundifolia*	*Aster ageratoides*
Litsea spp.	*Lithorcarpus spp.*	*Lycopodium spp.*	*Melastoma candidum*	*Baeckea frutescens*
Machilus chinensis	*Mallotus paniculatus*	*Melastoma sanguineum*	*Millettia spp.*	*Cirsium linearum*
Microcos paniculata	*Pinus ellioti*	*Miscanthus spp.*	*Musseanda pubescens*	*Dianella ensifolia*
Rhus spp.	*Sapium sebiferum*	*Phoenix hanceana*	*Phyllanthus embilica*	*Eurya japonica*
Schefflera octophylla	*Sterculia lanceolata*	*Psychotria rubra*	*Psychotria serpens*	*Lespedesa formosa*
Symplocos decora	*Syzygium spp.*	*Rhapiolipis indica*	*Rhodomyrtus tomentosa*	*Mimosa pudica*
		Rhus spp	*Rhamnus chinensis* *Sapium sebiferum*	*Rhapiolepis indica*
		Setaria glauca	*Smilax china* *Strophanthus*	*Rhodomyrtus tomentosa*
		divaricatus *Viburnum sempervirens*	*Wichstroemia indica*	*Solidago virgo-aurea*

Cultural Features

4.2.6 The Po Lin Monastery and Buddha statue at Ngong Ping are the main attractions for visitors to Lantau. The Ngong Ping area has a unique character which comprises a blend of religious, contemplative and peaceful ambience with the hustle and bustle of tour buses and large numbers of local and foreign visitors. To avoid detracting from the dominant religious character of Ngong Ping the proposed cable car and terminal building should in no way detract from the scale of the Monastery complex or intrude into the popular viewpoints towards the Buddha statue or Temple buildings. In addition, every opportunity should be taken in selecting a terminus site which improves the poor vehicle/pedestrian circulation and segregation at the existing bus terminal.

Fung Shui Features

4.2.7 The main ridge separating the Tung Chung Valley from the San Tau Valley is classified as an 'Elephant' feature whose trunk extends into the sea in the form of a sand spit at the mouth of the San Tau stream (refer to Figure 4.2). The trunk is regarded as having good Fung Shui for the village. During the NLD Study villagers stressed that the seabed comprising the trunk must not be dredged or severed in any way. In addition, the ridge line forming the western side of the San Tau Valley is considered to be an important 'Dragon's Back' and no development should be located on this ridge facing the existing village. It will be necessary to discuss the effects of the proposed cable car development with Village Representatives at San Tau to ensure compatability with the 'Elephant' feature during the detailed design stage.

4.3 Landscape Impacts

4.3.1 The key elements of the cable car system which are expected to intrude on the landscape and visual character of the study area are as follows:

- Terminal buildings and associated infrastructure
- Pylons, cable and gondolas
- Access tracks and firebreaks along the cable car route

It is expected that the Airport Island Intermediate Station will generate no major adverse landscape and visual impacts as the surrounding environment will largely be developed into commercial areas.

Terminal Buildings

4.3.2 The terminal buildings at Tung Chung and Ngong Ping will be the largest and potentially most visually obtrusive structures of the cable car system. Being seen by the largest number of people at short distance, and located in very different settings, it will be important to integrate the buildings sensitively minimising impacts on the landscape and visual amenity unique to each site.

Tung Chung Terminal

4.3.3 To ensure commercial viability and convenient access, it is recommended to integrate the Tung Chung cable car terminal with a multi-function complex containing a civic centre, commercial and retail outlets with convenient connections to the MTR Tung Chung Station. This location would require a section of the route to cross Tung Chung Bay and be incorporated within subsequent reclamation. The optimum route is one which utilises the southern edge of the airport island for the intermediate cable car station, minimising the distance over water and maximising the clearance from future residential development.

4.3.4 The landscape impact of this section of the route is not considered to be significant as the location will be on reclaimed land in an urban setting with no loss of vegetation. The main concern is the visual impact of the cable car close to the urban area which is discussed further below. The overall character of the terminal would ideally reflect the modern, hi-tech image of the new airport and become a focal point in the New Town.

Ngong Ping Terminal

4.3.5 In contrast, at Ngong Ping, it is imperative to retain the religious ambience of the monastery buildings and environs. If the terminal is restricted to two storeys and reflects the traditional architecture of the surrounding buildings using compatible materials and colour finishes then the landscape and visual impacts would not be significant. As discussed between MTRC and the Master of the Ngong Ping Monastery, the preferred location of the terminal building would be to the west of the Monastery complex. This location would create better opportunity to improve the conflicting and congested vehicle and pedestrian flows in the arrival courtyard at Po Lin Monastery.

4.3.6 The majority of the existing vegetation in this vicinity comprises numerous, scattered stands of amenity or exotic tree planting associated with the village housing. With careful refinement of the terminal site and cable route the loss of mature trees would be relatively low and those retained would form effective screening from the Monastery complex.

Cable car system

4.3.7 The cable car route will require the construction of pylons to support the cables and gondolas. Due to air traffic safety, the cable car pylons will be restricted to within 60m in height for the section near Tung Chung and the Airport Island. The spacing and number of pylons will depend upon the detail assessment of site conditions along the optimum route. The overall landscape impact and visual effect of the pylons and cable would be similar to that of an overhead powerline, the main difference being the moving line of gondolas and low-level lighting of the pylons and gondolas if operated during hours of darkness.

4.3.8 In order to minimise disturbance to the topography and vegetation during and after construction of the pylons, the following experience gained from installation of high voltage overhead powerlines in Country Parks and areas of similar landscape sensitivity can be used.

- Detailed refinement of pylon positions to minimise the number of pylons and disturbance to particularly sensitive landscape features or habitats.

- The bulk of construction materials can be airlifted to each pylon site by helicopter thus restricting the need for large access roads. Instead, temporary footpaths can be cut for workers to reach pylon sites and relatively easily revegetated upon completion.

- The typical siting for pylons is on spurs to maximise the span and ground clearance of the cables. To avoid leaving large scars by cutting level platforms for pylon foundations, each pylon should be custom designed with variable leg length to suit the local topography and slope profile.

- Total revegetation should be carried out in the pylon 'footprint'. By using the same species and planting density as those cleared during construction the reinstatement planting of the disturbed ground will blend better with the surrounding vegetation cover.

- Strict control should be applied on site during construction to avoid hill fires, e.g. banning smoking.

- Excavated soil and rock material should be carefully retained on site during construction for backfilling foundation works and reinstating the final ground profile. Excavated material should not be allowed to wash out into surrounding vegetation or stream courses.

Emergency Access Tracks

4.3.9 FSD have advised that in order to fight hill fires an access track of preferred minimum 1.5m width would be required along the route if site conditions permit. This track would not have to follow the straight line of the cable car route but can utilise existing paths which are close to the route with new connecting paths where necessary. It may be possible to use surplus rock material excavated for pylon foundations to build nearby portions of the access track.

4.3.10 Preliminary discussions with AFD highlighted the potential benefits of establishing the access track as an extension of the existing network of Country Park trails. By focussing public access on a specific route through remote areas the potential impact from littering, fires, and damage to habitats can be better contained. Some visitors may prefer making the return journey from Ngong Ping on foot via the most convenient trail. This would present good opportunities for establishing a compact, interpretative nature trail from mountain peak to coastal habitat of unique educational value. It is recommended that before provision of additional tracks is considered, careful monitoring is carried out to determine how well the initial access track is used and assess any impacts on the surrounding habitats.

Firebreaks

4.3.11 The Code of Practice for Aerial Ropeways recommends that a firebreak of 30m width be cut where the cable car passes over dense woodland, i.e. 15m either side of the cable alignment. The intention is to fell all trees in the firebreak corridor and maintain a low grass cover instead to minimise the risk to the cable car riders in case hill fires break out close to the cable car route. This requirement would have arguably the greatest landscape and visual impact on the hillside portion of the cable car route.

4.3.12 Preliminary discussions with AFD and FSD regarding the nature of Hong Kong hill fires and the established fire-fighting practice confirmed the following points:

- Most Hong Kong hill fires are self-extinguishing, unlike the large forest fires of North America, Australia or Europe. The main concern here is the more combustible grass and scrub rather than dense woodland areas. FSD would not require tree felling as a fire prevention measure or firebreak design.

- Hill fires in country park areas are dealt with by an initial response by AFD staff. FSD render assistance upon AFD's request and typically walk to the site (refer access track provision noted above) with beaters and water cannister back packs. If necessary, FSD staff will request air support to water bomb specific parts of the fire.

- A fixed irrigation system to dampen vegetation was not considered by FSD to be effective in preventing or fighting a hill fire. Large volumes of water directed to specific targets by bombing is more practical. Therefore, such a water supply system would not be a FSD requirement for the cable car development.

4.3.13 Accordingly, the basis for felling mature dense broadleaf woodland for fire safety reasons is therefore doubtful as the cleared, grass-covered 'firebreak' would burn more easily than the surrounding woodland. As the majority of the woodland in the Study area is in retreat as a result of periodic hill fires on adjacent grassland, it would be prudent to reinforce and supplement these more fire-resistant woodlands with additional tree planting. This planting would have to be carefully co-ordinated with AFD to recolonise the fire-risk grassland areas and reconnect the individual pockets of woodland.

4.3.14 It is considered that the natural surveillance by the cable car riders and close monitoring of the critical sections of the alignment by CCTV will be an effective way of detecting hill fires at the first instance. It will be within few minutes that the line can be completely cleared of passengers which can be unloaded from the cable cars both at the Intermediate Station on the Airport Island and at Ngong Ping Terminal. By maintaining a sufficient clearance of the cable car from the vegetation, it will not be necessary to fell the trees along the cable car route.

4.3.15 As this firebreak strategy contradicts the Code of Practice recommendations, exemption is required from EMSD not to fell the woodland areas as specified. There may be a need to fell selective mature trees which would interfere with the safe movement of the gondolas. In this respect, the minimum clearance of 3m below the gondolas recommended in the Code of Practice is noted.

4.3.16 A summary of the landscape impacts for the route alignments is shown in Table 4.2.

Table 4.2 Summary Of Landscape Impacts

LANDSCAPE CHARACTER UNIT	DESCRIPTION	QUALITY / SENSITIVITY	IMPACT	DEGREE OF IMPACT
Urban portion (Tung Chung terminal to San Tau village)	Landscape character of early development phases of Tung Chung New Town is one of construction site and transport interchange. Once more fully developed, despite the mountainous hinterland, the New Town will still be dominated by the scale, proximity, sight, sound and smell of the airport and associated road and rail transport infrastructure.	Moderate	***Terminal building:*** Will form part of the urban fabric and has potential to become a New Town landmark and point of interest. ***Cable car route:*** No vegetation lost and no alteration to existing topography as the alternative routes are located over recent and future reclamation or water. The more northerly alignments, preferably located on the airport island, will have minimal disruption to the New Town landscape character and are in keeping with the adjacent major road and rail transport corridor serving the airport and New Town.	Insignificant, possible enhancement Insignificant, potential for adding interest to New Town landscape and townscape character.
Lower hillside portion (San Tau Village to intermediate station)	Unlike the urban portion, the urban fringe is more sensitive to change. The dramatic topography, coastal vegetation, sea grass SSSI, fung shui landforms and woodland by San Tau and extensive areas of mature woodland extending up the into the more sheltered valleys combine to create a landscape of exceptional value and visual grandeur.	High	Overall impacts will arise from intrusion of permanent development into small scale, rural and natural environment. Specific impacts will arise from: Loss of vegetation during construction for towers, maintenance / fire-fighting track although full restoration planting below towers possible. Preliminary design indicates preferred route has no towers in woodland. Possible conflicts with local fung shui features for San Tau valley routes. Major loss of woodland to comply with Code of Practice regarding felling of trees along cable car route to provide 30m wide 'firebreak' although not FSD requirement.	Significant adverse for all routes

LANDSCAPE CHARACTER UNIT	DESCRIPTION	QUALITY / SENSITIVITY	IMPACT	DEGREE OF IMPACT
Upper hillside portion (Intermediate station to Nei Lak Shan)	Vegetation is predominantly scrub and grassland extending to highest point of cable car route on flank of Nei Lak Shan. Stark, remote and dramatic mountainous topography. Upland landscape sensitive to man-made elements, particularly crossing saddle and ridge skylines.	High	Overall impacts will arise from intrusion of permanent development into remote and uninhabited upland landscape. Specific impacts will arise from: Loss of scrub vegetation during construction for towers, maintenance / fire-fighting track although full restoration planting below towers possible. Greater public access to remote areas on new track with consequent increase in fire risk, littering and habitat damage.	Significant adverse for all routes
Ngong Ping plateau (Nei Lak Shan to Ngong Ping terminal)	Ngong Ping community and landscape character comprises a mixture of peripheral, ad hoc village settlement and associated pockets of woodland / plantation dominated by formality of central monastery complex and Buddha statue landmark. Bustle of tourists overlays religious / contemplative ambience of the monastery.	High	Potential large impacts depending upon the scale and location of the terminal and cable route. Westerly location will minimise loss of woodland and permit enhancement of traffic / pedestrian movement at main monastery arrival area. A low-rise design for the terminal building reflecting vernacular architecture will blend best with existing landscape character.	Significant adverse for eastern terminal Insignificant with potential enhancement for western terminal

4.4 Visual Impacts

4.4.1 The assessment of visual impacts is concerned with identifying the elements of the proposed development, their visual compatibility with the surroundings and the visual obstruction created to the main centres of population (visually sensitive receivers). The scale and severity of visual impacts will depend upon the proximity, duration and dominance of the development in the overall view and the ability of the landscape to absorb such changes.

4.4.2 The key elements of the proposed cable car development, as mentioned in the above section on landscape impact assessment, will be;

- Terminal buildings and associated infrastructure
- Pylons, cables and gondolas
- Access tracks and firebreaks along the cable car route
- Angle station

4.4.3 The cable car route can be subdivided into four main portions for comparison, namely;

- Urban portion: Tung Chung terminal to San Tau
- Lower hillside portion: San Tau to Intermediate Station
- Upper hillside portion: Intermediate station to Nei Lak Shan
- Ngong Ping portion: Nei Lak Shan to Ngong Ping terminal

4.4.4 The key groups of sensitive receivers identified and illustrated in Figure 4.3 are;

- Residents in Tung Chung New Town
- Passengers in transit through Tung Chung
- San Tau and coastal villages
- Visitors to country parks
- Visitors and residents in Ngong Ping
- Passengers on marine route along the West Lantau Coast

The anticipated visual impacts on these sensitive receivers and their relative severity are discussed in more detail below and summarised in Table 4.3.

Tung Chung Residents

4.4.5 The residents of Tung Chung New Town are the single largest group of sensitive receivers likely to be affected by the cable car development. The most visually prominent elements which have the potential to cause visual impacts will be the terminal building itself and the portion of the cable car system from the terminal building to San Tau.

4.4.6 It would be undesirable to have the gondolas close to or between areas of high-rise buildings where the visual impact and perceived intrusion of privacy for people living or working in the buildings would be high. Similarly, passengers in gondolas may feel discomfort at being overlooked at close quarters. Accordingly, it is recommended that the route from the Tung Chung Terminal should be aligned as far north as possible to skirt the future urban development. By so doing, the cable car system will be viewed against the far more imposing backdrop of the airport and associated road and rail infrastructure. Careful arrangement of the different land uses on the future reclamation to set residential areas back from the cable car route would further lessen any visual impacts.

4.4.7 As mentioned in the landscape impact section above, it is considered that the terminal building has good potential to become a focal point within the New Town. The movement and activity associated with the cable cars is more likely to provide a dynamic element to the Town Centre of interest rather than an intrusion to the population in general.

4.4.8 The hillside portion of the cable car route would be visible to Tung Chung residents if located in the Tung Chung valley from the urban fringe to the skyline at the head of the valley. Unlike the urban portion, the pylons and cables would be a permanent intrusion of man-made elements into the upland landscape. Accordingly, the visual impacts of this portion are anticipated to be high to moderate depending upon the distance of the viewer from the cable car route.

4.4.9 By contrast the preferred alignment to the west in the San Tau Valley would be mainly screened from Tung Chung residents' view by the intervening topography.

Passengers in transit through Tung Chung

4.4.10 Passengers on trains, buses or cars would have similar views of the urban and hillside portions of the routes as those for Tung Chung residents. However, the overall impacts are anticipated to be low since the duration of the views would be short and foreground views would be dominated by the mass of present and future high-rise buildings in the New Town.

4.4.11 The first portion of the proposed cable car route crosses the distributor road and sea channel and extends to the intermediate station on the southern edge of the Airport Island. The potential for visual distraction to drivers as the cabins cross above the road has been considered. However, as the clearance from road surface to the underside of cabins will be approximately 10m, i.e. almost twice that of a footbridge or flyover. This additional headroom is designed to take the cable car out of the main field of vision for drivers. The level of distraction is anticipated to be comparable to that of many other roads in urban Hong Kong adjacent to grade or elevated railways or criss-crossing of traffic on multiple flyovers. Mitigation measures to screen the cable car in this location, e.g. enclosure, or denser roadside planting, would not be practical. Enclosure structures would create a greater overall visual impact. Denser roadside planting may interfere with junction sight lines. In addition, longer, more open views of the cable car system for drivers approaching the road crossing are less likely to distract than surprise views at close quarters as cabins emerge from partial screening by planting or barriers.

Visitors to Country Parks

4.4.12 Walkers using the long distance trails on the North Lantau ridgeline would have potentially the highest visual impacts of the different sensitive receiver groups identified. From the vantage points of the high ground and adjacent Lantau Peak and Nei Lak Shan, the cable car system would be readily visible in either the Tung Chung Valley or San Tau Valley. It is unlikely that the urban portion of the route would have any significant visual impact to this group as it will be contained within the New Town fabric. However, the terminal at Ngong Ping will be highly visible and care must be taken to integrate the terminal and cable routing carefully with the Monastery complex and Buddha statue. This point is discussed further below.

San Tau & Other Coastal Villages

4.4.13 Within the heart of San Tau the majority of views to the south up to the valley to Nei Lak Shan, are screened by the mature woodland behind the village. The most prominent portion of the route will be as it passes the village to the east, particularly when viewed from the beach in front of the village.

4.4.14 Refinements to the San Tau Valley route may require siting of the intermediate pylon close to the ridgeline. If this is so, then the villages to the west of San Tau may have long distance views of the cable route in mid-hillside portion. Further detailed study of the actual views from settlements at Sha Lo Wan and Sham Shek Tsuen will be required at the detail EIA stage. Preliminary study of vegetation patterns in these areas suggest the mature woodland typically found behind the coastal villages will effectively screen long distance views.

Ngong Ping Residents and Visitors

4.4.15 The final section of the cable car route comprising the approach and terminal at Ngong Ping is arguably the most sensitive. It is imperative that the cable car alignment and terminal location do not intrude on the unique landscape/visual character and religious ambience of Po Lin Monastery and the Buddha statue. Visual impacts would likely be highest for visitors climbing the steps to the Buddha to enjoy the panoramic view. Like the hillwalkers mentioned above, the cable car and terminal would be clearly visible from the vantage point of the Buddha statue. Impact mitigation will therefore rely on sensitive design.

4.4.16 Impacts would be minimised if the scale and design of the terminal reflect the traditional, vernacular style of the Monastery buildings. Of the alternative locations considered for the terminal, the western site is preferred due to the opportunities this site can offer to enhance the current vehicle / pedestrian circulation. The current bus terminal could be relocated further back from the ceremonial area at the foot of the Buddha staircase thereby greatly improving the visual character of the Buddha statue - Monastery axis. The western terminal location is best served by the western cable car route as this will not encroach on the most popular views of the Monastery or the dramatic Nei Lak Shan/ Lantau Peak backdrop.

Passengers on marine route along the West Lantau Coast

4.4.17 Long distance views of the cable car route as it climbs up the San Tau Valley are possible from the sea channel. Shipping north of the airport island and along the west Lantau coast will be approximately 5 to 6 kilometres from the more visible section of the cable car route behind San Tau. The considerable distance from the viewer, prevalent smog layer and intervening mass, noise and visual distraction of the airport are expected to render the visual impacts of the cable car to this VSR group insignificant.

Table 4.3 Summary Of Visual Impacts

VISUALLY SENSITIVE RECEIVER GROUPS	TYPICAL EXISTING VIEWS	QUALITY/ SENSITIVITY	IMPACT	DEGREE OF IMPACT
Tung Chung residents	The seaward views to the north are dominated by the airport island. Landward views are dominated in striking contrast by the natural backdrop of the North Lantau ridgeline.	High	***Urban Portion:*** Terminal building will be viewed as part of the surrounding urban development with potential to become attractive focal point / landmark. Cable car route over water will be visually prominent in the short term, reducing as the reclamation and urban development proceeds. Cable car route via airport island will be more distant from VSRs and viewed against more dominant airport backdrop. ***Hillside Portion*** Unobstructed views and man -made intrusion of cable car against natural upland landscape if Tung Chung Valley alignments adopted. San Tau Valley routes concealed from view by intervening ridge.	 Insignificant, possible enhancement Significant adverse short term. Moderate adverse long term. Insignificant Significant adverse No impact

VISUALLY SENSITIVE RECEIVER GROUPS	TYPICAL EXISTING VIEWS	QUALITY/ SENSITIVITY	IMPACT	DEGREE OF IMPACT
Passengers in transit through Tung Chung	Mainly low-level views of road and rail corridor / noise barriers in Tung Chung with short duration, relatively distant views back towards the New Town and hills from airport island bridges.	Low	Foreground views dominated by road and rail infrastructure, noise barriers and urban development. Long distance views to hillside generally screened by existing / future New Town high-rise. Urban and airport context to traveller not significantly changed by cable car development although potential visual enhancement and focus to town centre if terminal building of appealing design. Large clearance from road surface will take the cable car out of the main field of vision for drivers using the roads beneath the cable car route.	Insignificant, potential enhancement
San Tau and coastal villages (Sha Lo Wan, Sham Shek Tsuen)	The low-level seaward views of San Tau are dominated by the airport island with well vegetated, steep hillsides behind the village containing landward views. Other villages have more open aspect seaward views with similar landward, mountainous backdrop.	High	***Urban Portion:*** Foreground views from San Tau dominated by cable car intermediate station and cable route passing to east of village. Not visible from other villages. ***Hillside Portion:*** Tug Chung valley routes not visible. Topography and mature woodland behind villages screen majority of long landward views for San Tau valley routes	Significant adverse Insignificant adverse

VISUALLY SENSITIVE RECEIVER GROUPS	TYPICAL EXISTING VIEWS	QUALITY/ SENSITIVITY	IMPACT	DEGREE OF IMPACT
Visitors to country parks	Unobstructed, panoramic views from trails and vantage points such as Lantau Peak and Nei Lak Shan. Majority of northerly views now dominated by airport and New Town detracting from formerly remote and natural/rural character of North Lantau hillwalking.	High	***Urban Portion:*** Little impact due to distance of views and predominantly urban context. ***Hillside Portion:*** Permanent intrusion of cable car into uninhabited upland landscape, particularly for more remote San Tau valley routes. Overall impacts reduced due to context of airport backdrop in most views. ***Ngong Ping Portion:*** Potential intrusion of cable car system into traditional architecture of monastery. Westerly location for terminal will have lower impact by avoiding most popular views of Monastery andBuddha statue.	Insignificant Significant adverse from short distance. Moderate adverse from more distant viewpoints with airport backdrop Moderate adverse

VISUALLY SENSITIVE RECEIVER GROUPS	TYPICAL EXISTING VIEWS	QUALITY/ SENSITIVITY	IMPACT	DEGREE OF IMPACT
Ngong Ping Residents and visitors	Dramatic visual character of monastery complex with Buddha statue landmark and backdrop of Lantau Peak and Nei Lak Shan. Panoramic views from Buddha statue platform	High	***Cable car route:*** Plateau topography of Ngong Ping conceals majority of hillside portion of cable car route, airport and New Town. The visible portion for all routes are more intrusive when seen against skyline and natural hillside backdrop, particularly from Buddha statue. The cable car route will be overlooking the Lin Tse Temple at a separation of approximately 30m. ***Terminal building:*** Westerly location for terminal will have lower impact by avoiding most popular views of monastery and Buddha statue with improvement to existing bus terminal and pedestrian circulation / vehicle segregation. Potential overall enhancement if terminal design reflects the scale and style of existing monastery architecture.	Adverse Insignificant, potential enhancement
Passengers on marine route along the West Lantau Coast	Non-interrupted by the cable car system	Low	The considerable distance from the viewer are expected to render the visual impacts of the cable car to this group insignificant.	Insignificant

6.0 EVALUATION OF ALIGNMENT OPTIONS

6.1 Introduction

6.1.1 This cable car project will serve two purposes. It will play an important part in increasing the capacity of the transportation network at South Lantau and in enhancing safety on Tung Chung Road. In addition, the cable car ride will stimulate interest and enhance the visitors' experience in visiting Ngong Ping.

6.1.2 Under the TDD's Study, 4 alignment options for the cable car system with different terminal locations at Tung Chung and Ngong Ping have been explored. This Study has reviewed these alignments and included another 3 alternatives (refer to Figure 1.1) for evaluation. These new alternatives are identified in the course of this Study taking into consideration the new findings and requirements of this cable car project.

6.1.3 There are a number of factors that will influence the choice of the alignments and this study has evaluated these factors and provide in the end with a matrix comparison for determining the most optimum solution.

6.2 Terminal locations

Tung Chung Terminal

6.2.1 The alignment of the cable car system will be firstly dictated by the terminal locations at Tung Chung and Ngong Ping. As shown in Figure 1.1, the 4 alignment options under the TDD's Study have different terminal locations A, B, C and D at Tung Chung. The alignment Option 1 was rejected in the TDD Study because of its impacts on the adjacent developments. No more evaluation will be carried out on this option. For the other 3 terminal locations, they are located respectively in Planning Areas TC74, TC71 and TC72. The other terminal locations E and E1 at Tung Chung which have been investigated under this Study is in Planning Area TC2 (refer to Figure 6.1).

Location B at Tung Chung West Area (TC74)

6.2.2 The proposed location for the CCT at area TC74 is next to the Tung Chung Hau Wong Temple and is proposed because of the two possibly available lots at the end of the existing footbridge to the west of the youth centre. The lots are irregular in shape of 0.89ha and 0.44ha. The larger lot is a government lot covering a number of Crown Land Licences and the smaller lot is a private land – Lot 125 in DD1 Tung Chung.

Location C at Pak Sha Tsui (TC 71)

6.2.3 The proposed location for the CCT in Area TC71 is on the future Pak Sha Tsui Island. The site was initially identified for the advantage of a short and direct routing (4km) to Ngong Ping. Furthermore, it ensures a highly visible and prestigious setting for the CCT in Tung Chung Wan and provide a scenic flight that has a good panoramic view on the new airport and Tung Chung New Town. Location C was also identified due to the proximity to the future Tung Chung West MTR Station and the scope for integrated development with other tourist related uses.

Location D at Pak Sha Tsui (TC72)

6.2.4 The proposed location for the CCT in Area TC72 would facilitate a direct routing (4.2km) to Ngong Ping. The site has ample area (4.4 ha) for an integrated development of the CCT including a hotel, recreational and public transport facilities. It will be approximately 800m on plan and 920m along public roads from the future Tung Chung West Station. This location will allow a less visually intrusive alignment for the waterfront developments in Tung Chung West should a link to the town centre become necessary.

Location E at Tung Chung Town Centre (TC2)

6.2.5 The proposed location for the CCT in Area TC2 is very close to the existing Tung Chung Station. This proposal focuses on the easy pedestrian walkway at an elevated level connecting between the MTR Station and Cable Car Terminal. The elevated walkway provides a convenient public pedestrian network linking the existing town centre to the new developments on the northern waterfront of Tung Chung.

Location E1 at Tung Chung Town Centre (TC2)

6.2.6 This location is within Area TC2 and is next to Location E. This location is proposed upon the identification of the most preferred alignment for the cable car route having the Intermediate Station on the Airport Island. The conditions of this location is very similar to Location E apart from the requirement for rezoning for the commercial development around the Terminal within the current 'G/IC' site as described in Section 5.

6.2.7 Evaluation of Different Tung Chung Terminal Locations :
(A rating of 5 is the best while a rating of 1 is the worst. A '0' rating may mean the conditions contradict the criteria)

Criteria	**Evaluation**		**Rating (1 – 5)**
Accessibility to Public Transport Interchange (Refer to Figure 6.1)	Location B -	This location is 450m from the future Tung Chung West Station which however will unlikely be in place before 2011 as advised by the MTRC. The site could be connected to Road P2 by extending the road half a kilometer. The location is approximately 2km from Tung Chung Station. Shuttle bus service between the CCT and the existing public transport interchange at Tung Chung Central will be required. This will make the option less attractive in terms of environmental protection. This will also reduce the commercial viability of this cable car project as it will have an adverse effect to the cable car ridership.	3
	Location C -	This location is within walking distance (570m along the MTR reserve, 720m along public roads) from the future Tung Chung West Station. Future connection could be made by way of elevated covered walkway (with potential provision of travelators) linking the podiums of the two developments. The walkway would follow the alignment of route L4, bridging the waterbody over to the island. Given the delayed programme of the Tung Chung West Station, this is likely to be a long term proposition. The location is approximately over 2km from Tung Chung Station. Shuttle bus service between the CCT and the existing public transport interchange at Tung Chung Central will be required. This will make the option less attractive in terms of environmental protection. This will also reduce the commercial viability of this cable car project as it will have an adverse effect to the cable car ridership.	2

Criteria	**Evaluation**		**Rating (1 – 5)**
Accessibility to Public Transport Interchange (con't)	Location D -	This location is approximately 1km from the future Tung Chung West Station and over 2km from the existing Tung Chung Station. Shuttle bus service between the CCT and the existing public transport interchange at Tung Chung Central will be required. This will make the option less attractive in terms of environmental protection	1
	Location E -	This location is only 250m from the existing Tung Chung Station. One primary difference of this Location E from the other proposed terminal locations is its easy accessibility to the existing transport interchange in Tung Chung Town Centre. As discussed in Section 2, a large proportion of the cable car riders is local residents most of which will prefer to take the MTR to Tung Chung and change the cable car to Ngong Ping. Although there may also be direct bus lanes reaching the other proposed terminal locations at B, C and D from Kowloon and Hong Kong Island, a direct link from the MTR Station to the CCT is clearly an overriding advantage.	5
	Location E1 -	Same as for Location E.	5
Adequacy of land for a comprehensive development	Location B -	One Government lot of 0.89 ha and one private lot of 0.44 ha owned by the Secretary for Home Affair Incorporated have been identified. These lots however are irregular in shape and are not desirable for comprehensive development. These two lots with some adjacent private land is about 2ha which is too small for an comprehensive CCT, tourist retail, commercial and transport development. DLO/IS has verbally advised that the football field within one of the identified lots has been vested in the name of Home Affairs Department but still remains as private lot no. 125 in DD1TC as with the playground, latrine and the adjacent garden. The site is adjacent to Hau Wong Temple and has the potential for an integrated development for tourist attraction.	3
	Location C -	The site provides an ample area of about 4.4 ha of land for the terminal, hotel and associated facilities and is of regular dimensions ensuring ease of site planning. It is the intention that this site is to be developed with the CCT integrated with a hotel, a retail complex and other entertainment facilities as a tourist attraction resort. Initial consideration is for the provision of a podium development across the site which will accommodate a retail area with bus terminus and carparking provision at the ground floor. The CCT will be accommodated on the south western section of the podium deck with a hotel tower constructed next to it.	5

Criteria	**Evaluation**	**Rating (1 – 5)**
Adequacy of land for a comprehensive development (cont'd)	Location D - The availability of land in this location is similar to Location C as a large area will be reclaimed in the future.	5
	Location E - The proposed location E is within the area zoned for town centre facilities including a "G/IC" zone, a "DO" (District Open Space) zone, and a "C" zone in addition to the "CDA" zone under construction at the Tung Chung Station (refer to Figure 4.3). The Terminal would be located mainly in the "G/IC" zone (Planning Area 2) and next to a "C" zone which spans across Tat Tung Road. Part of the "G/IC" zone would be needed as an easement for the cable car route. The part of the "C" zone nearer to the MTR station is fully required for a public transport interchange at ground level. A mix of retail and office uses has been planned for the "C" zone with a plot ratio of 3. The allowable GFA has been specified in the land sale document prepared by Lands Department (subject to the current land sale freeze). Apparently, the mix between retail and office would be up to the developer to decide. The planning intention within the OZP for Tung Chung Town Centre is to develop Tung Chung into a balanced community in support of the Hong Kong International Airport. The Tung Chung Town Centre plan includes a civic centre with a swimming pool complex in the "G/IC" zone (Planning Area 2) to serve the local community. Other than private and public residential developments, major land uses in the town centre will be commercial /office developments in the "C" zone and "CDA" zone (Planning Area 3 and 14) and a District Open Space in Planning Area 1. It is understood that the boundaries for each of the particular zones have not been rigidly defined. There is flexibility that they can be adjusted to suit the detailed planning objectives. In order to minimise the cable car terminal's impacts on existing planning intentions for the Tung Chung Town Centre and the "G/IC" zone, the cable car terminal, the public transport interchange, and the adjacent District Open Space could be planned and developed under an integrated design. It would allow the town centre to be developed with a coherent planning concept which will provide the greatest benefits to the amenity of the town centre.	3
	Location E1 - Similar to Location E. An integrated design within the "C", "G/IC" and "O" sites is required.	3

Criteria	Evaluation		Rating (1 – 5)
Timely provision of the cable car link	Location B -	The formation of the site would require diversion and training of the existing water stream. the Foreshore and Seabed (Reclamation) Ordinance procedure will need to be carried out. Time is also required to resolve the Government Land Allocation and other private land's resumption and clearance for the site area and the extension of Road P2. The statutory procedures for complying with the ordinances make this site less attractive in programme terms.	2
	Location C -	The Pak Sha Tsui Island is an artificial island to be formed in phase 3 development of North Lantau. If Location C is to be chosen as the terminal location, at least the southern corner of the Island will need to be formed in advance for the construction of the terminal and other accesses. Under normal procedure requirements, reclamation of the Tung Chung west area including Area 71 could not begin until mid 2000.	2
	Location D -	This location is very similar to Location C but a larger area (requiring longer time) of the Pak Sha Tsui Island will need to be formed in advance for a timely provision of the cable car facilities.	1
	Location E -	Both in the North Lantau Development Study and the statutory plan preparation stage for Tung Chung, a cable car scheme was not envisaged for the town or town centre. However, apparently in many OZPs prepared since 1994, standard schedules to the OZP have been used, and they include the land use of "cable car route and terminal building." In this way, the cable car use appears in two zone types in Tung Chung, namely: • In all G/IC zones, "cable car route and terminal building" is in Column 1 which means it is permitted without requiring the permission of the Town Planning Board. • In all "O" zones, "cable car route and terminal building" is in Column 2 which means it may be permitted with conditions on application to the Town Planning Board. There is a "C" (Commercial) zone in the town centre, but "cable car route and terminal building" appears in neither Column 1 nor Column 2. The proposed location for the cable car terminal in the Town Centre is within the "G/IC" zone with other associated facilities in the "C" zone. The cable car terminal construction can start immediately because of the availability of existing land.	5
	Location E1 -	Similar to Location E. Location E is within the current "G/IC" site. The cable car terminal construction can start immediately after the rezoning exercise.	5

Criteria	**Evaluation**	**Rating (1 – 5)**
Visual Impact (Refer to Figure 6.1)	Location B - In order to keep the alignment further away from the existing village site at TC60, the CCT has to be located to the north west corner of TC74 which will be very close to the schools at TC37. This would create visual/environmental impact on the schools.	2
	Location C - The site is within Area TC71 and will affect the residential development in the area. The site is also close to TC46 and will affect the housing site in this area.	2
	Location D - The site will be further away from the planned housing site at TC46 resulting in a lesser degree of visual/environmental impacts to the housing site.	3
	Location E - It is considered that with the terminal located at the heart of Tung Chung Town Centre, the terminal building has good potential to become a focal point within the New Town. The movement and activities associated with the cable cars is more likely to provide a dynamic element to the Town Centre of interest rather than intrusion to the population in general.	5
	Location E1 - Same as for Location E.	5
Ecological Impact	Location B - This location will be on the edge of the existing land in an urban setting with small scale of loss of vegetation	2
	Locations C and D - These locations will require the reclamation of the Pak Sha Tsui Island and will have impacts on the San Tau Beach SSSI.	1
	Locations E & E1 - These locations will be on reclaimed land in an urban setting with no loss of vegetation.	3
Commercial Viability	Locations B, C and D - As accessibility is always a crucial factor determining the popularity and sustainability of a tourist attraction, these locations with poor accessibility will reduce the development potential and commercial viability of the cable car project	2
	Locations E & E1 - This location provides a very good connection to the public transport interchange including the Tung Chung Station as well as the bus terminus in Tung Chung New Town. This can surely induce more people to make the journey to Tung Chung and take the cable cars to Ngong Ping.	5

Ngong Ping Terminal

6.2.8 Location Y to the East of Po Lin Monastery

All alignments in Options 2, 3 and 4 under the TDD's Study end at terminal location Y at Ngong Ping. This location is on the east corner outside the courtyard of Po Lin Monastery (refer to Figures 6.2 and 6.3). This site is on an existing slope and require site formation works for constructing the terminal and other associated buildings. Moreover, the available areas of the site are constrained by the existing Youth Hostel and a number of graves which will limit the development potential of the terminal. For this location, a vehicular access as well as a pedestrian access is required to be constructed to connect it to the existing Ngong Ping Road. This will require a substantial vegetation clearance along the access route and will cause adverse ecological impact to the area.

Location X to the West of Po Lin Monastery

6.2.9 The alternative terminal location at Ngong Ping being investigated in this Study is as shown in Figures 6.2 and 6.3. The site is located on the western side of Po Lin Monastery and is very close to the Giant Buddha (400m). The proposed location possesses the advantages of being close to the existing Ngong Ping Road and having large existing paved areas (i.e. less site clearance works are required). The terminal proposal includes a redevelopment of the existing bus terminus and 'hawker' areas in front of Po Lin Monastery. The new cable car terminal, relocated bus terminus and the redesigned taxi/coach areas will form a new public transport interchange at Ngong Ping. This terminal proposal has got full support from the Master of Po Lin Monastery.

6.2.10 Evaluation of Different Ngong Ping Terminal Locations :
(A rating of 5 is the best while a rating of 1 is the worst. A '0' rating may mean the conditions contradict the criteria)

Criteria	**Evaluation**	**Rating (1 – 5)**
Accessibility to Public Transport Interchange	Location Y - 400m from the existing PTI in front of Po Lin Monastery.	3
	Location X - The new PTI will be integrated with the Terminal development proposal.	5
Adequacy of land for a comprehensive development	Location Y - Limited by the topography and existing structures/graves.	2
	Location X - 2.8 hectares most of which are existing paved areas and to be redeveloped as open space and walking areas.	5
Timely delivery of site	Location Y - Large scale of site formation works is required	2
	Location X - Most of the land required is existing paved area and is ready for construction. The two private lots in concerned are just agricultural lots. Their acquisition is not considered as critical as the time for carrying out the large scale site formation works at Location Y.	5
Impacts on ecology	Location Y - A substantial vegetation clearance is required for the construction of the terminal and emergency/ maintenance access.	1
	Location X - Relatively small as there are large paved areas available and is close to the existing Ngong Ping Road.	4

Criteria	Evaluation		Rating (1 – 5)
Utilities supplies/ upgrading	Location Y -	Relatively more substantial upgrading works need to be carried out as it is not close to the existing Ngong Ping Road.	2
	Location X -	Relatively simple as close to the existing Ngong Ping Road.	4
Effects to the Ngong Ping Community	Location Y -	Relatively smaller as the location is not close to the majority of the Ngong Ping community.	5
	Location X -	Although this location is closer to the Ngong Ping community, the impact of the Terminal to the community is not expected to be large as the Terminal is still at a certain distance from it.	2
Support from the Master of Po Lin Monastery	Location Y -	Not supported	0
	Location X -	Supported as it can improve the overall layout in front of Po Lin Monastery	5

6.3 Alignment Options

6.3.1 This Study has investigated 3 alternative alignments for the cable car route in addition to the 3 alignment options examined in the TDD's Study (refer to Figure 1.1). The factors that will govern the choice of the alignment are different from those factors that will dictate the terminal locations. The alignment of the cable car will traverse over a large area between Tung Chung and Ngong Ping. It is necessary to understand the general environment and other related issues in the area as described in Sections 3 and 4 before the evaluation of the different alignments can start.

6.3.2 Of particular importance is the prediction and judgement of the significance of the effects of the cable car alignment on the country park, landscape character and visual amenity of such an attractive area in north Lantau. However, it should be noted that visual impact assessments, in particular, involve subjective opinion.

6.3.3 Since the circulation of the Draft Interim Report, this Study has investigated the suggestion made by the Steering Committee of extending the Alternative Alignment 2 northward and locating the Intermediate Station on the Airport Island. For matching the existing landform and infrastructure nearby, this Alternative Alignment 2 (Modified) will need to start at a slightly different location (Location E1) at Tung Chung. The alignment will run parallel with the Channel Bridge at approximately 13m apart until it reaches the Intermediate Station located within the planned commercial area on the Airport Island. The cable car will make the first turn at the Intermediate Station and crosses the sea channel onto the Lantau North Country Park.

6.3.4 Initially, the Intermediate Station on the Airport Island will only be used as an angle station to enable the cable car to change direction. However, the design of the Intermediate Station will incorporate provisions to allow the Station to be converted into a passenger station at a later stage when the surrounding commercial areas on the Airport Island is developed by the Airport Authority.

6.3.5 This modified alignment has offered an important advantage that there exist cable car systems (refer to Section 7) that can span the distances over the sea channel traversed by this alignment. (i.e. no towers are required in the sea channel and this project will no longer be governed by the Foreshore and Seabed Ordinance).

6.3.6 Evaluation of Different Alignment Options - refer to Sections 3 and 4 for the background information
(A rating of 5 is the best while a rating of 1 is the worst. A '0' rating may mean the conditions contradict the criteria)

Criteria	Evaluation	Rating (1 – 5)
No. of sections, length and maximum level of route	Option 2 - One straight section, horizontal distance 4km, reaches a maximum level 680mPD.	4
	Option 3 - One straight section, horizontal distance 3.5km, reaches a maximum level 620mPD.	5
	Option 4 - One straight section, horizontal distance 4.2 km, reaches a maximum level 680mPD.	4
	Alt. Aligmt. 1 - Two sections with one intermediate station, total horizontal distance 5.4km, reaches a maximum level 680mPD.	3
	Alt. Aligmt. 2 (Modified) - Three sections with two intermediate stations, total horizontal distance 5.7km, reaches a maximum level 550mPD	2
	Alt. Aligmt. 3 - Three sections with two intermediate stations, total horizontal distance 5.6km, reaches a maximum level 550mPD.	2
Visual impact (Refer to Figure 4.3)	Option 2 - The first portion of the alignment coming off the terminal at Area TC71 will cause visual impact to the housing sites in Areas TC46 and TC37. The majority of the alignment is clearly seen from Tung Chung New Town and will cause visual impact to the largest group of the sensitive receivers.	2
	Option 3 - The first portion of the alignment coming off the terminal at Area TC74 will cause visual impact to the housing sites in Area TC38 and TC81. This alignment will even impinge on the housing site in Area TC81. Since this route will be closer to those indigenous villages in the Tung Chung valley, it will have adverse visual impact to the existing residents, particularly in areas TC60 (Ngau Au Village), TC65 (Shek Lau Po), TC62 (Mok Ka) as well as the house scattered in Lam Che and Nim Yuen to the north of Mok Ka. The majority of the alignment is clearly seen from Tung Chung New Town and will cause visual impact to the largest group of the sensitive receivers.	1
	Option 4 - The first portion of the alignment coming off the terminal at Area TC72 will cause visual impact to the residential site in Area TC71. The majority of the alignment is clearly seen from Tung Chung New Town and will cause visual impact to the largest group of the sensitive receivers.	3

Criteria	Evaluation	Rating (1 – 5)
Visual impact (cont'd)	Alt. Aligmt. 1- the first section of the alignment coming off the terminal at Area TC3 will cause visual impact to the housing and residential sites in Areas TC4, TC72 and TC73. The proposed uses in Areas TC72 and TC73 are for an OU site, a hotel and service apartments. The closest distance of the centre line of the cable car alignment to the service apartments is approximately 100m.. Among the key issues considered in visual impact assessments, most relevant to the urban portion of the cable car are the degree to which the development obstructs views, the ability of the surrounding environment to absorb the new built elements, the number of sensitive receivers and their proximity to the development. The following description of the cable car route and the character of the Tung Chung environs outlines the anticipated nature of the visual impacts. • All seaward views from Tung Chung are dominated by the airport, the continuous background noise and movement of aircraft and, at times, the smell of engineer exhaust. The foreground views are similarly dominated by the extensive bridge, road and rail infrastructure and incessant traffic thereon. The residents of Tung Chung will view the proposed cable car route against this backdrop. • The cable car alignment, starting from the preferred terminal location, will cross the sea channel and be conspicuous in the short term until the future reclamation is completed and partly encompasses the route. The more the set back the more the impact of the cable car will recede and merge visually with the mass of the airport background. • The cable car system will have a generally similar appearance and scale to that of a high voltage powerline, i.e. relatively transparent tower structures and slender cables. The main difference is the moving gondolas, which, compared with the movement of road vehicles on nearby roads, are quiet, efficient, safer, non-polluting and do not operate 24 hours a day. The majority of the rest of the alignment can be seen from Tung Chung New Town and will cause visual impact to the largest group of the sensitive receivers. However, the effect will be less serious compared to the above 3 options as the alignment is further away from the New Town.	2

Criteria	Evaluation	Rating (1 – 5)
	Alt. Aligmt. 2 (Modified) - although section 1 of this alignment is also running out to the sea channel in front of the Tung Chung developments similar to that of the Alt. Aligmt. 1, it is further away from the Tung Chung development and cause less visual impact. For the hillside section, as the alignment is on the other side of the ridgeline separating Tung Chung New Town, its impact on the largest group of the sensitive receivers is much less. However, it will cause visual impact to the relatively small number of residents/hill walkers on the northwest coast of Lantau.	3
	Alt. Aligmt. 3 - the first section is the same as in Alt. Aligmt. 1. For the hill section, as the alignment is on the other side of the ridge line separating Tung Chung New Town and is furthest away from the Town, its impact on the largest group of the sensitive receivers is the least. However, it will cause visual impact to the relatively small number of residents/hill walkers on the northwest coast of Lantau.	2
Landscape (refer to Fig. 4.2)	Option 2 - The alignment crosses the largest amount of woodland (2090m) and has therefore the greatest potential for tree felling to accommodate the tower construction. This alignment begins in Area TC71 on the western fringe of Tung Chung and traverses the hillside directly west of housing sites in Areas TC37 and TC 46. The majority of housing in these areas is surrounded to the north, east and south by predominantly urban development. In contrast, the slopes to the west offer an attractive, natural landscape setting. Therefore, the intrusion of the cable car route on to these slopes will detract seriously from the undeveloped, rural landscape character of the western flank of the Tung Chung valley. The terminal at Ngong Ping would be to the east of the Po Lin Monastery and would likely require significant tree felling to accommodate the terminal and upgraded road and utility infrastructure.	2
	Option 3 -This alignment crosses the second largest amount of woodland (1590m) with relatively high potential for tree felling to accommodate tower construction. The Tung Chung terminal is located on the urban fringe close to residential sites in Areas TC 38 and TC 81 as well as village communities to the south-west. Like Option 2, where the cable car leaves the urban area and traverses the wooded hillside it will detract significantly from the landscape character of the traditional village communities and natural hillside scenery. The landscape impacts at Ngong Ping will be similar to Option 2.	2
	Option 4 - This alignment crosses similar amount of woodland (1590m) as in Option 3 with similar potential for tree felling to accommodate tower construction. The hillside portion of the route is very similar to that of Option 2.	2

Criteria	Evaluation	Rating (1 – 5)
Landscape (ref to Fig. 4.2) (cont'd)	Alt. Aligmt. 1 - This alignment utilises the Tung Chung town centre terminal with the intermediate station at Pak Sha Tsui Island. The first portion of the route should not detract significantly from the predominantly urban landscape character of the tow centre and airport backdrop. The hillside portion is aligned further to the west close to the main ridgeline crossing it north of Nei Lak Shan and terminating to the west of Ngong Ping. By so doing the route crosses the least area of hillside woodland (780m) and would require only selective tree felling at the Ngong Ping section. However, the stark, bold outline of the ridge is very sensitive to intrusion by development and the cable car will detract seriously from the landscape character and topography of the upland skyline as seen from Tung Chung	2
	Alt. Aligmt. 2 (Modified) - This route utilises Location E1 as the Tung Chung Terminal and has the same Ngong Ping terminal as Alt. Alignment 1. The hillside portion is aligned still further west on the east flank of the San Tau valley just below the ridgeline. The route crosses the second least amount of woodland (1390m) skirting the main concentration of trees on the lower slopes. The San Tau valley is less developed than Tung Chung valley and the intrusion into this natural and more remote upland landscape is potentially high. However, unlike Options 2, 3, 4 and Alt Alignment 1, this is countered by the seclusion of San Tau valley and the intervening ridgeline effectively concealing and helping to mitigate the landscape impacts of the hillside portion of the route from the New Town. Preliminary study indicates that only one tower for Alt. Alignment 2 may fall within woodland areas and, as with all the routes, replanting below the tower is possible.	3
	Alt. Aligmt. 3 - This route utilises the same Tung Chung and Ngong Ping terminal as Alt. Alignments 1 and 2. It is the most westerly route crossing the north end of San Tau valley and following the western ridgeline to Ngong Ping. The route crosses a similar amount of woodland (1430m) to Alt. Alignment 2, skirting the majority of the woodland which is concentrated on the lower slopes and valley floor. The route is similarly concealed from Tung Chung although portions on the ridgeline may be visible as intrusions into the natural skyline from coastal villages to the west.	3
Scenic view	Option 2 - The lower 600m of the route will provide a panoramic view on Tung Chung New town and the east end of the airport island. The portion of the alignment that can see Po Lin Monastery/ Giant Budda is relatively short and the view is relatively poor.	3

Criteria	**Evaluation**	**Rating (1 – 5)**
Scenic view (cont'd)	Option 3 - The first section of the route from the Tung Chung Terminal will offer a good view on Tung Chung Road, Tung Chung valley and the east end of the airport island. The spur line of the first knoll will however block the view to the west end of the airport. The portion of the alignment that can see Po Lin Monastery/ Giant Budda is relatively short and the view is relatively poor.	2
	Option 4 - The lower 600m of the route will provide a panoramic view on Tung Chung New town and the east end of the airport island. The portion of the alignment that can see Po Lin Monastery/ Giant Budda is relatively short and the view is relatively poor.	3
	Alt. Aligmt. 1 - Panoramic view on the New Town and the Airport on the downhill ride. The view on the Giant Buddha is better than the above 3 options when approaching Ngong Ping.	4
	Alt. Aligmt. 2 (Modified) - Panoramic view on the New Town and the Airport on the downhill ride. Unobstructive view of Giant Buddha and Po Lin Monastery when approaching Ngong Ping.	5
	Alt. Aligmt. 3 - Panoramic view on the Airport and the northwest coast on the downhill ride. Unobstructive view of Giant Buddha and Po Lin Monastery when approaching Ngong Ping.	5
Impacts to Ngong Ping environment	Options 2, 3 and 4 - These alignment will traverse across the country side on the east of the Monastery where most visitors to Ngong Ping will enjoy a walk in the quiet area beyond the bustle of the tourist development.	3
	Alt. Aligmt. 1 - This alignment will traverse over Lin Tse Temple and is closer to the residents at Ngong Ping.	2
	Alt. Aligmt. 2 (Modified) & 3 - This alignment will be clear of Lin Tse Temple and is further away from the residents at Ngong Ping.	4
Availability of existing footpaths as rescue/ maintenance trail	Options 2, 3 and 4 - No existing footpaths running close to these alignments.	0
	Alt. Aligmt. 1 - No existing footpaths running close to this alignment.	0
	Alt. Aligmt. 2 (Modified) - Existing footpaths are running close to this alignment over quite a long length of the alignment within the Country Park.	2
	Alt. Aligmt. 3 - An existing footpath is running close to the last section of this alignment near Ngong Ping.	1

Criteria	**Evaluation**	**Rating (1 – 5)**
Ecological impact	Option 2 - This alignment will have impacts on the key habitats including woodlands on the east of the Tung Chung valley.	2
	Option 3 - This alignment crosses habitats and species considered to be ecologically important.	1
	Option 4 - Similar to Option 2.	2
	Alt. Aligmt. 1 - This alignment is the least damaging ecologically as it impacts mainly on grassland and scrub habitats.	4
	Alt. Aligmt. 2 - Similar to Alt. Aligmt. 1 but with slightly severe impacts on habitats.	3
	Alt. Aligmt. 3 - This alignment will impact on the woodland and stream valley south of San Tau.	2
Fung shui issue (Refer to Figure 4.2)	Options 2, 3 and 4 - Clear of the ‘Elephant Trunk’ and ‘Dragon’s Back’.	3
	Alt. Aligmt. 1 - Clear of the ‘Dragon’s Back’ but slightly impinge on the ‘Elephant Trunk’.	2
	Alt. Aligmt. 2 - Clear of the ‘Dragon’s Back’ but impinge more on the ‘Elephant Trunk’.	2
	Alt. Aligmt. 3 - Clear of the ‘Dragon’s Back’ but significantly impinge on the ‘Elephant Trunk’.	1

6.4 Conclusions

The following summarise the ratings for different terminal locations at Tung Chung and Ngong Ping and the 6 different alternative options for the cable car alignment.

6.4.1 Tung Chung Terminal

(A rating of 5 is the best while a rating of 1 is the worst for individual criterion)

Criteria	**Location B**	**Location C**	**Location D**	**Location E**	**Location E1**
Accessibility to Public Transport Interchange	3	2	1	5	5
Adequacy of land for a comprehensive development	3	5	5	3	3
Timely provision of the cable car link	2	2	1	5	5
Visual Impact	2	2	3	5	5
Ecological Impact	2	1	1	3	3
Commercial Viability	2	2	2	5	5
Total score	**14**	**14**	**13**	**26**	**26**

6.4.2 Ngong Ping Terminal
(A rating of 5 is the best while a rating of 1 is the worst for individual criterion)

Criteria	**Location Y**	**Location X**
Accessibility to Public Transport Interchange	3	5
Adequacy of land for a comprehensive development	2	5
Impacts on ecology	1	4
Utilities supplies/ upgrading	2	4
Effects to the Ngong Ping Community	5	2
Support from the Master of Po Lin Monastery	0	5
Total score	**13**	**25**

6.4.3 Cable Car Alignment
(A rating of 5 is the best while a rating of 1 is the worst for individual criterion)

Criteria	**Option 2**	**Option 3**	**Option 4**	**Alt. Aligmt. 1**	**Alt. Aligmt. 2 (Mod.)**	**Alt. Aligmt. 3**
No. of sections, length and max. level of route	4	5	4	3	2	2
Visual impact	2	1	3	2	3	2
Landscape impact	2	2	2	2	3	3
Scenic view	3	2	3	4	5	5
Impacts to Ngong Ping environment	3	3	3	2	4	4
Availability of existing footpaths as rescue/ maintenance trail	0	0	0	0	2	1
Ecological impact	2	1	2	4	3	2
Fung shui issue	3	3	3	2	2	1
Total score	**19**	**17**	**20**	**19**	**24**	**20**

6.4.4 From the above evaluation, the preferred terminal location at Tung Chung is Location E1 at Area TC2. The preferred terminal location at Ngong Ping is Location X to the west of Po Lin Monastery. The preferred alignment is Alternative Alignment 2 (Modified) with the Intermediate Station on the Airport Island.

7.0 CABLE CAR SELECTION

7.1 Background and Approach

7.1.1 The objective of the cable car selection is to conduct a detailed study of the existing proven cable car systems available in the market. For each of the systems examined, the following process has been used to systematically consider and evaluate the system requirements.

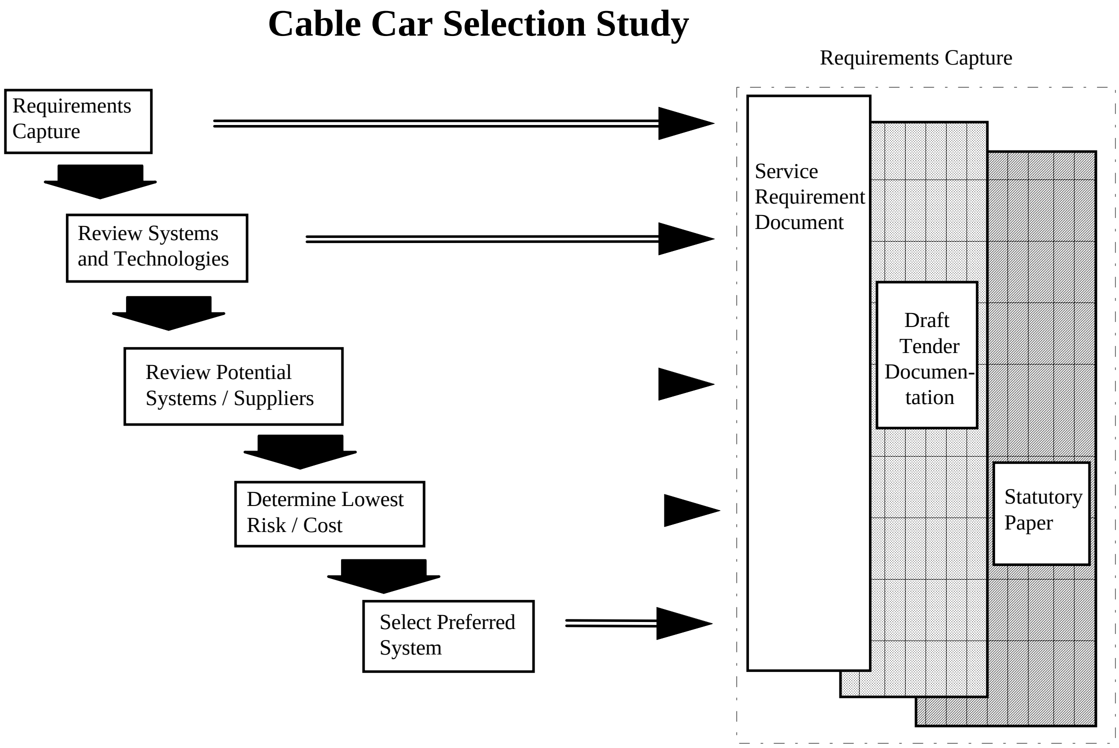

Diagram 7.1

The objective is accomplished through translating the process into the following key tasks.

- Systems requirements capture (Task C1).
- Review of current systems and available technologies (Task C2).
- Review of potential suppliers and their systems (Task C3).
- Selection of the preferred system (Task C4).
- Procurement methodology (Task C5).

7.2 System Requirements Capture

7.2.1 To populate the requirements database, the first objective was to identify the systems requirements. To achieve this, reviews of a number of project documents including the following have been conducted:

- Working Paper WP10
- Hong Kong Code of Practice (Design, Manufacture and Installation of Aerial Ropeways).
- Preliminary Appraisal for the Tung Chung to Ngong Ping Cable Car Final Report 1997.

From these documents the base requirements for the cable car system were extracted, analysed and distilled to create the System Requirement Specification.

Height Restriction over Tung Chung Channel

7.2.2 The Government Flying Services (GFS) have stated that the towers and cables strung over the Tung Chung Channel between the Airport Island and Tung Chung should not be higher than 60m above ground level. This is one requirement for designing the cable car system in this area.

Vertical Clearance to Roads

7.2.3 The initial discussion with Highways Department indicates their requirements as follows :

- The minimum clearance between cable car bottom and road surface is to be 6 to 7m.
- To ensure that no passengers can throw dangerous particles from the cable cars down to the road, 10mm or smaller wire mesh is suggested to cover any ventilation openings and windows inside the cabins.
- The cable car operator shall carry out regular maintenance to ensure no loose parts from the system will drop down onto the road.

Wind Resistance

7.2.4 One of the main requirements for the cable car system is its resistance to wind. To ensure that the cable car system is available throughout the operating year, the preferred system must not only be able to withstand the average and gust winds but remains operational in these conditions.

7.2.5 In Ocean Park where the Monocable systems are used, the operating procedure is whenever the wind sensors installed at the top of the two highest towers record three no. times of wind gusts of more than 76 km/hr, the systems will need to be shut down. Based on the information from Ocean Park, there were approximately 30 days in 1998 that the systems were shut down due to strong wind.

Wind Characteristics in Tung Chung and Ngong Ping

7.2.6 There are limited wind data available in Tung Chung and Ngong Ping as recorded at the few wind stations in the area. Figures 7.1 shows the wind gust data recorded at the wind station at Tung Chung Police Station for a period of 16 months between 1994 and 1995. These data show a relatively calm wind situation at the low level of the proposed cable car alignment. Figures 7.2 and 7.3 show the wind gust data recorded at Nei Lak Shan (at approximately 740mPD) for a period of 21 months between 1994 and 1998. These data show that quite a proportion of time that the 76 km/hr wind gust speed were exceeded. In statistical terms, it is estimated that approximately 17 days within a year this will occur. As a reference, for a Tropical Cyclone Warning Signal 3, it means that strong wind is expected to blowing in the Victoria harbour, with a sustained speed of 41-62 km/h, and gusts which may exceed 110 km/h. Operation of cable car under Signal No. 3 is however prohibited under the Aerial Ropeways (Operation and Maintenance) Regulations.

7.2.7 To maintain the operation of the cable car between Tung Chung and Ngong Ping all year round, it is recommended that the cable car system to be adopted should be able to resist a wind speed of 90 km/hr.

7.2.8 According to the cable car manufacturers' submitted proposals as described below, the following are the persistent wind speeds under which the respective systems can still be in operations :

Moncable – 50 km/hr
Bi-cable – 90 km/hr
Funitel – 90 km/hr
3S – 90 km/hr

7.2.9 There are manufacturers claiming that their systems can resist a slightly higher persistent wind speed than the above. For a conservative approach, these have been ignored and the above wind speeds are taken as the criteria for assessing which systems can comply with the operational requirements.

Operating Procedures

7.2.10 To determine at what wind speed the respective cable car systems should not be operated will require to know the safety margins that have been allowed in the stated permissible wind speeds (i.e. at what persistent wind speeds the systems will start to fail by grip detachment or cables coming off the sheaves for example). However, there are no cable car manufacturers that can provide this information. In view of the disastrous consequence that will be resulted from this type of failure, it will be prudent to adopt a conservative approach by using these permissible wind speeds as the criteria for terminating the operation of the systems even for a temporary period. This is believed to be the criteria adopted in Ocean Park for their cable car system.

7.2.11 Wind in a particular speed does not normally last long. The quoted persistent wind can be interpreted as the mean wind speed which is the average of the wind speeds over a sufficiently long period of time. However, relying on such a data for the monitoring of the cable car operation will be too risky as the wind phenomenon is such a random event that an intolerable wind gust may occur within the monitoring period. The monitoring procedure should make use of a data that can be recorded 'instantaneously' as the determining data. For wind, it refers to the gust speed.

7.2.12 To understand how gusts can be related to mean wind speeds, it is necessary to understand their relationship in general terms.

7.2.13 Gust speed (of certain gust duration t) is usually defined as the largest averaged wind speed with an averaging period of t seconds occurring within a certain period. Thus it can be visualized that, the shorter the gust duration the higher will be the gust speed. On the other hand, if the gust duration is lengthened, then the gust speed will be lowered, and eventually will approach the hourly mean wind speed. The gust speed is often expressed in terms of the gust factor which is defined as

$$G(t) = \frac{v(t)}{V}$$

Where G(t) is the gust factor of gust duration t;
v(t) is the gust speed of gust duration t; and
V is the hourly mean wind speed.

7.2.14 Figure 7.13 shows the variation of gust factor with gust durations for wind recordings obtained from various locations in Hong Kong. In general they have the shape of an exponential decay curve with values approaching unity at large gust durations. Furthermore for the same gust duration, gust factors at different locations have different values. In fact they are different at different heights even at the same location.

7.2.15 It has been accepted in some similar past projects that a gust factor of 1.5 to 1.6 is appropriate. Applying a gust factor of 1.5 to the stated persistent winds that the respective systems can tolerate under normal operation, the following are the gusts that should be used as the criteria for terminating the operations of the respective systems.

- Monocable – 75 km/hr
- Bi-cable – 135 km/hr
- Funitel – 135 km/hr
- 3S – 135km/hr

Recommendation for Future Work

7.2.16 It is understood that the data collected at these two wind stations are limited and may not reflect the long term characteristics of the wind conditions along the proposed cable car alignment. Moreover, when the air flows over embankments and hills the air becomes 'squeezed' as it travels over the crest leading to strong flow accelerations. Flows down embankments or steep hills lead to a large area of sheltered flow in the leeside. Inside this region the flow can even reverse as a contra-rotating eddy is formed. For hills with little longitudinal extent, the wind flow tends to go around the hills leading to local wind direction changes and accelerations. With all these complexities, it is recommended during the detailed design stage to create a mathematical model to investigate the local wind conditions and to carry out a wind tunnel analysis to verify all the local effects of the wind along the whole preferred alignment.

7.2.17 The System Requirement Specification was structured to capture the various design, functional, performance and safety requirements. This document forms the basis of the requirement database which is being maintained under configuration control. Requirements including the preliminary hazard analysis that have been identified are being incorporated into the document as they arise to ensure that this is maintained up to date. Around 200 requirements have been identified for the system and these provide the criteria against which the suppliers' proposed cable car systems have been evaluated.

7.3 Review of Potential Suppliers and Systems

7.3.1 The initial approach was to hold review meetings with each of the suppliers and review their proposals as proposed in working paper WP10, the review has included the following suppliers:

- Doppelmayr
- Garaventa.
- Nippon Cable.
- Poma.
- Waagner-Biro.

7.3.2 In preparation for the review, a checklist to assess each of the suppliers' systems was developed. This approach ensured that a consistent review of each was maintained. The checklist included

- Capacity
- Cabin size
- Rescue method
- Wind resistance
- Spanning ability

First Request for Proposals from Suppliers

7.3.3 In recognition of and in response to the changing circumstances and to create a common baseline to assess each supplier, a Draft Cable Car System Specification was developed and issued to each of the suppliers. This exercise was carried out twice within the period of this Study. The suppliers was first requested to submit proposals for the base alignments as shown in Figure 7.4.

Response to the 1st Draft System Specification

7.3.4 Despite the short two week timescale to respond to the specification, all five suppliers have submitted proposed systems. Three generic systems (refer to Figure 7.5) were proposed as summarised below :

Table 7.1 Proposed Cable Car Systems from Suppliers for the 1st Proposal

	Supplier				
System	Doppelmayr	Garaventa	Nippon Cable	Poma	Waagner Biro
Mono-cable	✓	✓	✓	✓	✓
Bi-cable			✓		✓
Funitel	✓	✓		✓	

Proposals other than these 3 common systems have been ignored at this stage of assessment

Mono-cable system

7.3.5 The Mono-cable system comprises a drive station and tensioning station between which a single rope is used to both support and haul the passenger cabins. The cabins are attached to the haul rope using a detachable rope grip which when in the station is released, enabling the cabins to be detached and subsequently re-attached.

7.3.6 The rope and attached cabins are suspended above the ground using a number of line towers. As the cabins enter the station, the cabins are automatically detached from the cable, decelerated onto the conveyor system and passengers unloaded. Once unloaded, the cabins are cycled by the continuous conveyor system into the loading area, as the cabin moves forward, passengers embark. When the cabin reaches the acceleration area, it is accelerated back upto rope speed, when rope speed is attained, the cabin is re-attached to the rope and exits the station.

Bi-cable system

7.3.7 The Bi-cable system comprises a drive station and tensioning station between which two ropes are used. The first rope supports and guides the passenger cabins and the second hauls the cabins. The cabins are attached to the haul rope using a detachable rope grip which when in the station is released, enabling the cabins to be detached and subsequently re-attached. However, the support rope acts as a fixed guideway for the cabin to travel on.

7.3.8 The rope and attached cabins are suspended above the ground using a number of line towers. As the cabins enter the stations, the cabins are automatically detached from the hauling and guideway cables, decelerated onto the conveyor system and passengers unloaded. Once unloaded, the cabins are cycled by the continuous conveyor system into the loading area, as the cabin moves forward, passengers embark. When the cabin reaches the acceleration area, it is accelerated back upto rope speed, when rope speed is attained, the cabin is re-attached to the rope and exits the station.

Funitel system

7.3.9 The Funitel system comprises a drive station and tensioning station between which, typically, 2 ropes are used to suspend and haul the passenger cabins. The cabins are attached between the ropes by 4 detachable rope grips, such that when the cabin enters the station the grips are released, enabling the cabins to be detached and subsequently re-attached.

7.3.10 The rope is suspended above the ground using a number of line towers. As the cabins enter the station, the cabins are automatically detached from the cable, decelerated onto the conveyor system and passengers unloaded. Once unloaded, the cabins are cycled by the continuous conveyor system into the loading area, as the cabin moves forward, passengers embark. When the cabin reaches the acceleration area, it is accelerated back upto rope speed, when rope speed is attained, the cabin is re-attached to the rope and exits the station.

Summary of Assessment of the First Proposals

7.3.11 All suppliers stated that their Mono-cable design cannot operate in the specified wind conditions. To achieve the final design capacity of 4,300 pphpd in phase 2, two independent Mono-cable systems with around 80 towers are required.

7.3.12 Mono-cable systems are installed in many places world wide and proved to be a popular choice for locations other than those installed to serve ski resorts. At around 50% of the cost of a Funitel system, the systems that have been reviewed, with the exception of the Nippon system, offer significant initial system cost advantages over the Funitel system despite the requirement for two independent systems to achieve the phase 2 capacity requirements. This requirement impacts the size of the land corridor required and the station sizes and thus presents additional cost and economic considerations to be borne in mind during comparison.

7.3.13 The most significant factor that renders the systems unsuitable for this application is their inability to meet the wind requirements. With a safe operational wind speed of 50 km/h, the systems fall a long way short of the required 90 km/h. A further disadvantage of the Monocable System is that it requires a significant number of additional line towers. On average, requiring 45 more than the Funitel systems.

7.3.14 Funitel system generally meets all the specified requirements with around 30 towers. It provides the maximum resistance to wind

7.3.15 A significant amount of power is required at the terminal stations to drive the systems proposed. Where the drive station is located at Ngong Ping and at the angle station in the Country Park an investigation of the available power supply needs to be undertaken along with any associated costs of providing such a supply.

7.3.16 Waagner Biro have stated that their Bi-cable system can operate in wind speeds of upto 90km/h. The Bi-cable design proposed requires fewer line towers over both the Funitel designs by around 20.

7.3.17 Irrespective of system choice, a significant number of cabins will need to be stored when the system is non-operational. The storage location and space requirement must be addressed.

7.3.18 The choice of cabins for the system should be carefully considered, not only for their technical, safety, reliability and comfort features, but also for their aesthetics and appearance since this is the image that will be presented to the passengers and members of the public.

Second Request for Proposals from Suppliers

7.3.19 It is clear from the assessment of the initial proposals from various suppliers that Mono-cable system is not a suitable system for this project.

7.3.20 As the Study developed and the preferred alignment for the cable car route gradually established, the suppliers were requested to submit detailed proposals to meet the 2nd Draft System Specification based on the alignment shown in Figure 7.6. They were also requested to prepare a presentation to supplement their proposals after the submission.

7.3.21 However, Nippon dropped out at this stage as they considered that their systems would not be able to meet the wind resistance requirements of this project. Poma and Garavanta did not submit a proposal although they came to the presentation for general discussions. Detailed proposals were received from Doppelmayr and Waagner Biro based on Funitel and Bi-cable systems respectively.

Summary of Assessment of the Second Proposals

7.3.22 Both the Funitel and Bi-cable systems generally meet the system specification.

7.3.23 The Funitel system represents the modern cable car technology and is normally designed to convey larger capacity cabins (28 passengers) compared to the Bi-cable system (15 passengers).

7.3.24 The Funitel system, inherent with its dual cable design in a horizontal plane, is considered to be more stable under strong wind conditions.

7.3.25 The Bi-cable system however requires less towers (8 no. as against 27 no. in Funitel), consume less energy and require less maintenance work than the Funitel system.

7.3.26 For further assessing the performance of these two systems in complying with the project requirements and their suitability to Hong Kong conditions, a trip to Switzerland and Austria was made by a joint delegation comprising representatives from MTRC, EMSD and Consultants (Mott Connell Ltd.) to visit a number of recent installations. The experience gained in the visit was compared against the submitted proposals and the current operational regime of the Mono-cable system in Ocean Park.

7.4 Review of Current Systems and Available Technologies

7.4.1 At the beginning of the Study, a visit to the Ocean Park system was made. This system began operation around 20 years ago, it therefore is not typical of modern cable car installations found around the world. The review however provided an understanding of the operating conditions in Hong Kong. A trip was made to Switzerland and Austria in January 1999 to visit a number of recent installations of cable car systems that have been identified as having the potential of meeting the requirements of this Project. The systems visited are summarised in Table 7.2.

7.4.2 Before the visit to Switzerland and Austria, it is considered that the Bi-cable and Funitel systems may be the promising cable car systems for this project as it meets both the capacity and wind resistance requirements. During the visit, a tri-cable now designated the "3-S" system (see Figure 7.5) was introduced by Doppelmayr and was found to be capable of complying with all the specified requirements. Its ability of spanning long distance and superb riding comfort has made it comparable to the Funitel system in technical terms.

7.4.3 The 3S system was designed by the Swiss company Von Roll Transport Systems Ltd. and was a world innovation in 1987. The installation visited is the only 3S system installed in the world at the present time. The triple cable endless ropeway with two support cables and one traction cable combines the advantages of the aerial tramway with those of the gondola-lift. It allows long spans and obstacles to be covered with just a few pylons. The tri-cable system is practically unaffected by winds and reaches a considerable travelling speed and transport capacity with low friction loss and energy consumption.

7.4.4 A detailed comparison between the 3S system and Funitel system was made before the second section of the cable car in Saas Fee was constructed. The tri-cable system has minimum maintenance costs. The Funitel system has a greater proportion of parts subject to wear and tear. The annual energy consumption of the Funitel is a great deal larger than that of the tri-cable system. The same is also true with respect to the comparison of wear and tear.

7.4.5 In technical terms, the Bi-cable system apparently also meets the project requirements though it is considered that it has less wind resistance compared to Funitel or 3S systems.

7.4.6 In Ocean Park, the designed speed for operating the cable car is 4 m/s though the cable car is normally operated at 3.2 m/s with a cabin speed in the stations of 0.18 m/s. When compared to current operating speeds for cable car systems world-wide, these are found to be significantly lower. Typically, rope speeds between 6 and 7 m/s are commonplace for modern installations with cabin speeds in stations set at between 0.2 and 0.3 m/s.

7.4.7 The critical factor for an urban transportation system is the loading and unloading speed and hence the time available at the stations. This speed will also dictate the capacity of the system as it governs the space between cabins within the station. For achieving the high capacity required, it seems to be appropriate to adopt the maximum station speed of 0.25m/s allowed in the Hong Kong Code of Practice for Ropeway Design in conjunction with the maximum designed rope speed during peak hours. This speed can be reduced by lowering the overall line speed of the system when elderly people and children are required to be assisted to board the cabins.

7.4.8 Cable car systems, being elevated above the ground, are susceptible to effects of wind, the extent of this susceptibility is largely dependent upon the system type, i.e. Mono-cable, Bi-cable, Tri-cable or Funitel system. For the Mono-cable system in Ocean Park, in the event of a wind gust in excess of 56 km/h an alarm is generated to the controller, the controller, using his judgement assesses the situation and can choose to manually reduce the system speed. Should the wind gust exceed 76 km/h the cable car system is automatically shut down. In addition, if typhoon signal number 3 is hoisted, no operation is permitted.

Table 7.2 Details of the Overseas Installations Visited

System	**Tricable (3S)**	**Funitel**	**Funitel**	**Bi-cable**	**Funitel**
Location	**Saas Fee (Switzerland)**	**Montana (Switzerland)**	**Ischgl (Austria)**	**Mayrhofen (Austria)**	**Hintertux (Austria)**
Manufacturer	**Doppelmayr**	**Garaventa**	**Doppelmayr**	**Waagner-Biro**	**Doppelmayr**
Year of operation	1991/1994	12/1995	12/1998	12/1995	1994
No. of sections	2	1	2	2	1
Means of separation between sections	2 independent sections (passengers required to change cabins)	N/A	Intermediate station with embarking and disembarking facilities / deflection angle 2deg.	Deflection tower / 7 deg.	N/A
Inclined length (m)	2905/1478	3211	1954/1984	2980 total	2280
Max. gradient (%)	66	63.5	73.1	80	61.81
Vert. rise (m)	808/390	656	323/638	1150	578

System	**Tricable (3S)**	**Funitel**	**Funitel**	**Bi-cable**	**Funitel**
Location	**Saas Fee (Switzerland)**	**Montana (Switzerland)**	**Ischgl (Austria)**	**Mayrhofen (Austria)**	**Hintertux (Austria)**
Manufacturer	**Doppelmayr**	**Garaventa**	**Doppelmayr**	**Waagner-Biro**	**Doppelmayr**
Number of towers	4/3	5	12/11	3	7
Max. tower height (m)	51/62	33	23	36/20/10	31
Max. span (m)	1300	1100	690	1360	580
Haul rope dia. (mm)	44.5	50	47	43	45
Track rope dia. (mm)	51.5	N/A	N/A	52	N/A
Tensioning method	Counter wt.	counter wt.	hydraulic	hydraulic	Hydraulic
Max. rope speed (m/s)	6/5	6	6	5.5	6
Station speed (m/s)	0.15	0.3	0.3	0.25	0.3
System capacity (pers/h)	2000/1500	2400	3400/3400	2000	3200
Cabin capacity (pers)	30 standing	30 standing	18 seating 6 standing	15 standing	18 seating 6 standing
Cabin no.	25/14	20	31/32	49	34
Cabin size (m x m)	3.8 x 2.9	30x1.2m	3.6 x 2.5	1.97 x 2.015	3.6 x 2.5
Cabin interval (sec)	54/72	45	25.12	27	
Cabin communication	Wireless one way	Wireless one way	Wireless one way	Wireless one way	Wireless one way
Drive station location	Inter. stn.	Top Stn.	Top Stn.	Top stn.	Top stn.
Max. claimed wind resistance (km/h)	90	90	90	90	90
Max. operating wind speed (km/h)	70	70	75-80	75-80	80
Rescue method	vertical/ horizontal	vertical/ horizontal	vertical	vertical/ horizontal	vertical
Staffing	1 at each station	1 at each station	2 at each station	2 at each station	2 at each station
Riding Comfort	Best	Worst at tower locations and swing significantly	Generally stable.	Generally O.K. but less stable compared with Funitel. Perform well at tower.	Generally stable.

7.4.9 Under the Swiss authority's requirements, the cable car systems should be shut down at a wind speed of 60km/h. The reason is not because the systems cannot tolerate a higher wind speed but the systems are largely installed for skiers and most of them will not take the risk to ski when the wind is at a speed higher than 60km/h. The normal design for these cable car systems is thus only for a wind speed of 80km/h. The Swiss authority stated that they were prepared to accept the operation of the cable car under a higher wind speed provided that the design demonstrates that the system is still safe at 1.25 times the limiting operational wind speed.

7.4.10 The Austria authority will allow different systems of Funitel or Bi-cable (but not Monocable) to operate under different warning wind speeds so far as the designs can demonstrate that the systems can work to the corresponding wind speeds with sufficient safety margin (normally 20%). If the warning speed is exceeded, it will be up to the operator to determine when the system should be shut down. In most cases, the systems were only shut down at speeds higher than 75km/h or 80km/h persistent wind.

7.4.11 To rescue passengers from the cabins in the event of an emergency, in accordance with the HKCOP the Ocean Park system uses the vertical rescue technique. In emergency situation, rescue teams will be sent out to the line and by using a rescue winch and harness, the passengers will be lowered in turn to the rescue path on the ground. For this operation, it is clear that the rescue path is required to permit both access to the towers for the rescue teams and to facilitate egress for the rescued passengers. However, in 20 years of operation, this technique has never been actually used.

7.4.12 Rescue cabins are provided in 3 of the installations visited in Swiss and Austria. However, they are not provided along the whole route. The general method of rescue is still by vertical rescue and with the rescue cabins installed within sections that are inaccessible at ground level. None of the installations have experience of breaking down or accidents that require emergency evacuation of the line. They have not maintained a special rescue team for this purpose. The general principle adopted is to make the line running again in all cases wherever possible and bring the passengers back to the stations in their own cabins. In case of any breakdown, a service cabin which is operated independently of the passenger ropeway will be sent out to repair the system and vertical rescue is used only as the last resort when all other ways fail.

7.4.13 Most of the systems visited in Swiss and Austria cross highways, rivers and powerlines. No special measures are installed to prevent accidents caused by falling cables or cabins. The manufacturers consider that the cables for the systems are safe elements and will not consider in normal design the case that the cable breaks.

7.4.14 No specific clearance is required along the cable car alignment by the Swiss and Austria authority provided that the alignment is at a sufficient horizontal and vertical clearance from and above the trees. Trees are removed only when the cable car route is close to or interfere with the trees along the alignment.

7.5 Selection of the Preferred System

7.5.1 As a consequence of the visit and upon the finalisation of the preferred alignment (Airport Island alignment), the suppliers are requested to modify their second proposals to suit the latest development of this Study. Doppelmayr is also requested to submit a proposal based on the 3S system. The approach to the selection of the preferred systems has been modified to evaluate the three system types against the following key criteria:

- Achievement of ultimate design capacity of 5000pphpd (2016)
- Wind resistance
- Spanning ability
- Proven technology
- Stability
- Safety and reliability
- Riding comfort
- Rescue method
- Tower height
- Cabin shape/seating arrangement
- User’s feeling
- System cost
- Operation and maintenance costs
- Potential environmental impacts

7.5.2 To minimise the environmental impact and costs of repeated civil engineering works in the country park, the design for phase 2 capacity should be completed in phase 1. In general, this will involve ensuring the design of the civil works includes the predicted phase 2 loading requirements. If the cable car system design for phase 1 incorporates the requirement for the forecasted ultimate capacity at phase 2 then the transition to the phase 2 capacity is simply a case of increasing the number of cabins on the line. This provides the ability to increase the system capacity as demand increases.

7.5.3 The following table summarise the comparisons between the 3 systems submitted by different suppliers. It should be noted that the following evaluation is not intended to compare suppliers and therefore should not be used for this purpose.

Table 7.3 Comparison between Funitel/3S/Bi-cable systems
(data given in this table only base on conceptual design)

Item	**Funitel**	**3S**	**Bi-cable***
General			
System Capacity (pph)	6,000	5,000	4,000
Patronage Demand (pphpd) - Phase 1 - Phase 2	 3,600 4,300	 3,600 4,300	 3,600 4,300
Tolerable Operation Wind speed	90 km/h at reduced speed	90 km/h at reduced speed	90 km/h at reduced speed
Spanning ability	not as good as the other two systems	good	good
Proven technology	yes	yes	yes
Stability	good	good	not as good as the other two systems
Safety and reliability	good	good	good
Riding Comfort	good	Best	O.K.
Rescue Method	Vertical / Horizontal	Vertical / Horizontal	Vertical / Horizontal
Route Length – Horizontal - Inclined	5,598 5,669	5,598m 5,669m	5,555m 5,635m
Journey Time - Phase 1 - Phase 2	13.9 min 13.9 min	15.4 min. 15.4 min.	15.4 min 14.0 min
Station Speed (loading / unloading)	0.25 m/s at max. rope speed	0.25 m/s at max. rope speed	0.25 m/s
Angle Station Speed	1.5 m/s	1.5 m/s	To be confirmed
Drive			
No. of driving systems	1 no. for Section 1 1 no. for Sections 2 & 3	1 no. for Section 1 1 no. for Section 2 & 3	1 no. for Sections 1, 2 & 3
Main Drive Emergency Drive	Electric drive Diesel drive (operated at 1 m/s)	Electric drive Diesel drive (operated at 1 m/s)	Electric drive Diesel drive (operate at lower speed)
Type of Drive Machine	Fully automatic vault type	Fully automatic vault drive	Fully automatic
Drive Power - Phase 1 - Phase 2	780 kW (Section 1) 2,370 kW (Sections 2 & 3) 840 kW (Section 1) 2550 kW (Sections 2 & 3)	160 kW (Section 1) 1320 kW (Sections 2& 3) 180 kW (Section1) 1500 kW (Section 2&3)	1060 kW (Sections 1, 2 & 3) 1,200 kW (Sections 1, 2 & 3)
Rope			
Ropeway Configuration	Doubel Haul rope with no Track Rope	Single haul rope with double track ropes	Single haul rope with one track rope
Rope Diameter - Track - Haul	- 52mm (2 nos.)	Section 1 : 50mm (2 nos.) Section 2& 3 : 60mm (2 nos.) 50mm (1 no.)	62mm (1 no.) 40mm (Phase 1) (1 no.) 46mm (Phase 2) (1 no.)

Item	Funitel	3S	Bi-cable*
Rope Speed (m/s) - Phase 1 - Phase 2	7 m/s 7 m/s	5 m/s Section 1 7 m/s Section 2 & 3 5 m/s Section 1 7 m/s Section 2 & 3	6 m/s 6.6 m/s
Type of Rope Tensioning	Hydraulic	Hydraulic	Hydraulic
Maximum Horizontal Deflection of Haul Rope	2.85m		3.5m
Cabin			
No. of Passenger Cabin - Phase 1 - Phase 2 No. of Service Cabins	 91 2	 91 2	 119 124 2
Cabin Capacity - Seating - Standing	18 10	18 10	10 8 (Total capacity can be upgraded to 25 with additional cost)
Cabin Size	3.6m x 2.4m	3.6m x 2.9m	2.3m x 2.3m
Cabin Spacing - Phase 1 - Phase 2	 156m Section 1,2 & 3	 136.5m Section 1 191m Section 2 & 3	138m 100m
Cabin Interval - Phase 1 - Phase 2	36 sec 23 sec	 27 sec	23 sec 15 sec
Cabin Parking Area	2 Terminals, 1 Intermediate Station, 1 Angle Station	2 Terminals, 1 Intermediate Station, 1 Angle Station	2 Terminals
Cabin / Control Room Communication	Intercommunication System	Intercommunication System	One-way receiver
Max. Longitudinal Swing of Cabin at max. 45º gradient of haul rope	19º	New hanger to be designed	To be confirmed
Max. Lateral Swing of Cabin	Minimal	Minimal	11º
Tower			
No. of Line Towers	31	8	9
Line Tower Height	Max. 53m Min. 6m	Max 55m Min 20m	Max. 60m Min. 28m
Line Tower Structure Type	Steel tubular with smaller foundation	Lattice towers	Steel truss with larger foundation
Span between Line Towers	Max. 543m Min. 10m	Max. 1388m Min. 200m	Max. 1,060m Min. 220m

*data is still based on Alternative Alignment 2

7.5.4 The tower locations and the longitudinal profiles for the above systems are shown in Figures 7.7 to 7.12. It should be noted that the number, locations and heights of the towers shown in these Figures are only indicative of the scale of requirements for the respective systems. The final layout will still be subject to detailed design.

7.5.5 The basic Funitel system would not be able to span across the sea channel and likely requires a tower to be constructed in the sea. This is a major disadvantage of the system on top of its high energy consumption and maintenance costs.

7.5.6 Funitel systems represent the latest system technology in the developing cable car industry, consequently many new systems are being installed and commissioned. The suppliers also claim that with modifications to the basic design, the Funitel system may also be able to span the distance in the sea channel to eliminate the tower required.

7.5.7 Both the 3S and Bi-cable systems have similar tower number and heights. Both systems can span across the sea channel.

7.5.8 World wide the Bi-cable systems are being replaced by Mono-cable systems although they are still available and popular for certain applications. Though its capacity can meet the current project requirement, it is already at its limit. Further expansion of the system to meet an increased demand is not possible. The system appears to be designed for skiers. Its stability and riding comfort could not match those of the Funitel and 3S systems.

7.5.9 The 3S system can allow long spans and obstacles to be covered with just a few pylons. This tri-cable system is practically unaffected by winds and reaches a considerable travelling speed and transport capacity with low friction loss and energy consumption. Its superb riding comfort is one crucial advantage of the system.

7.5.10 Both the 3S and Funitel systems are recommended to be taken forward for procurement tendering based upon a common performance and technical specification.

7.6 Conformance to the Hong Kong Code of Practice for Aerial Tramways

7.6.1 As the study is progressing, the proposed systems are compared to the requirements specified in the Hong Kong Code of Practice for Aerial Tramways (HKCOP). This exercise will be an on-going exercise through to the detailed design stage and the following is a summary of the observations to date:

- The HKCOP is written for Mono-cable and Bi-cable design. In the event that a Funitel or a 3S design is selected, the code would need to be amended to accommodate the differences.
- As described in Section 4, the requirements in the HKCOP for providing 15m wide clearance either side of the cable car alignment is to be reviewed for this project.
- The suppliers are proposing to use rope speeds of between 6 and 7 m/s, these are significantly above the HKCOP specified 4 m/s.

7.6.2 Detailed discussions with EMSD are required to confirm the requirements for designing the cable car for this project.

7.6.3 The European Community will soon (probably in May 1999) publishes a new European Community Cope of Practice (COP) to govern the design/manufacturing/design/safety for ropeway systems covering Monocable and Bi-cable systems. However, this COP will not cover Funitel as it is too new to the Community. This EC COP can be used as a reference for the detailed design.

7.6.4 The Swiss authority also has a reference document for governing the design for the 3S system.

7.7 System Assurance

7.7.1 This System Assurance Plan (SAP) comprises the organization and activities required to ensure that Tung Chung Cable Car system is reliable, cost efficient, easy to maintain, and safe. The SAP includes the application of a management structure and analysis techniques required to achieve acceptable levels of safety, reliability, and maintainability.
Authority

7.7.2 The Hong Kong SAR Government has statutory authority over the construction of the Tung

Chung Cable Car system including safety-related activities, procedures, and equipment. The laws and ordinances of the Hong Kong SAR Government will define the acceptable standards for the transit system construction and safety requirements.

Policy

7.7.3 It is a common requirement worldwide that System Assurance (SA) be a primary consideration throughout the development of a cable car system from preliminary engineering through revenue operations. To fulfill such an obligation, all applicable codes and regulations, augmented by modern SA engineering technology and industry standards, will be used to ensure that equipment achieves a level of SA that meets or exceeds the contractual requirements.

7.7.4 During the Preliminary Engineering and Final Design phases of the cable car system, the emphasis of the SA program will be on maximizing safety, reliability, and maintainability through design analysis, review, and equipment selection. During the Construction/Acquisition phase, the emphasis will shift to assuring that the system meets the SA requirements identified by the contract through testing.

Goals

7.7.5 The goals of the SAP are to define activities, management controls, plans, procedures, and monitoring processes to ensure that:

- SA considerations, compatible with other system requirements, are incorporated into Tung Chung Cable Car System design plans and procedures to minimize the potential of accidents when operations commence.
- Hazards associated with the Tung Chung Cable Car System are identified and then eliminated, controlled, or minimized to obtain an acceptable level of safety.
- A certification process is established to ensure that all elements of a safe, reliable, and cost efficient Cable Car system are present prior to revenue service.
- A pro-active safety philosophy is inculcated within the project team that emphasizes preventive measures over corrective measures to eliminate unsafe conditions.
- Safety and fire/life safety considerations are coordinated with reliability, maintainability, and testing activities.

7.7.6 The objective is to prevent patrons, personnel, and property from being exposed to hazards and unsafe conditions. An additional goal is to ensure that no single-point failure results in an unsafe condition.

Purpose

7.7.7 The purpose of this SAP is to set forth the requirements for identifying, evaluating, and eliminating or minimizing system assurance (SA) risks throughout all phases of the Tung Chung Cable Car project. The SAP identifies safety, reliability, and maintainability activities which will occur during Engineering, Construction, Acquisition, Pre-Operational Testing, and Revenue Operations. The plan defines formal requirements including the:

- Functional structure of the SA management organization
- Implementation of established SA analysis methods
- Mechanisms for identifying and assessing safety hazards and reliability and maintainability problems
- Methods to eliminate, minimize, or control identified hazards and reliability and maintainability problems to acceptable levels.

Scope

7.7.8 The scope of the SAP encompasses the management and technical SA activities performed during all phases of the project. The SAP defines requirements for designing, constructing, and testing the Tung Chung Cable Car system so that it can safely, reliably and cost effectively operate during revenue service.

Glossary Of Terms

7.7.9 The following presents a glossary of terms used in this program plan:

C/CIL	Critical/Catastrophic Items List
CMA	Corrective Maintenance Analysis
FHA	Fault Hazard Analysis
Fire/Life Safety	Fire/life safety deals with fire protection, fire suppression and emergency preparedness.
FMECA	Failure Mode, Effects and Criticality Analysis
LRUs	Line Replaceable Units are those assemblies of parts that would normally be removed and replaced in the field to correct equipment problems.
MTBF	Mean Time Between Failure
OHA	Operating Hazard Analysis
PHA	Preliminary Hazard Analysis
PMS	Preventative Maintenance Schedules
System Safety	The integration of skills and resources specifically organized to achieve accident prevention over the entire life cycle of a given System.

System Description

Overview

7.7.10 Diagram 12.1 below provides a graphical description of a typical cable car system. Typically, a cable car system will consist of the following major sub- systems:

- Top Station
- Cabins
- Supports
- Rope
- Communications
- Bottom Station
- Control Room.

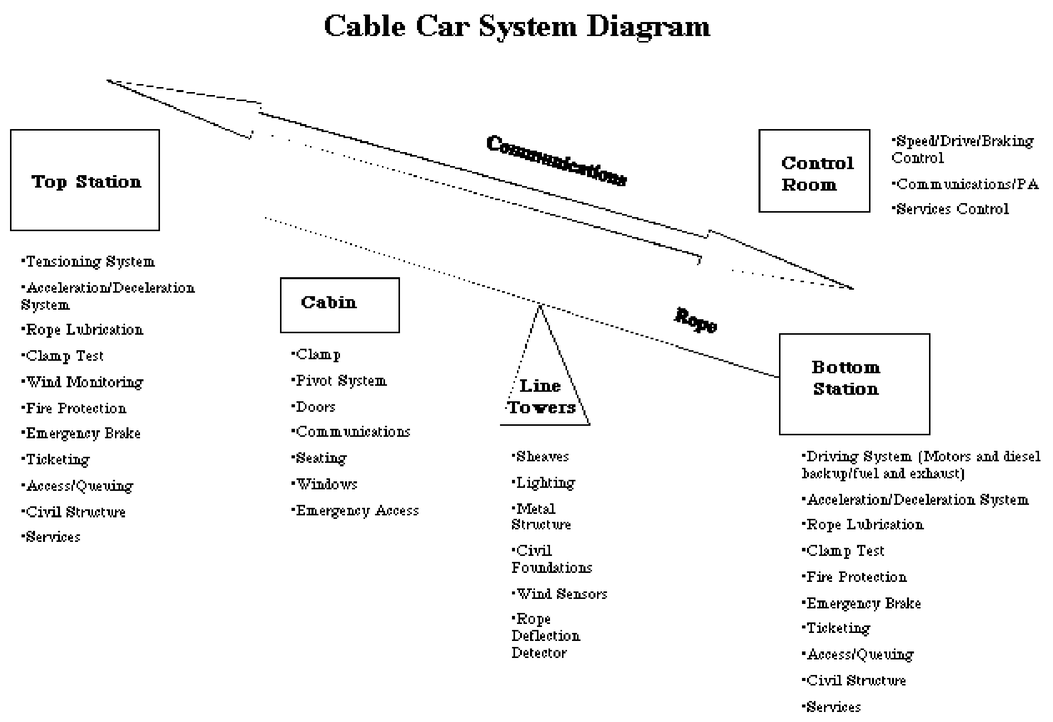

Diagram 7.1 Cable Car System Diagram

Top Station

7.7.11 The top station is a civil structure which contains all of the electrical and mechanical services required to perform the following functions:

- Hydraulic tensioning of the rope to provide optimum tension under altering load conditions.
- Acceleration and deceleration of cabins arriving and departing from the station. In a typical cable car system, this function will be performed by slopes and rubber tyres.
- Lubrication of the hauling rope to reduce friction losses.
- Testing of the clamp strength of the cabin onto the rope.
- Monitoring of wind speed.
- Protection against fire.
- Emergency brake
- Issuing of tickets.

Bottom Station

7.7.12 The bottom station performs similar functions to the top station with one exception, the bottom station provides the drive (both main and auxiliary) for the tensioning system.

Cabin

7.7.13 The Cabin performs the following functions:

- Clamping the cabin to the rope.
- Allowing the cabin to pivot about the rope in both directions
- Providing space for passengers to sit
- Providing passengers with a view out
- Providing an emergency exit.

The Support system

7.7.14 The support system provides the following functions:

- Allowing movement of the hauling rope
- Providing a structure to support the mass of the rope and cabins.
- Detecting excess rope deflection.
- Sensing wind speed.

Control Room

7.7.15 The control room provides the command and control location for the cable car system. The control room houses the command centre which controls the cable car:

- Speed
- Braking
- Communications
- Building services.

Rope

7.7.16 The rope provides the hauling and guidance system for the cable car.

System Assurance Program Tasks

General

7.7.17 The SAP focuses on activities which are required throughout the development of the Tung Chung Cable Car System to achieve a high level of SA. The Tung Chung Cable Car System procurement process is generally divided into four phases:

- Engineering
- Construction/Installation
- Pre-Operational Test
- Revenue Operations.

7.7.18 Due to its potential capability to cause injury or damage, the Cable Car System requires a thorough system assurance program. This program will be implemented to insure the systematic review of the safety, reliability, and maintainability of equipment, procedures, and training prior to final design approval.

Prepare and Update a System Assurance Plan (SAP)

7.7.19 The SAP will integrate safety, reliability, and maintainability requirements in order to provide a framework for ensuring the successful construction and operation of the cable car system. The SAP identifies all required system assurance related tasks, plans, and tests. Updates to the SAP may be required to reflect changes over time in the Cable Car System.

System Safety Tasks

7.7.20 All system safety tasks will be prepared in accordance with appropriate guidelines and regulations. Analyses will be prepared using the appropriate software and will be submitted on a computer disk and in hard copy format. The following hazard analyses will be prepared to identify and resolve all potential hazards.

Perform a Preliminary Hazard Analysis (PHA)

7.7.21 Based on preliminary design data, a Preliminary Hazard Analysis of the system will be performed on all subsystems. The purpose of the PHA is to provide an early assessment of the potential hazards associated with the cable car systems. The PHA is an inductive tool used to determine what the effects are of a hazardous event or system malfunction. The PHA systematically identifies system hazards for implementing the following process:

- Identify all functions perfomed by a system (see Section 2)
- Postulate hazards based on malfunctions or loss of functions
- Derive the probable effect of the malfunctions on people and/or equipment
- Assess the frequencies of the identified hazards and the severity of the worse case hazardous effects using generally accepted techniques such as the MTRC risk matrix.
- Identify possible safeguards that may implemented to mitigate the hazard.

Perform a Fault Hazard Analysis (FHA)

7.7.22 Based on preliminary design data, A FMECA will be performed on all major subsystems by the Contractor. The purpose of the FMECA is to identify and analyze possible failures early in the design phase. The FMECA will be focussed on subsystem to determine the cause and effect of each single primary mode of failure on the reliability of the system. In addition to the FMECA, to establish the hazardous effects of the failures a FHA will be performed on all subsystems. Failure modes for any Line Replaceable Units (LRUs) will be evaluated for potential hazards. The severity and probability of identified hazards will also be determined to identify the need for hazard resolution. To complete the FHA, the following steps will be followed:

- Develop a complete system description with an exhaustive list of all LRUs.
- Systematically identify all potential failures modes of each LRU
- Postulate each failures modes' effects on passenger, personnel and/or equipment
- Identify the probability of the failures mode occurring.
- Identify possible safeguards for the identified failure mode. In addition, identify additional analyses or activities, such as fault tree analysis or design changes, which may be required.

Perform an Operating Hazards Analysis (OHA)

7.7.23 Based on preliminary operating and maintenance data, the tasks required to support and operate the cable car system will be systematically evaluated. The OHA will be conducted on tasks and human actions, including acts of omission and commission, by persons interacting with the cable car system. Specifically, the tasks will be evaluated for error potential and subsequent hazardous effects.

Undertake Deterministic Safety Assessment

7.7.24 Based on the design data, a Deterministic Safety Assessment (DSA) of the system will be performed on all subsystems. The purpose of the DSA is to indicate and confirm how the safety related designs, standards, codes and practices are complied with.

Compile a Critical/Catastrophic Items List (C/CIL)

7.7.25 The purpose of the C/CIL is to compile in one document all safety-critical items, to provide visibility for immediate corrective action to control personal injury or system damage when a Category A hazard is identified.

Compile, monitor and update a Project Hazard Log

7.7.26 The purpose of the Project Hazard Log is to compile in one document ALL the identified hazards from the various SA activities. The PHL, will be maintained and updated throughout the duration of the project. Once the project is completed, as part of the system handover and acceptance, the project hazard log will handed to the system operator and maintainer.

Reliability And Maintainability Plans And Analyses

Reliability Requirements, Calculations and Substantiating Data

7.7.27 The reliability requirements will be validated based on actual field data from similar equipment provided by the equipment manufacturer. Where applicable field data is not available, both the MIL-STD-217F and Missile Material Reliability Prediction Handbook LC-76-1 data and the RACs Non-electronic Parts Reliability Data 1995, will be used. A Reliability Block Diagram will be created to substantiate the MTBF calculations.

7.7.28 Critical single-point failures which cause system shut down or results in unacceptable performance degradation will be documented in a single-point failure summary. In addition, latent failures will be identified along with critical secondary failures.

Reliability Test Plan

7.7.29 To provide a basis for performing Reliability Demonstration tests (RDT), a Reliability Test Plan for all major subsystems will be developed by the Contractor. The plan will include a test schedule, test procedures, and success/failure criteria. The plan will ensure that Reliability Demonstration tests are conducted at sub-system and system level. Furthermore, prior to system acceptance and handover, the plan will require the satisfactory completion of RDTs on the entire system prior to final system acceptance. Most of the equipment proposed for the installation of the cable car system will already have an extensive field service history. Therefore, in certain cases, sufficient data is already available to validate reliability performance. Newly designed equipment, or equipment with limited field history, will be subjected to Reliability Demonstration tests

Maintainability Calculations and Substantiating Data

7.7.30 Based on preliminary data, The contractor will perform quantitative allocation of maintainability requirements of all major subsystems.

7.7.31 Common failure modes for LRUs will be reviewed for ease of maintenance during fault isolation, repair/replace and checkout. Skill level, elapsed time, labour hours, spares requirements and required tools/test equipment/facilities will be documented based on the contractor’s historical data and reliability analysis.

Maintainability Demonstration Plan

7.7.32 To validate maintainability calculations in the field, a Maintainability Demonstration Plan will be developed to identify sample tasks, equipment/facility/resource needs, test procedures and quantitative accept/reject criteria.

Maintenance Items List

7.7.33 Based on all the SA analyses, a Preventive Maintenance Schedule will be developed to determine the resources required for preventative maintenance and to identify if equipment availability could be compromised by frequent/lengthy corrective maintenance. In addition to standard preventative maintenance, additional scheduled functional testing will be developed from the safety and reliability analyses to improve system assurance.

Safety Test Program

7.7.34 Based on the SA analyses, a Safety Test Program will be established to verify that assumptions made in the analyses are correct and can be substantiated. Specifically, SA requirements will have input in the following tests:

- Qualification Tests
- Acceptance Tests
- Integration Tests.

Fire Life Safety And Environmental Evaluation

7.7.35 A Fire/Life Safety Committee will be established to evaluate the compliance with appropriate codes and regulations. They will also evaluate the evacuation of all cabin riders in the event of failure of the cable car system that vertical rescue has to be carried out. The Committee will investigate and mitigate any fire life safety and environmental issues that can degrade the safety of the system. The Committee will organise with local fire and police departments to establish emergency contingency plans and conduct periodic emergency response exercise.

Safety Certification Program

7.7.36 As the final step in the SA process, a safety certification checklist will be prepared and verified. The fundamental question to be answered by the safety program is: When is the cable car system safe for operation? This question will be answered as a result of completing a safety action item list. The selected elements will be based on all the SA activities, including as a minimum, the items identified in codes, PHA, FMEA, and Fault Tree Analysis findings.

7.7.37 All items identified in the safety analysis and review will be compiled into a Safety Certification Checklist. The Safety Certification Checklist will identify each item, its origin, and its current certification status.

7.7.38 Each item contained in the Safety Certification Checklist will require evidence that demonstrates its satisfactory completion of all SA activities. Compliance with these requirements will need to be verified by design reviews, audits, inspections and tests.

7.7.39 There are several types of documentation that are acceptable for certification. Other forms of documentation may include:

- Vendor data or cut sheets
- Vendor test or analysis reports
- Drawing number
- Operating and maintenance manual (i.e., page and section number).

Final Report

7.7.40 At the conclusion of the required SA effort, a final report summarizing all aspects of the SAP will be submitted. The report will include analyses, test procedures, actual values, assumptions, descriptions of the program, final audit results, and problems encountered.

8.0 ENGINEERING ISSUES

8.1 Site Constraints

8.1.1 The proposed cable car system includes the construction of two termini and two intermediate stations, namely, the Tung Chung Terminal, the Ngong Ping Terminal, the Intermediate Station on the Airport Island and the Angle Station located within rugged terrain. Cable support towers are spaced between these stations. All these sites impose constraints that will influence the final choice and design of structural forms and foundations.

8.1.2 The proposed Tung Chung Terminal is to be situated in close proximity to existing housing blocks within the urban area of Tung Chung New Town. Therefore, the construction activities will be required to comply with the same typical environmental control as in any other urban area. The foundation works would not fall within the MTR protection zone (the protection boundary is approximately 30m from any MTR structure) and would not be subject to the Corporation's stringent requirements for protection of their structures.

8.1.3 The proposed development will span over the Tat Tung Road, thus requiring sufficient headroom above it.

8.1.4 A drainage reserve area within the site will prohibit the installation of foundations. Other than these constraints, the choice of structural forms and foundation types will be primarily governed by superstructure loadings and ground conditions. Previous site investigations, indicate that the site is overlain by about 8m of reclamation material (thought to be composed of relatively uniform dredged silty sand overlying marine sand) below which there are gravel/boulder deposits with rockhead being at about 26m to 33m below grade. These ground conditions should not pose any unusual or abnormal construction difficulties.

8.1.5 The Ngong Ping Terminal is located adjacent to the Statue of Buddha and Po Lin Monastery. Construction activities should be such that there is no inconvenience or disruption caused to tourism in this area. Additionally, environmental nuisance from construction operations should be kept under stringent control and be acceptable to local residents and Po Lin Monastery. Vehicular access to the site will be limited and delivery by helicopters of construction materials will be required. These factors must be taken into account together with superstructure loadings and ground conditions in considering the optimum structural forms and foundation type. Initial investigations indicate that the site is potentially overlain by a variable thickness of fill, alluvium and interbedded fine to course ash tuff. Rock outcrops were identified at the surface nearby suggesting bedrock within the site could be shallow.

8.1.6 The proposed Angle Station construction, in particular its foundation construction, would be subject to the most difficult constraints among the four stations. The site would be located on slopes inaccessible by roads for construction. Construction materials and equipment will need to be delivered to site by helicopters. At the same time, construction activities and the selection of structural forms and foundation types should not destabilise or impose adverse effects on the existing slopes, and will have to meet environmental requirements for construction within the Country Park. Geological details of the site are estimated from published maps and memoir sources, indicating superficial deposits of colluvium mixed with residual soil underlain by bedrock about 3m to 6m below ground levels.

8.1.7 All terrestrial cable support tower locations will be located either within the Country Park and/or inaccessible sites. Environmental concerns of the Country Park Authority will not permit the driving of access roads to these locations, therefore construction will require the application of helicopters.

8.2 Geotechnical assessment

Introduction

8.2.1 At the initial stage all available relevant data including aerial photography, published memoirs and maps, Special Geotechnical Engineering Office (GEO) Planning Division reports of the North Lantau area, and previous site investigation reports, either over or in close proximity to the proposed alignment, was collated. From these sources a Desk Study was carried out centering on the identification of general topography, geomorphological, geological and hydrogeological characteristics of the project area. Preliminary aerial photography interpretation was undertaken to identify/confirm landslides or potential areas of instability, geomorphological and structural geological features, as well as, some delineation of areas into rock at or near the surface and colluvial covered valley slopes. A Walkover Survey was carried out covering all accessible sections of the 'Preferred Route'. From the Desk Study and the observations made on the Walkover Survey, a preliminary geotechnical assessment of the proposed cable car route has been undertaken. This has involved the identification of potential ground conditions over the alignment, which have been used to identify inherent and associated geotechnical problems and possible design solutions. Finally, proposed additional site investigations have been presented which will provide the necessary data to allow preliminary and detailed design to be carried forward.

Potential Ground Conditions over the Proposed Alignment

8.2.2 *Topography* - The Tung Chung Terminal is to be situated within an existing hardstanding and grass area section of reclaimed land, adjacent to a major bus station and the MTR Tung Chung Station. The initial 0.43 km of the alignment will pass over further reclaimed land including a grass area, an existing major roundabout, and run in parallel with the bridge over the Tung Chung Sea Channel (in a single span, ie., no towers will be located within the sea) linking into Chek Lap Kok airport. From previous investigations the water depth within the Channel is indicated to be approximately 0.5 to 3.2 m. From here the alignment will traverse approximately 0.45 km running in parallel and above the major dual carriageway leading to airport facilities (incorporating an existing cut slope), before passing over a further airport link road, the extreme southern limit of a delineated fuel tank farm area and finally reaching the proposed Intermediate Station within the AA 'Proposed Commercial Area'. This area is presently a vacant site consisting of a hardstanding surface. From the Intermediate Station the alignment will traverse 0.88 km across Tung Chung Bay in a single span (again no towers are to be located within the sea). From previous overwater site investigations the depth of the sea water in the Bay varies between approximately 0.13 and 5.00 m, with a tidal range of about 1.00 to 2.00 m. On encountering the main shore line the 'Preferred Route' will cross approximately 0.08 km of mangrove swamps passing to the south of an established beach and offshore SSSI (Site of Special Scientific Interest), before reaching the base of the coastal slope. From here the remaining, approximately 3.90 km, of the route will traverse across steep valley slopes and ridge lines varying in elevation between about 20 to 560 mPD. Sections of this land route will traverse the North Lantau Country Park.

8.2.3 Vegetation of the Lantau land section of the alignment reflects both the changes in topography, geology and geomorphology, and in general trees are only located within sheltered valleys, with the more exposed higher elevations characterised by small shrubs and grasses. The Ngong Ping Terminal development will be located in close proximity to both the Po Lin Monastery and 'The Statue of Buddha', sited on area encompassing an existing carpark, rough ground, concrete and hardstanding areas and sections of private lots. The general elevation of this development varies between 436.50 and 439.30 mPD.

8.2.4 *Geomorphology* - Due to geological, geomorphological, topographic and climatic parameters, the Lantau land section of the 'Preferred' alignment will traverse a landscape characterised by a number of landslides and associated debris flows. From aerial photography interpretation and the GEO SPR 5/97 report, many old and recent landslides were identified within the vicinity of the alignment and were confirmed by the Walkover Survey. All landslides observed, and many documented in this area, are of a shallow debris type, being characteristically small and occurring on steep sided slopes either at a sharp break in slope (usually a convexity), in places at the same elevation, or commonly associated with occurring incised stream, gully or ephemeral drainage channels. The slides are associated with colluvial or residual soil deposits rather than deep seated features, the result of failure along a distinct plane of weakness in joint/bedded rock masses (a view supported by the GEO GASP reports). Run out distances are variable, but generally not extensive. Some of the proposed tower locations of the 'Preferred Route' will potentially be within these unstable, active areas.

8.2.5 At the base of the hills around the village of San Tau the main hill slope draining water course discharges onto a relatively flat plain before entering the sea. This area is probably a colluvial outwash fan which may be periodically inundated by either land runoff in a high intensity rainfall event or a high tide.

8.2.6 *Geology* - From previous investigations, the proposed Tung Chung Terminal will be located on reclaimed land, thought to be composed of relatively uniform dredged silty sand, beneath which is a variable thickness of Marine sand, an Alluvial gravel to boulder deposit, before reaching rock head, Rhyolite of variable decomposition state, at approximately 26 to 33 m below ground level. Competent rock head (Grade III or better) is indicated to occur at between 26 and 36 m below ground level.

8.2.7 Previous investigations indicate that the sea bed deposits of the Tung Chung Sea Channel consist of approximately a 25 m thickness of Marine Sand overlying a cobble and gravel Alluvial deposit with Grade III Granite and an intrusive Rhyolite dyke encountered at approximately -35 mPD. The HKGS geological map (Tung Chung - Sheet 9, 1994) indicates the hillside, of the original island through which the alignment will pass, to be composed of a fine to medium grained Granite (megacrystic in character) intruded by Quartzphyric dykes and quartz veins. The fuel tank farm area and the 'Proposed Commercial Area' were reclaimed during construction of the new airport. Limited previous drillhole investigations indicate that below the placed fill a 2.3 to 4.6 m layer of Marine sand overlies 'Loose Rock' which possibly represents the top of the Alluvial cobble and gravel layer or the uppermost horizons of the bedrock.

8.2.8 From the previous drillholes, within Tung Chung Wan over the marine alignment a possible sequence of superficial deposits may consist of a thin Marine clay, an Alluvial or Marine sand and an Alluvial gravel to boulder layer. The actual thickness of these horizons and their strength/density characteristics is uncertain, but it is suggested that they may form in total a maximum thickness of 20 m above Grade V rock. Grade III (or better) rock is thought to be between -15 and -40 mPD.

8.2.9 Because of the lack of previous site investigation data geological details of the Lantau land route have been ascertained from published map and memoir sources. The initial 1.10 km of the 'Preferred Route' will cross solid geology consisting of a complex of intrusive rocks composed of Granites, Feldsparphyric Rhyolite and Quartz Seynite. Remaining sections of the alignment will traverse a sequence of Rhyolite Lavas and Tuffs (metamorphosed in places, especially near Ngong Ping), which, from the Walkover Survey, were also identified as having subordinate interbedded layers of sandstone along the ridge lines. Potentially the intrusive rocks may have a maximum weathered mantle up to 20 m thick (especially along major joint or intrusion trends) being perhaps in the region of 10 m for the Rhyolite Lavas and Tuffs. These stated thicknesses may be significantly less at high elevation ridge and crest lines where bedrock has in places been identified close to, or at the surface.

8.2.10 The Lantau land alignment superficial deposits consist mainly of a mixture of colluvium, residual soils and/or regolith, limited in extent on the intrusive rock sections (possibly a reflection of their lithology and slope angle). Many of these deposits are indicated on maps, and have been identified from both aerial photography interpretation and the Walkover Survey, to blanket many of the slopes formed of Rhyolite Lavas and Tuffs. An isolated area of Beach Deposits is indicated to occur at the shore line, while Alluvium is shown to be present near the coast to the northeast of San Tau and together with Terrace Alluvium, to occur on the Ngong Ping plateau.

8.2.11 From map and previous investigation sources the proposed Ngong Ping Terminal development area will be potentially underlain by a variable thickness of fill, alluvium and/or terraced alluvium and interbedded fine to coarse ash Tuff. During the Walkover Survey rock outcrops were identified at or near the surface in a rough ground section within the proposed Public Transport Interchange.

8.2.12 A number of major and minor faults/photolineations have been identified from various sources which cross cut the route and in places are associated with incised gully/streams and possibly landsliding.

8.2.13 *Groundwater* - Little details of groundwater conditions over the land sections of the alignment exist due to the distribution and number of previous investigations. It is presumed that over the proposed Tung Chung Terminal and Intermediate Station sites that the water table will be at approximately sea level and be somewhat affected by tidal changes. The route sections at, or adjacent to the coast, will be affected by tidal action, as well as periodic inundation from land runoff. The water table will in most cases be at or just below ground level for the flat area of land between the coast line and the foot of the hills in the vicinity of San Tau. The groundwater table is presumed to be at the superficial/bedrock interface over the land alignment traversing the hills to the Ngong Ping Terminal, however localised perched water tables may exist within the more permeable colluvium strata. At the Ngong Ping Terminal development site, near by previous investigations suggest the water table to be at $\geq$ 1.00 m below ground level.

Major Geotechnical Issues

8.2.14 *Airport Link Alignment* - Where the initial section of the ‘Preferred Route’ traverses the existing cutting, associated with the dual carriageway linking into the airport, two alternative locations for towers are being considered. One tower could be located on a berm of the cut or one tower could be built on either side of the cutting. It is obvious that the tower proposed within the cut is a more sensitive issue, however both alternatives will require consideration of the implications to the present slope design and road usage. Any foundation design, and its related construction methodology, should seek to minimise any adverse effects to the existing slope morphology and road design, and will require risk assessments.

8.2.15 *Lantau Land Alignment* - Natural slope instability is the key geotechnical consideration for this land alignment. The mechanism of landslide failure relates to both geology, topography and rainfall intensity. In general a greater number of land slides have occurred on the Rhyolite Lavas and Tuffs than the Granite intrusive rocks (as supported by both the GEO GASP and GEO SPR 5/97 reports), however these strata form the lower coastal slope areas which have more gentle gradients. In both rock types the residual soils (which also form the source for colluvium) are silt based materials which generate high pore water suction when unsaturated with associated high apparent cohesion. On full saturation soil suction is released, cohesion decreases to near zero and slides occur. Saturation of these deposits is obviously related to rainfall intensity, with a stated return period of an intensity slide promoting event quoted to be every two years (GEO Report SPR 5/97). From the aerial photography interpretation many slides were observed to have occurred between 1990 and 1995, apparently correlating well with a number of unusually high rainfall intensity events over this period.

8.2.16 From the present alignment, potentially an initiated landslide may cause disruption or ultimately destruction of towers. The effects of landslides will most probably act upon the supporting columns or towers above the ground, as it is perceived that in all circumstances piles into competent rock will be used as a foundation. Design of mitigation measures to control these features relies upon a detailed consideration of the type, distribution and size of potential landslides at each individually proposed tower sites and it is suggested that both a 'Landslide Hazard Zonation' assessment coupled with a Quantitative Risk Assessment (QRA) be undertaken so that cost effective mitigation measures can be identified. Mitigation measures should be adopted to minimise impact to the environment (including the use of natural materials), and require the minimal labour and access requirements. However, in certain circumstances major engineering works could be necessary. With regard to the detailed mechanism of failure and resultant debris flow morphology, at present a number of potential engineering solutions could be applied to either prevent landsliding occurring or to deal with the resultant debris flows. These measures are summarised in Table 8.1.

Table 8.1 Possible Engineering Solutions to Landsliding Potential

Instability Prevention	Description	Potential Measures	Environmental Impact
Landsliding due to Saturation	Drainage and Infiltration Protection	Surface Drainage Sub-Surface Drainage Shotcrete/Chunam	Minimal Minimal Moderate/High
General Landsliding	Stabilisation of body of potential slip mass	Soil Treatment Chains and Cables Anchored Mess Nets Excavation of Unstable Material Regrading of Slope	High Minimal/Moderate Minimal/Moderate High High
Collapse of tower/column by debris flow	Energy Dissipation and Flow Control	Check Dams Deflection Walls Debris Containment Basins Sacrificial Piles Channelling of debris chutes Baffles	Moderate Minimal Moderate/High Minimal Minimal Minimal

8.2.17 Where possible the Lantau land route should avoid areas of slope deposits or significant thicknesses of residual soil or completely weathered rocks, as stated these are more susceptible to landsliding. In essence the most suitable areas could be ridge lines where rock outcrops are at or near the surface and weathering profiles or thickness of slope deposits may be limited. Additionally, structural features should also be avoided if possible due to potential deep seated ground movements (ie., within rock masses) and their possible association with landsliding.

8.2.18 As part of the present cable car system design provision of permanent access is required in the form of a footpath along the entire land section of the route. It is evident that for much of the alignment an existing trail does exist either directly below or in close proximity to the 'Preferred Alignment' (refer to Figure 4.1). During the Walkover Survey the trails which were traversed, were found to be in a relatively good condition. Depending on the specific design requirements for the access footpath, these trails may need upgrading, however the environmental impact will be minimal.

8.2.19 If vehicular access is required then over many sections of the route substantial work could be needed to construct a useable road. Major slope cuts and/or stabilisations, embankments and culverts could be necessary, which would be costly and perhaps environmentally unacceptable. If required the alignment of such a road could follow the existing foot trails.

Proposed additional site investigations

8.2.20 A phased approach for additional site investigations is suggested. Phase 1 investigations would incorporate geomorphological and geological mapping, as well as geophysical surveys over the Lantau land alignment. The data from these surveys would be used to refine the type, location and quantity of field investigations and laboratory testing in Phase 2 ground investigations. A summary of the proposed field investigations is presented in Table 8.2, while Table 8.3 sets out envisaged laboratory testing requirements.

Table 8.2 Proposed Phase 2 Investigations

Location	No. & Type of Investigations	Depth	Insitu Testing	Sampling	Installations
Tung Chung Terminal	6 Boreholes	5.00m into competent rock	SPT, Rising Head Permeability Tests	Mazier samples in soils and coring in rocks	Pair of piezometers in each borehole
Tung Chung Terminal	6 Trial Pits	4.00m	Hand Vane in cohesive soils.	Bulk and disturbed samples	None
Airport Link Tower Locations	1 Borehole at each location	5.00m into competent rock	SPT	Coring	Single piezometer in each borehole
Intermediate Station	3 Boreholes	5.00m into competent rock	SPT	Coring	Pair of piezometers in each borehole
Intermediate Station	6 Trial Pits	4.00m	Hand Vane in cohesive soils.	Bulk and disturbed samples	None
Lantau Land Tower Locations	1 Borehole at each location	5.00m into competent rock	SPT, Rising Head Permeability Tests	Mazier samples in soils and coring in rocks	Pair of piezometers in each borehole
Lantau Land Tower Locations	1 Trial Pit at each location	Excavated to rock head or 4.00m	Hand Vane in cohesive soils	Block, bulk and disturbed samples	None
Angle Station	2 Boreholes	5.00m into competent rock	SPT	Mazier samples in soils and coring in rocks	Pair of piezometers in each borehole
Between Lantau Land Tower Locations	5 Boreholes	5.00m into competent rock	SPT	Mazier samples in soils and coring in rocks	Pair of piezometers in each borehole
Between Lantau Land Tower Locations	5 Trial Pits	Excavated to rock head or 4.00m	Hand Vane in cohesive soils	Block, bulk and disturbed samples	None
Ngong Ping Terminal Development	6 Boreholes	5.00m into competent rock	SPT, Rising Head Permeability Tests	Mazier samples in soils and coring in rocks	Pair of piezometers in each borehole
Ngong Ping Terminal Development	6 Trial Pits	Excavated to rock head or 4.00m	Hand Vane in cohesive soils	Bulk and disturbed samples	None

Table 8.3 Proposed Phase 2 Additional Laboratory Testing

Location	Type of Investigations	Sampling	Proposed Testing
Tung Chung Terminus	Boreholes	Mazier samples in soils and coring in rocks	Soils - Effective Stress, Strength, Index and Chemical. Rocks - UCS (with Young's Modulus) and Point Load
Tung Chung Terminus	Trial Pits	Bulk and disturbed samples	Index and Chemical
Airport Link Tower Locations	Boreholes	Coring	Soils - Effective Stress, Strength, Index and Chemical Rocks - UCS (with Young's Modulus) and Point Load
Intermediate Station	Boreholes	Mazier samples in soils and coring in rocks	Soils - Effective Stress, Strength, Index and Chemical. Rocks - UCS (with Young's Modulus) and Point Load
Intermediate Station	Trial Pits	Bulk and disturbed samples	Index and Chemical
Lantau Land Tower Locations	Boreholes	Mazier samples in soils and coring in rocks	Soils - Effective Stress, Strength, Index and Chemical. Rocks - Saw Cut Shear Box, UCS (with Young's Modulus) and Point Load
Lantau Land Tower Locations	Trial Pits	Block, bulk and disturbed samples	Effective Stress, Index and Chemical
Between Lantau Land Tower Locations	Boreholes	Mazier samples in soils and coring in rocks	Soils - Effective Stress, Strength, Index and Chemical. Rocks - Saw Cut Shear Box, UCS (with Young's Modulus) and Point Load
Between Lantau Land Tower Locations	Trial Pits	Block, bulk and disturbed samples	Effective Stress, Index and Chemical
Ngong Ping Terminal Development	Boreholes	Mazier samples in soils and coring in rocks	Soils - Effective Stress, Strength, Index and Chemical. Rocks - UCS (with Young's Modulus) and Point Load
Ngong Ping Terminal Development	Trial Pits	Bulk and disturbed samples	Index and Chemical

8.3 Station Foundations and Structural Form

Tung Chung Terminal - Foundation

8.3.1 The Tung Chung Station is proposed to be a multi-storey building with various facilities and to house machinery for the cable cars. Three types of supporting foundation piles have been considered:-

- Large diameter cast in-situ bored piles.
- H-section driven steel piles.
- Prebored rock socketed steel H-piles.

8.3.2 Prebored rock socketed steel H-piles are presently suggested to be the most applicable, however the final selection of pile type will depend on the height of the station structure and the results of further ground investigation. Shallow foundations (i.e. spread or raft footings) are not considered because of the associated potential settlement problems which would not be tolerated by the cable car machinery. Anchorage of the cable ropeway can be provided by a mass concrete anchor block or piled foundation.

8.3.3 Large diameter bored piles ranging from 1.0m to 2.5m (up to 3.0m if required) diameter to be founded on bedrock are commonly employed in Hong Kong. Under-reaming of piles to achieve permissible rock bearing pressures is common practice. Pile depth of about 40m to reach bedrock in this site should not pose any construction difficulties, and if required to resist large horizontal thrust from the machinery, the bored piles can be socketed into bedrock or shear pins inserted into the bedrock at the pile toes. However, a large diameter bored pile can sustain very heavy loads (for example, a 2.5m diameter bored pile can sustain approximately 25,000 kN if founded in Grade III rock or 37,000 kN in Grade II rock) and this foundation type would be economical only if the station is proposed to be a heavy building (perhaps a 10 storey structure).

8.3.4 H-section driven steel piles are as commonly used as bored piles in Hong Kong; however they are subject to noise control restricting the time available for pile driving. The load capacity of a pile is approximately 3,000 kN appropriate for a medium height building such as the proposed structure and the potential range of loads imposed by the cable car machinery. However the potential presence of boulders under the site, as identified from initial investigations, may prohibit the use of driven piles. Additional ground investigation is required to confirm this.

8.3.5 Prebored rock-socketed steel H-piles are commonly employed to replace driven steel H-piles at a greater cost when underground obstructions, such as boulders, are encountered. Each pile can attain a pile capacity of about 4,000 kN (for H section 305 x 305 x 180 kg/m of Grade 55)where the rock socket is approximately 4m deep. Compared to the other two types of piles, this pile type requires a smaller drilling rig and working area, and therefore would be preferred if the work site for the terminal has to be minimised to cause minimum disturbance to the surrounding area. The resistance to horizontal loads will be provided by subgrade reaction along the piles and the bending capacity of piles. Heavy steel H-sections would be inserted into prebored holes of about 600mm diameter, lined with temporary steel casing, and subsequently grouted. Pile depths will be in the range of 40 to 50m. It should be noted that pile testing may be required by the Buildings Department to demonstrate rock socket depth for this type of pile. The cost of testing will have to be included in cost assessment of the piles.

8.3.6 Anchorage of the cable ropeway in the order of 1000 to 1500 kN could be provided by a mass concrete anchor block (perhaps with dimensions 6 x 6 x 6m) embedded in the ground if the ropeway can be taken down to ground level from the terminal point on the top floor of the terminal building. Alternatively, a mass vertical concrete column could be used as the anchor point for the ropeway extending down to ground level to be supported on piles. The potential large overturning moment could be resisted by up and down reactions of the rock socketed steel H-piles or minipiles of diameter about 0.3m.

Tung Chung Terminal

8.3.7 As discussed, no serious site constraints could be imposed on the proposed construction and it is envisaged that common cast-in-situ concrete construction of simple beam slab systems can be employed, except that steelwork will be needed to suspend the trackwork of the cable cars. Because of the need to span over the road and a drainage reserve area, prestressed concrete construction may be a more economical option in these areas subject to a more detailed analysis and finalisation of the architectural layout. The construction over the road will have to be carefully planned. One option is to install substantial temporary works over the road for cast-in-place construction. This will require the permanent works to be well above the road to allow sufficient room for the temporary works in such a way to maintain enough headroom for traffic. Supports for the temporary works will have to be properly located to minimize disruption to traffic. Another option is to launch precast prestressed girders over the road using mobile cranes at night when the road is closed off. Once the precast beams are in-place, they will form a working platform for the construction above. Compared to the first option, the second option will cause more inconvenience but at a much shorter period. Liaison with the Transport Department will be needed for the assessment of construction methods.

Ngong Ping Terminal - Foundation

8.3.8 Because of the possibility of shallow bedrock at the proposed site, footing foundations would be an economical option for the proposed two-storey Ngong Ping Terminal. If required and if rock quality permits, shear pins can be inserted into sound rock at the bottom of the footings to provide resistance to horizontal loads of the cable car machinery. If sound bedrock occurs at depth, piled foundations using prebored rock-socketed steel H-piles is a technically viable option. As discussed, these piles use smaller machines, which could be delivered by helicopters, since road access will probably be not permitted, occupying minimum work areas and thus reducing adverse construction impacts on tourism at the adjacent Po Lin Monastery. Anchorage of the cable ropeway could be by a similar concrete anchor block system as the Tung Chung Station.

Ngong Ping Terminal – Structural Form

8.3.9 The Ngong Ping Terminal will be a basic 2-storey terminal structure with minimum necessary facilities. It will be preferable to use as much prefabricated steel construction as possible for this building because site access by road will be restricted, requiring air delivery of construction equipment and materials. The structure steel will be applied with timber finishes to suit the architectural requirements. As discussed later for tower structural forms, light weight construction is more cost effective due to the cost of air transport. Since steelwork will also be necessary for trackwork support, it is a logical choice to construct the entire building frame from steel with cast-in-place concrete floor topping or precast concrete floor panels. Another advantage of steel construction is the potential reduction of construction noise compared to that of cast-in-place concrete work, which would be desirable in this area being adjacent to the Po Lin Monastery. However, a composite floor tends to vibrate more easily than a conventional reinforced concrete floor. It is important that the composite floor is designed against excessive vibration.

Intermediate Station - Foundation

8.3.10 The station will initially be an angle station for turning of cable cars. It will be designed as a two storey building housing cable car machinery, and to provide anchor supports for the cable ropeways. Similar to the Tung Chung Terminal driven or prebored rock-socketed steel H-piles could be an viable foundation option for the potential building and machinery loads subject to further ground investigation. Anchorages of the cable ropeways (in two different directions) can be provided by concrete anchor blocks.

Intermediate Station – Structural Form

8.3.11 The Intermediate Station on the Airport Island, which will primarily serve to house cable machinery for turning of cable cars at the early stage, will be constructed on reclaimed land. The site conditions are similar to those of the Tung Chung Terminal and therefore the station can be built of cast-in-site concrete with the steelwork needed to suspend the cable car trackwork.

Angle Station – Foundation

8.3.12 Mini-piles involving small drilling rigs are the preferred option for construction on steep slopes with the aid of helicopters. Small working platform will need to be erected at each pile group location, on which a drilling rig can be installed. Because of the need to avoid any cutting of the slope, pile heads will be at different levels and a station platform (preferably in steel) layout will need to be designed to suit the slope profile. Each mini-pile will consist of a group of 5T50 high yield bars cement grouted into rock (about 6m into rock) at the base and contained within a permanent 273mm diameter steel casing between rock head and ground surface. Each mini-pile can provide a bearing capacity of about 2,000 kN. Mini-piles can be raked to provide horizontal resistance while not imposing any adverse effects on slope stability.

Angle Station – Structural Form

8.3.13 The requirement to transport materials and workers by air for station construction will dictate the choice of structural form, therefore prefabricated steel building frames are suggested to be the most appropriate forms.

8.4 Tower Foundations and Structural Form

Terrestrial towers

8.4.1 For tower foundations on hillsides, mini-piles would be a preferred option where the slope is steep and any large excavation is not possible. In this case, the tower would require a concrete pad with the base to suit the slope profile or a number of smaller pads for connection to the pile heads. Raking piles will be needed against sliding. It should be noted that mini-piles should be socketed into rock (approximately 4 to 6m), and their tensile capacity, important for over-turning stability of the towers, will be as effective as their compressive capacity subject to rock joint spacing and orientation. Where the slope is not steep and excavation is permissible, or where rockhead is near the surface, raft foundations may be a more economical option to provide the base for the tower against sliding and over-turning.

8.4.7 In determining the height of a tower on the hillside, the foundation could be a governing factor because of the restriction on excavation and the maximum number of mini-piles that could be installed.

Tower structural forms

8.4.8 Tower heights could range from 5 to 60m depending on spacing and location and the cable system to be adopted. In choosing structural forms of the towers, the following factors should be considered :-

- Primary loadings of a tower are its self-weight and wind loads it attracts, therefore the tower should preferably be light, attract minimum wind loads but at the same time be stiff enough and aerodynamically efficient against excessive movements and vibrations induced by wind.

- Constructability is a major issue as imposed by site constraints. For towers on rugged hills with construction access only possible by air, the towers will need to be assembled on-site in segments light enough to be transported by helicopters.

- Maintainability should also taken into account in selection of the structural forms which should be such to avoid corrosion, if possible, and to facilitate maintenance.

- Aesthetics - pleasing appearance and integration with the environment are important considerations.

- Uniformity of design is equally important as it will facilitate construction and reduce cost and time.

8.4.9 These factors have been used to evaluate three basic options of construction materials for the towers, cast-in-place reinforced concrete, precast concrete and structural steel. A preliminary analysis suggests that structural steel is the best option.

8.4.10 A reinforced concrete tower in the form of a circular, rectangular or octagonal hollow section can be constructed by cast-in-place concrete using slipforms. The main advantage of cast-in-place concrete is its common use for construction in Hong Kong. For towers on rugged hills, delivery of wet concrete by helicopters would be a more costly option than delivery of prefabricated steel members, as a concrete tower is significantly heavier than an equivalent steel tower and therefore would require a greater number of helicopter flights to each site. In hillside environments, finishes to concrete surfaces will have to be applied on-site; the work will be time consuming, expensive and its quality difficult to control.

8.4.11 Precast concrete construction making use of precision moulds, steam curing and early finishing under factory controlled conditions will resolve some of the above problems, and therefore be preferable to cast-in-place construction. However, its heavier design is still a disadvantage when compared to steel construction.

8.4.12 Structural steel is suggested to be the best construction material for the towers because of the imposed site constraints. With this in mind the following points are important considerations:-

- As much prefabrication as possible should be undertaken, taking advantage of mechanised welding, application of corrosion protection and early painting under factory controlled conditions. It should be noted that each prefabricated section should be designed for ease of handling by helicopters (application of lifting eyes and alignment markers) and its weight be compatible with the capacity of the helicopter used.

- Fabrication details should be kept as simple as possible and should be designed to avoid corrosion and facilitate maintenance. Most likely, the sections will be joined together by high resistance bolts which are tightened to torque with adequate fatigue resistance.

- Tolerances for on-site connections should be made generous because of the difficulties associated with working on steep slopes.

- To achieve uniformity of design, a flat concrete base will be required for each tower and most likely cast-in-place, a method of construction easily suiting the various site conditions. For an over water tower, a concrete platform can be constructed on a number of piles (alternatively, if a single large diameter bored pile can be used to support the tower, the tower can be directly anchored into the pile top). For the situation of a tower on a slope, if mini-piles are used, a pile cap with the bottom to suit the slope profile and a flat top or a number of pile caps with the same top level will need to be constructed in-situ. If footing foundations are possible, the tower will be directly anchored into the top of the footing. (It should be noted that the heavier concrete structures, if selected, may help to reduce the overturning moments and thus to enable the use of smaller base. This advantage of concrete construction for the towers should be factored into the design assessment once their locations are determined and the slope conditions are known to check if the concrete option should be ruled out.)

8.4.13 It is envisaged that because of the high wind loads that the towers will be required to be designed for (as per the Hong Kong Wind Code), a latticed (truss) tower attracting minimum wind loads, yet inherently rigid, is preferable to a slim closed type composed of welded thin plates forming a hollow section in the shape of a box, a circle or an octagon, attracting full wind load. This is partially true for very tall towers, however, a slim hollow tube tower appears to be more architectural pleasing. A compromise could be that for towers taller than a certain height, the bottom section could be latticed providing a rigid skeleton with the upper section a hollow tube. Figure 8.1 shows one of this type of tower. This approach should be subject to a more rigorous study involving a cost comparison particularly for the 3S system for which the tubular type tower may not be applicable.

8.4.14 Presently it is estimated that, for a 20m tall latticed tower would require a base dimension of approximately 5 x 5m, thus entailing the need of a fairly substantial concrete base. However, prefabricated steel assemblies can be easily lifted by helicopters and on-site connections will be straight forward. A 20m tall hollow tube tower could be more slender with a base approximately 1.6 x 1.6m, thus requiring a smaller concrete base (note that resistance against overturning requires a minimum size larger than this). For a hollow section of these dimensions and a steel thickness of about 6mm (adjusted to account for stiffeners), the maximum length that can be lifted by a helicopter is about 2.6m (if the maximum carrying capacity is 875 kg), thus requiring about 8 or less flying trips (upper sections could be smaller or thinner, enabling longer sections to be air lifted) to build a fully completed tower (not including the top cross-arms). Because of the difficult working conditions, bolted connections on-site are preferable to site welding.

8.4.15 As discussed, for towers to be built on steep hillsides, the size and height of the towers could be limited by the foundation capacity achieved at particular site locations. Alternatively, the sites of towers could be selected to minimise construction difficulties to achieve the desired foundation capacities as required.

8.5 Building Services Requirements for Station Buildings

Design brief

8.5.1 This engineering study covers the initial building services requirements based on the Client's brief and conceptual architectural design sketches of the Tung Chung Terminal and Ngong Ping Terminal to enable smooth operation of the cable car system and ancillary building facilities. Innovative design considerations of the following major building services systems will be presented in this section, namely:

- Electrical Services System
- Mechanical Ventilation and Air-Conditioning System
- Fire Services System
- Plumbing and Drainage System

Identification of the sizing of all major equipment rooms and location of utilities infeed, and in particular power supply requirements, will also be considered.

Design intent

8.5.2 Building services engineering systems will be designed under the objectives of satisfying, to the maximum reasonable extent, the following basic criteria :-

- Environmental friendly
- Energy conservation and efficiency
- Reliability
- Operation flexibility
- Maintenance accessibility
- Cost effectiveness
- Safety

Design criteria

8.5.3 The purpose of this report forms a basis to develop the basic design concepts and recommend system arrangements of building services systems in accordance with the engineering study conducted in this feasibility study stage for the approval of the Client.

The design concepts to be developed will be based on the following :-

- Architectural design drawings.
- Project meetings held with the Client, Architect and other sub-consultants to discuss the design criteria and principles of the building services systems.
- Internal coordination meetings held with the building services systems design members.
- Review of the public utilities in proximity to the building sites and conducting ad hoc meetings with the utilities companies and statutory bodies.

- Regulations, statutory requirements and codes of practice issued by the relevant Government authorities and utilities companies such as the WSD, BD, DSD, EPD, HyD, FSD, EMSD, CLP, HKT, HKCG, CAD etc.
- Design guides, technical memorandum, technical papers, handbooks and international codes published by the various professional bodies such as the CIBSE, IMechE, IEE, LPC, FOC, NFPA, ASHRAE, IOP, BSI, ISO, UL, IES, HKIE, etc.

Identification of key issues

8.5.4
- The project will be constructed under a "fast track" programme.
- This engineering study will identify the critical paths and consolidate appropriate approaches to shorten the project duration.
- The project will be proceeded in efficient and cost effective manners without sacrificing the quality of design and the workmanship of installations on site.
- The latest issues of LPC Rules, EPD Ordinance, CLP Codes of Practice and EMSD Codes of Practice will be carefully reviewed and applied to the design of fire services system, noise and air pollution control, transformer room layout, and energy efficiency design of lighting and air-conditioning systems respectively.

Understanding of constraints and special requirements

8.5.5 Aiming at a fast track programme, the design of building services systems will hinge upon the planning and design of utilities services by the various utilities companies. Under current practice, the response time of the WSD, DSD, HKT and HKCG will be in the range of 1 to 1.5 months while the response time from the CLP will take 4 to 6 months or potentially longer for a newly developed site such as the project under consideration. The lengthy design process for the CLP on the underground high voltage cable routing and transformer room layout will certainly affect the project design and may impose possible variations to the construction contract. It is therefore recommended that early submission and negotiation should be made to the CLP.

8.5.6 Coordination will be considered carefully so that the final manhole locations will not clash with the other utilities services such as water mains and gas mains, incoming power cables and telephone lines, etc., and affect the completion date of the whole project under a fast track construction programme.

Electrical services system

8.5.7 *Key Issues* -

- Consolidation of the incoming power cable arrangement and transformer room layout with the CLP is an ultimate concern.
- High flexibility system design will be required as the floor layouts may change frequently.
- Contingency electrical supply for fire services and computer systems is a major consideration.
- Ambient temperature will be assumed to be 35 ^{o}C which is slightly higher than the average maximum temperature so as to prevent overheating of cables.
- When sizing the cables for identical equipment, only the full load current of equipment is used to prevent oversizing. The loading of standby equipment should be equal to the duty ones.
- Harmonic effect consideration on non-linear loads should be minimised.
- Suppression of electromagnetic interference between different voltage types of cables will be considered in the cable arrangement.

8.5.8 *Extent of Services* -

- Main power supply distribution system
- Lighting system
- Telephone system
- Communal antenna broadcasting distribution system
- Security system
- Emergency power supply system
- Building management system
- Vertical transportation system

8.5.9 *Electrical Load Estimation* -

Based on the information shown on the conceptual architectural sketches, the estimated electricity consumption is listed as follows :-

a) Tung Chung Terminal

1) Shopping Arcade
Total building GFA = 43300 m^2
Loading factor = 0.19 kVA/m^2
Load = 43300 x 0.19 = 8227 kVA
Cable Car System
Load = 3530 kVA

2) Maximum Demand
Total load = 11757 kVA

b) Ngong Ping Terminal

1) Tourist Centre
Assumed building GFA = 10000 m^2 (in 30000 m^2 site)
Loading factor = 0.19 kVA/m^2
Total load = 10000 x 0.19 = 1900 kVA

8.5.10 *Transformer Provision* -

Based on the electricity demand calculation, the power supply demand required will be arranged as follows :-

a) Tung Chung Terminal – 8 nos. 1500 kVA transformer

b) Ngong Ping Terminal – 2 nos. 1500 kVA transformer

Mechanical ventilation and air-conditioning system

8.5.11 *Key Issues* -

- Aside from the temperature control, the ultimate concerns for an air-conditioning system in the 21st century will be the implications of indoor air quality, energy efficiency, environmental considerations, flexibility and maintainability.
- BD Codes of Practice for Overall Thermal Transfer Values of Buildings will be checked against the building fabric materials.
- EMSD Codes of Practice for Energy Efficiency of Air-Conditioning Installation will be considered in the system design.
- Cooling method and medium (i.e. air-cooled or water-cooled) for the air-conditioning system will be a major concern.

- Principles of water distribution system and air distribution system to achieve energy efficiency will be elaborated.

8.5.12 *Special Considerations* -

- Carbon dioxide monitoring system and high efficiency filters will be adopted to control the indoor air quality.
- Fully automatic system integrated with the building management system will be used to optimise the operation of the air-conditioning system in order to automatically shut down the system in unoccupied zones and to slow down the variable speed fans during part load conditions.
- As the sites are located in the countryside, sufficient noise control equipment will be provided to maintain the quiet environment to the satisfaction of the EPD.
- Materials and equipment to be used in the system will be environmental friendly and harmless to the human health.
- Due to the expected frequent change of layout in the shopping arcade, the system will be designed to allow easy modification and alteration.
- Sufficient access points will be designed for the system for future maintenance and the automatic control system will be capable to log necessary data for analysis.
- A gas monitoring system will be provided in the carpark to avoid undue flue gas accumulations.

8.5.13 *Extent of Services* -

- Mechanical ventilation system
- Air-conditioning system
- Smoke extraction system
- Staircase pressurization system

Cooling Load Estimation -

a) Tung Chung Terminal

Shopping Arcade
Total building GFA = 43300 m^2
Load = 8000 kW

b) Ngong Ping Terminal
Tourist Centre
Assumed building GFA = 10000 m^2 (in 30000 m^2 site)
Load = 2000 kW

Fire services system

8.5.14 *Key Issues* -

- Life safety protection includes fire precaution, escape route, fire alarm annunciation, structure fire resistance and fire fighting means.
- Property protection includes fire precaution, fire alarm annunciation, structure fire resistance and fire fighting means.
- An analytical approach on the natures of buildings will be performed in certain aspects:
- High hazard zone such as lift machine room, generator room, carpark, switch room, meter room, transformer, etc.
- Caution of fire due to electrical fault, high fire load and human error.
- Egress problem due to high population and extent of development.

- Analysis of fire protection requirements will be used for comparison with the relevant statutory requirements (i.e. FSD Codes of Practice).
- Possible causes of false fire alarm, interaction with the building management system and human response to fire will be the factors to be considered.
- Hydraulic pressure and flow rate of the Government water mains will be checked with WSD to ensure the sufficiency of inflow requirements.
- Aspirating smoke detection system will be considered for the atrium hall of the shopping arcade in the Tung Chung Terminal to enhance the smoke detection capability.

8.5.15 *Extent of Services* -

- Fire hydrant / hose reel system
- Street fire hydrant system
- Automatic sprinkler system
- Manual operated / automatic fire alarm system
- Portable fire extinguisher and hand appliance
- Exit signs and emergency lighting
- Visual fire alarm system
- Aspirating smoke detection system
- Total gas flooding system

Water Supply and Water Tank Capacity -

8.5.16 The estimated sizes of incoming water mains and storage capacities of water tanks are tabulated as follows:

Table 8.4 Estimated Sizes Of Incoming Water Mains and Storage Capacities of Water Tanks

Location	Description	Tung Chung Terminal	Ngong Ping Terminal
G/F	Incoming water mains connection	1 no. 100 mm dia.	2 nos. 100 mm dia.
G/F	Fire services water tank capacity	36000 litres	36000 litres
G/F	Sprinkler water tank capacity	107000 litres	90000 litres
G/F	Street hydrant water tank capacity	-	245000 litres

Classification of Occupancies -

8.5.17 The classification of occupancies for both the Tung Chung Terminal and Ngong Ping Terminal will be categorized as Ordinary Hazard Group III (OH III) in compliance with the LPC Rules.

Plumbing and drainage system

8.5.18 *Key Issues* -

- Hydraulic pressure and flow rate of the Government water mains will be checked with WSD to ensure the sufficiency of inflow requirements.
- Locations, levels and alignments of the foul water and storm water terminal manholes will be coordinated with DSD for making new connections to the Government foul sewers and storm water drains.
- The construction of a sewage treatment plant will be considered since the foul sewer connection may not be available in rural areas.

- Grease traps for restaurants and petrol interceptors for carparks will be provided in compliance with the BD/EPD/USD requirements.

8.5.19 *Extent of Services* -

- Fresh water supply system
- Hot water supply system
- Flushing water supply system
- Sewage disposal system
- Storm water disposal system
- Piped gas supply system

8.5.20 *Water Supply and Water Tank Capacity* -

- Under current WSD's practice, the normal water mains pressure will be advised to be 300 kN and 150 kN for potable and salt water supplies respectively.
- Direct supply for the fresh water supply system will be considered in view of the building heights in order to save the pumping energy.
- Indirect supply with associated water tank for flushing water supply system will be required in compliance with the waterworks requirements.
- Sizing of water tanks will be determined based on the quantity of sanitary fixtures shown on the architectural layout plans.
- The estimated sizes of fresh and flushing water mains connections will be 100 mm dia. and 80 mm dia. respectively for both the Tung Chung Terminal and Ngong Ping Terminal.

Spatial requirements for services plant rooms

8.5.21 *Electrical Services System* -

a) **Table 8.5 Tung Chung Terminal Electrical Services System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
G/F	Transformer Room	13 x10 (3 nos.)	4.5
G/F	LV Main Switch Room	13 x 4	4
G/F	TBE Room	6 x 4	4
G/F	Meter Room	2.4 x 0.9	3.6
1/F	BMS Room	10 x 4	3
1/F	Security Room	2.4 x 0.9	3
R/F	Generator Room	8.5 x 6	3.6

b) **Table 8.6 Ngong Ping Terminal Electrical Services System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
G/F	Transformer Room	8 x 6	4.5
G/F	LV Main Switch Room	6 x 4	4
G/F	TBE Room	3 x 2	4
G/F	Meter Room	2.4 x 0.9	3.6
1/F	Security Room	2.4 x 0.9	3
R/F	Generator Room	8.5 x 6	3.6

8.5.22 *Mechanical Ventilation and Air-Conditioning System -*

a) **Table 8.7 Tung Chung Terminal Mechanical Ventilation and Air-Conditioning System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
Each Floor	AHU Room	15 x 6	3.6
R/F	PAU Room	8 x 5	3.6
R/F	Chilled Water Pump Room	18 x 7	3.6
R/F	Motor Control Centre Room	10 x 5	3.6
R/F	Chiller Plant Room	50 x 15	Open Space

b) **Table 8.8 Ngong Ping Terminal Mechanical Ventilation and Air-Conditioning System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
Each Floor	AHU Room	5 x 3	3.6
R/F	PAU Room	4 x 2.5	3.6
R/F	Chilled Water Pump Room	10 x 5	3.6
R/F	Motor Control Centre Room	6 x 3.5	3.6
R/F	Chiller Plant Room	10 x 8	Open Space

8.5.23 *Fire Services System -*

a) **Table 8.9 Tung Chung Terminal Fire Services System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
G/F	FS Pump Room	6 x 4	3
G/F	Sprinkler Pump Room	6 x 4	3
G/F	FS Control Room	4 x 3	3

b) **Table 8.10 Ngong Ping Terminal Fire Services System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
G/F	FS Pump Room	6 x 4	3
G/F	Sprinkler Pump Room	6 x 4	3
G/F	FS Control Room	4 x 3	3
G/F	Street Fire Hydrant Pump Room	6 x 4	3

8.5.24 *Plumbing and Drainage System -*

a) **Table 8.11 Tung Chung Terminal Plumbing and Drainage System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
G/F	Transfer Pump Room	7 x 5	3

b) **Table 8.12 Ngong Ping Terminal Plumbing and Drainage System Plant Room Schedule**

Location	Description	Dimension (m x m)	Headroom (m)
G/F	Transfer Pump Room	7 x 5	3

8.6 Utilities

8.6.1 The respective utilities undertakers including DSD, WSD, CLP, HKCG and HKTC have been approached for seeking their comments on providing supplies to the facilities proposed under this Project.

8.6.2 Ngong Ping is a remote plateau at Lantau Island. The Great Buddha and Po Lin Monastry however attract thousands of visitors in every week end and Public Holidays. After the opening of North Lantau Highway and the Airport Railway, the number of visitors to Ngong Ping has increased. It is expected that the visitor level will further increase after the cable car is built.

8.6.3 Existing utilities provisions - the present electricity supply, telephone service, water supply and drainage facilities are adequate to support the present villages and visitors. With the cable car project, upgrading of the existing utilities services to the area will be required to support the development proposal.

Water Supply

8.6.4 Potable water supply system has been installed to supply drinking and flushing water to the village and Po Lin Monastry, but is estimated not adequate for the proposed development. WSD will determine upgrading requirements for their project after the development plan in the area is finalized. No salt water supply for flushing is proposed because the site is remote from sea side.

. Electricity

8.6.5 Based on the preliminary development layout at Ngong Ping, the estimated electricity consumption for the commercial development is about 1900 kVA. The estimated electricity consumption for cable car operation with driver at Ngong Ping Terminal is about 2000kVA.

8.6.6 CLP was consulted for the supply of this level power consumption to the development. They advise that their existing facilities at Ngong Ping are adequate for this project. Based on the electricity demand, a new ESS should not be required but a transformer room will need to be provided in the Ngong Ping Terminal.

Gas

8.6.7 At present, there is no gas supply to the area due to the remoteness of the site and low demand. However, the development of Tung Chung New Town and North Lantau Highway raised opportunity to develop the gas supply network to North Lantau. The Towngas advised that gas supply to Ngong Ping from Tung Chung would become feasible if the installation of a pipeline either along Tung Chung Road or the future link road between Tung Chung West to Tai O is possible. An IPA pipeline under the possible cable car route will be the most economical solution. The pipe size will depend on the development scale of Ngong Ping. However, this proposal is subject to the final approval by the Country Parks Board. Towngas will investigate the feasibility of constructing a pipeline to Ngong Ping after the development scheme and the consumption rate is confirmed.

Telephone

8.6.8 It was informed by HK Telecom that the existing telecommunication system serving the Ngong Ping area will be sufficient for the proposed development.

Sewerage System (Sewage Treatment Works)

8.6.9 Drainage Service Department (DSD) has planned to construct a sewage treatment plant at Ngong Ping by 2002/2003 to handle the sewage effluent from the villages, Po Lin Monastry and visitors to Ngong Ping. According to DSD, the design of the treatment works has not taken account of the possible additional visitors to Ngong Ping resulted from the cable car project and the size of the treatment works may need to be doubled if the flow from these visitors is also considered.

8.6.10 The planned site for the plant is located opposite to the proposed terminal development. Although EPD/DSD consider that the treatment plant can be designed to limit its impacts to the proposed development to within an acceptable limit, it has been recommended to resite the treatment plant away from the proposed development area at Ngong Ping under this project. PlanD has suggested alternative sites for the treatment works so that the plant would be further away from the Giant Buddha and the approach road from the cable car terminal which is the major future gateway to Ngong Ping.

8.6.11 Discussions with PELB, DSD, EPD and PlanD were held. EPD emphasised that the cable car system can only be allowed to be put into operation with the treatment works in place. The treatment works will need to be designed to handle the additional flow from the visitors resulted from the cable car project to minimise any possible pollution to the water gathering ground at Ngong Ping..

8.6.12 As advised by DSD/EPD, the scope of the sewage treatment works project has been changed due to the comments from WSD. As a result, the sewage treatment works can only be completed around 2003, on the assumption that it is to be built on the originally proposed site. It is therefore not possible to dovetail the sewage treatment works project with the cable car project. If the project is to be undertaken by the Government and the site is to be relocated, the sewage treatment works will unlikely be in place before 2006.

8.6.13 For the sake of expediting the cable car project, it is considered, from the discussion among PELB/DSD/EPD/MTRC, that entrusting the sewage treatment works to the agent of the cable car project is the only solution to enable the cable car system to be commissioned by end 2002 (the programme now has been revised to early 2003). The scope of entrustment work should cover the sewage treatment plant, the export pipeline and the sewerage connections to the two public toilets at Ngong Ping.

8.6.14 According to PELB/EPD/DSD, it will take approximately one year, counting from the day policy support is given to the cable car project, for the Administration to obtain funding approval to entrust the implementation of the Ngong Ping Sewerage Scheme to the cable car operator. This will mean a delay of 1 year to the cable car project.

8.7 Construction methods

8.7.1 Construction of the land towers between the Tung Chung Terminus and the Intermediate Station will require both traffic management and relevant permissions from the Highways Department and the Airport Authority (AA), in terms of both access of the existing road network and allocation of work areas.

8.7.2 Due to the fact that the majority of the 'Preferred Alignment' is located within a mountainous area, a large portion of which being within the North Lantau Country Park, with no direct sealed or metalled road access (or even rough tracks) to many sections of the alignment, construction of the towers and Angle Station is deemed to be only feasible by means of helicopters. Additionally, potential access constraints on the construction traffic use of the Ngong Ping Road may also require materials, and ultimately construction of the Ngong Ping Terminal development, to be in part by the use of helicopters.

8.7.3 It is believed that even if construction of this part of the system could be achieved by the use of construction roads, the stringing of cables for the system would most probably be by the application of helicopters.

8.7.4 Wide experience of helicopter construction of cable car systems has been gained over a number of years both within Europe, North America and Asia (most recently with the building of the Genting Highlands Project in Malaysia). Within Hong Kong although helicopters were not believed to be used on the construction of the Ocean Park system, similar methods of construction in similar environmental conditions, have been utilised for the construction of electrical pylons for China Light & Power.

8.7.5 In Hong Kong two helicopter companies exist which undertake building projects, Heliservices and Helicopter Hong Kong. Heliservices have been established for many years and have a wide experience in many different construction projects with an impressive safety record (Helicopter Hong Kong have only been operating within the SAR for approximately two years).

8.7.6 Mott Connell have carried out discussions with both helicopter companies and carried out helicopter surveys of many of the alignments under consideration. From these activities the following major points of the potential use of helicopters have arisen :-

- Flying restrictions exist over Chep Lap Kok airport (cannot be over flown), Tung Chung Town Centre (flights are required to be at least 500 feet above ground level) and low level flying is not permitted over the summit of Nei Lak Shan where a communications tower is situated.

- Logging of flight plans and flight control is dealt with by the air traffic controllers at Chek Lap Kok airport.

- Aerospatiale Lama Helicopters have been successfully used for the construction of the electrical pylons with a standard lifting hook capacity of 875 kg. They have been used to carry both steel lattice segmental sections and concrete (transported in specially designed non-leakable 0.3 m^3 bins/hoppers). All steel sections have lifting hooks and alignment markers. If the loads required to be transported are greater than the 875 kg then other types of helicopters with increased lifting capacities could be made available.

- The standard area required for a helipad is usually twice the diameter of the rotor disc of the helicopter used. If Lama type helicopters were to be used then this would equate to an area in the order of 33 x 33 m (this is a conservative approach with the area equivalent to twice the length of the helicopter with rotors turning, a potential requirement of the Hong Kong Authorities).

- Under the current regulations no helicopters lifting materials under hook will be allowed to fly over public roads or bridges.

- Lama type helicopters carry sufficient fuel (Jet A1 Aviation) for approximately one hour of flight. Refueling is performed at the helipad.

- The helipad should be sited in an area to allow safe and easy landing and takeoff, ie., flat locations away from buildings/structures and trees.

- For construction over a long term period (months) a provisional hourly hire sum for a Lama type helicopter would be HK$10,000.

8.7.7 It is obvious that if construction by use of helicopters is to be undertaken, then the positioning of the helipads should follow the above requirements, as well as, to minimise the flying time between the work site and the cable car alignment. It would be a good practice if the location of the helipads was in the vicinity of the Construction Contractor's work site, which would be used for prefabrication of structural forms and production of wet concrete, as well as a staging post for helicopter transportation. With this in mind a potential area for both the work site and helipad location (preferably two pads for refueling and maintenance purposes) has been identified to the west of the Tung Chung New Town in development area TC35 at the end of the existing P2 road development (at present under construction) of Phase IIB of the NL6 Contract (refer Figure 8.1). This proposed site is approximately 0.22ha and is presently an unused privately owned agricultural plot having been reserved for structural steel fabrication and a general work area. The area meets the criteria set out in Section 8.7.6 for helicopter use and has the advantage of being situated in close proximity to an existing batching plant and road network so that construction materials, fabrication components and aviation fuel (conceivably sourced from the fuel tank farm within the airport) could be transported to this location with construction of only a minor section of haul road.

This proposed site forms part of the resumed area for development under the NL6 TDD contract. Permissions from TDD and from the Lands Department (LD) would be required for temporary allocation of the land and for an access permit for use of the presently uncompleted road. In addition, the site is located within the Tung Chung & Tai Ho Phase 3 development boundary and would require to be leased by LD to the cable car project proponent under a temporary license, or directly leased from the land owner before resumption takes place.

The proposed helipad location is approximately 2.60km from the Angle Station and 3.65km from the Ngong Ping Terminal development, equating to approximately 4 round trips per helicopter per hour.

8.7.8 An additional helipad site would be preferable, with perhaps the only feasible alternative being a large concrete open area within the proposed Ngong Ping Terminal development. However, the Po Lin Monastery and government agencies may impose flying constraints and at this stage it is thought that limited use of this site may only be allowed. This site could also act as a secondary Contractor's work site for both storage and fabrication facilities and potentially limited road transportation of materials could be allowed during restricted hours.

8.7.9 It is presently thought that two Lama type helicopters could be used for construction, but the number, type and ultimately time required for construction will depend on the cable car system chosen (ie., the number of towers), structural forms, ie., steel or concrete, weight lifting capacities required and weather conditions experienced. It should be borne in mind that both at the proposed tower locations and the site of the proposed Angle Station, topographic, ground stability and environmental controls may result in a very small working area at each of these locations. Therefore the handling of large steel structural units and greater volumes of 0.3 m^3 of concrete, delivered regularly potentially over very short time intervals, may not be feasible.

8.7.10 Transportation to the Angle Station will also involve the lifting of motors, gear boxes and drive wheels irrespective of the cable car system adopted. This would require these units to be broken down into smaller components and reassembled on site (which may prove difficult and be unacceptable), or alternatively a larger lifting capacity helicopter used for this operation.

8.7.11 In conclusion, helicopter construction is feasible for those sections of the cable car system which are not accessible by roads, with not only suitable helicopters and companies with good experience in this form of construction available in Hong Kong, but also the existence of plausible helipad and work sites considering the physical and environmental constraints of the project.

11.0 STATION INTERFACE PLANNING

11.1 Planning Transport Interchanges

11.1.1 The WP10 Report produces the forecast of mode split for cable car riders as shown in Table 11.1 The WP10 results are drawn from the CTS-2 model. This methodology may treat both tourist and resident leisure travellers more like commuters and would lead to a very different split between access modes. There is a concern about the high percentage of car usage (26%) in 2001, especially as a large proportion of users of the cable car will be tourists. The level of car usage seems very high when compared to the MTRC usage and would lead to a large number of car-parking spaces being required at Tung Chung. Another concern is regarding the decrease in car usage in future years. Car ownership is rising and car usage is expected to grow.

Table 11.1 Mode Split of Cable Car Riders and Average Occupancy – WP10

Mode	Average Occupancy	Percentage		
		2001	2006	2011
Car	2.13	26%	13%	10%
Taxi	2.05	3%	2%	1%
Bus	33.62	48%	37%	38%
MTRC/Shuttle Bus	33.62	23%	48%	51%
Total		100%	100%	100%

11.1.2 A separate analysis has been conducted based on forecast points of entry (refer to Table 2.9 in Section 2) and a set of modal split factors to cable car terminals. This analysis shows a very different pattern of access mode. Table 11.2 shows the numbers of arriving passengers to each cable car terminal for 2006 and 2016 respectively.

Table 11.2 Mode of Access to Cable Car Terminals - Medium Scenario (Peak Hours)

Station/Mode	2006		2016	
	Average Day	Peak Day	Average Day	Peak Day
Tung Chung Terminal Passengers				
MTR	402	1446	461	1658
Bus	227	818	266	958
Tour Coach	165	593	215	775
Taxi	14	51	17	62
Private	15	55	15	54
Airport Transit Shuttle	96	96	-	-
Tung Chung Total	919	3059	974	3507
Ngong Ping Terminal Passengers				
Bus	128	462	156	562
Taxi	14	51	17	62
Ngong Ping Total	142	513	173	624
Air Transit Station Passengers*				
Airport Transit Shuttle	-	-	128	128
Total	1061	3572	1275	4259

* Airport Transit Station is opened by 2007

11.1.3 The feeder services required can then be derived according to different occupancies for individual mode. The numbers of vehicles going to each cable car terminal are summarised in Table 11.3.

Table 11.3 Required Feeders Services - Medium Scenario (Peak Hours)

Station/Mode	2006		2016	
	Average Day	Peak Day	Average Day	Peak Day
Tung Chung Terminal				
Bus Departures	4	14	5	16
Tour Coach Departures	5	15	6	20
Taxi Drop-off	5	17	6	21
Private Car	5	19	5	18
Airport Transit Shuttle	4	4	-	-
Ngong Ping Terminal				
Bus Departures	3	8	3	10
Taxi Drop-off	5	17	6	21
Air Transit Station				
Airport Transit Shuttle	-	-	5	5

11.1.4 Various loading and unloading times for different modes of transport were assigned. Table 11.4 shows the resulting requirements on the interchange facilities assuming that loading and unloading activities would happen simultaneously. For the private car parking spaces, half of the daily usage were assumed to occur within the peak hours. Taxi stand was also suggested at the Airport Transit Station.

Table 11.4 Interchange Facility Requirement at Cable Car Terminals (Medium Scenario)*

Facility	loading/ unloading time (min)	2006			2016		
		Tung Chung	Ngong Ping	Airport Transit	Tung Chung	Ngong Ping	Airport Transit
Bus Bays	5	4	2	-	4	2	-
Coach Bays	5	4	-	-	4	-	-
Spaces of Taxi Stand	2	2	4	-	2	4	1-2
Car Parks		43	-	-	53	-	-
Transit Shuttle Bays	5	2	-	-	-	-	2

11.2 Road Traffic Movements Around the Cable Car Terminals

11.2.1 The cable car station at Tung Chung will also generate additional traffic flow around the terminal area. The Tung Chung road links of 2011 expected levels of traffic and the design capacity of the adjacent road system are identified in Figure 11.1 and Table 11.5. The remaining capacities of these adjacent roads can accommodate the additional traffic as mentioned in Table 11.3 without any difficulty.

Table 11.5 Expected Levels of Traffic Around Tung Chung Terminal

Link	Design Capacity /Cars per hour (Not. Including Junctions)	2011 Expected Traffic Volume Peak Hour (Not including cable car)	Volume/Capacity Ratio in 2011
A – One Way	2,400	800	0.33
B - North	2,800	1,400	0.5
B - South	2,800	700	0.25
C - North	2,800	1,400	0.5
C - South	2,800	1,400	0.5
D - East	2,800	2,400	0.86
D - West	2,800	2,300	0.82

11.2.2 The traffic levels at Ngong Ping Terminal will be relatively small compared to the planned traffic levels. Additional traffic to Ngong Ping should add approximately 19 taxis and 9 buses per peak day peak hour in 2011. This will have very little impact on the overall traffic figures and hence should not cause significant additional congestion especially after the shift of passengers from buses to Cable Car system. These figures are however for those accessing cable car at Ngong Ping only and do not include additional traffic generated by the retail and entertainment facilities in the commercial areas surrounding the cable car terminal.

11.3 Pedestrian Movement

11.3.1 Table 11.6 shows the number of passengers accessing the cable car system at Tung Chung via the MTRC in 2006 - 2016.

Table 11.6 Passengers Arriving by MTRC – Medium Scenario

Year	Average Day Peak Hour	Peak Day Peak Hour
2006	400	1450
2011	430	1560
2016	460	1660

11.3.2 These passengers will access the cable car station via two pedestrian linkages. The present station Exits at Tung Chung has been assessed and their forecast usage are shown in Table 11.7

Table 11.7 Passengers Arriving by MTRC – Medium Scenario

Exit	Description	Forecast Usage
A	Housing Authority Development, Kiss & Ride and Taxi Rank	10%
B	Public Transport Terminus	74%
C	Footbridges to Commercial Development East of North Lantau Expressway	12%
D	Taxi Rank & GMBs	4%

(Source: Chek Lap Kok MTRC Connection Planning Study)

11.3.3 Exits B and C are recommended to be used as the route for cable car passengers from the MTRC, as shown in Figure 11.2. This recommendation is based on the following arguments:

- The two possible exits from the MTRC to the cable car are B or C, i.e. the North exits;

- The Chek Lap Kok MTRC Connection Planning Study forecasts overcrowding at Exit B. This may be mainly at commuter peak hours, i.e. not at the cable car peak times. However, with the numbers of passengers transferring from MTRC to cable car it would be sensible to avoid further congestion by using only Exit B for the cable car passengers;

- Exit C footbridges are at a high level connecting into the commercial development stretching across the North Lantau Expressway. The cable car Terminal will be connected to the commercial development by a number of walkways. Hence, it is more sensible to bring people up to this commercial development level and then allow them to walk at this level through to the cable car building. The walk through the commercial area will ensure an air-conditioned comfortable passage. Passage through the commercial area will also benefit the retail development;

- The Exit B route will be at ground level on the western side of the commercial development – Pedestrians will access the commercial development by escalators on the western side of the commercial development and proceed to the cable car via a series of walkways.

12.0 PROJECT IMPLEMENTATION

12.1 Project Programme

12.1.1 Following extensive consultation with concerned Government bureaux and departments, it is understood that if this cable car project is to be pursued under the current statutory provisions and procedures, it is unlikely that the target date of opening the cable car in early 2003 can be met. It is also probable that, unless the cable car link can be accepted by Government to demonstrate as being "a public transportation project", statutory authorisation and land acquisition could not be achieved either within a reasonable project timescale or at all. New ordinance or suitable amendments to the existing legislation are required to establish a well structured statutory framework for timely implementation of the cable car project. There are also private lots and some land licences involved at Ngong Ping where the cable car associated development will be positioned. This will require prompt action from Government for land acquisition / resumption.

12.1.2 As one of the primary functions of the cable car is to provide an alternative means of transport between North and South Lantau, the existing Aerial Ropeway Ordinance is suggested to be engaged, with necessary amendments, to address the construction and operation of the cable car system, and possibly future aerial ropeway projects generally in Hong Kong. With regard to land acquisition, the (Crown) Lands Resumption Ordinance could be a possibility in the event that there was any need to acquire private lots. However, because of the nature of this project, there may be legal hesitation to implement it.

12.1.3 It would be possible for a new ordinance to be enacted to deal with the cable car as a one-off project, similar to the approach taken by Government with regard, for example, to the Eastern Harbour Crossing and Western Harbour Crossing projects. The Peak Tram Ordinance and Route 3 Ordinance are also precedent cases. In view of the time required to enact a new ordinance which could be lengthy, the option of amending an existing ordinance which involves the minimum of time and legislation is preferred.

12.1.4 There are, in addition to the new/amended statutory authority described above, other statutory procedures which will need to be implemented, including :-

- Environmental Impact Assessment Ordinance
- Land (Miscellaneous Provisions) Ordinance
- Town Planning Ordinance
- Country Parks Ordinance, and
- Building Ordinance

12.1.5 All of these approval procedures and/or regulatory processes will need to be implemented once policy decision to proceed with the cable car project is granted by Government. Without the need to invoke the Foreshore and Seabed (Reclamation) Ordinance as a consequence of the Preferred Alignment (across the south shore of the Airport Island) which does not necessitate any marine works on the sea channel, it becomes more optimistic that the cable car link between Tung Chung and Ngong Ping can be commissioned by the early 2003. However, to satisfy all the other statutory procedures as shown in Figure 12.1 within the time period available is still very tight and will rely on Government's support to streamline procedures and constraints.

12.1.6 Of particular concern are the procedures for acquiring the required land for positioning the line towers and terminals, and for amending the Outline Zoning Plan to suit the development proposals. If the time frame for execution of the relevant statutory procedures cannot be shortened, it may not be possible to "fast-track" the entire project procurement process in accomplishing the objective of opening the cable car to the public by early 2003 as per the programme presented in Figure 12.1.

12.1.7 For the Aerial Ropeway Ordinance, it will require a submission of the cable car system detailed design to EMSD. Similarly for the EIA Ordinance, it will require a detailed EIA Study to be carried out. This EIA Study will become the 'kick off' activity upon the commissioning of this project by the Government. The Town Planning Ordinance, land acquisition and Country Parks Ordinance will proceed with the completion of the EIA report and public consultation process under the EIA Ordinance.

12.1.8 AFD/EPD stipulate that an ecological survey as part of the ecological assessment in the EIA Study should cover at least one wet season (i.e. July – September). Depending on the date the Government confirm their decision to commission this project, this requirement will more or less dictates the timing of processing the statutory procedures and influence the progress of the project.

12.1.9 Assuming that the EIA Study can start in July and will be completed in November 1999, other procedures can start immediately afterwards. By overlapping the activities for tendering the cable car system and civil/structure contracts with the statutory procedures, the order for the cable car system can be placed in mid 2001. For achieving the commissioning date for the cable car system in early 2003, some civil/building construction work may need to start prior to the full compliance of the respective statutory procedures. It should be noted that any delays in the Government's decision on this project will make the scheduled commissioning date of the cable car system doubtful.

12.2 Procurement Strategy

12.2.1 It is assumed that the procurement of the cable car system will form part of an overall package of development for the two Tung Chung/Ngong Ping Terminals and the Intermediate Station.

The aim of the procurement strategy for the cable car element should be to ensure that the risks of the project lie with the organisation best able to manage them. The risks for this project are broadly:

- The financing and revenue risks;
- The programme and budget risk of the design and construction phase; and
- The risk of operating the cable car reliably and safely;

Financing and Revenue

12.2.2 The cost of raising finance for the project can fall either on the operator or the contractor. In the first case the client will essentially fund the contractor as the project progresses, with payment based on agreed measures of progress. In the second case, the contractor will be expected to raise the finance and repay it from revenue generated during operation.

12.2.3 Normally the cost of raising finance will be lower for the operator than for a small company such as those likely to be supplying the cable car system. Similarly, such small companies are unlikely to be able to bear the risk of generating adequate revenue to finance, operate and maintain the system.

Design and Construction

12.2.4 The operator may not be experienced in the design and construction of cable car systems. The risks of this phase are best managed by the supplier. This means a design-build, performance-based contract in which the supplier is paid to deliver a system with an agreed level of performance rather than a particular design.

12.2.5 To ensure that the risks are genuinely transferred, the operator should also avoid being closely involved in approving designs and construction methods. They should rather concentrate on ensuring that the contractor has in place an appropriate system assurance regime to demonstrate that the contracted performance (particularly safety) will be delivered.

12.2.6 All of the potential suppliers have constructed numerous systems around the world and must be presumed to be fully competent. Some analysis of their performance on previous projects should, however be performed and this will be a factor in selecting the final contractor. An investigation into the contractors' system assurance methods will be part of this analysis.

Operations and Maintenance

12.2.7 The risks here are balanced. It may be assumed that the supplier will be better to operate and maintain their own system, however setting such an organisation up in a new country without knowledge of local labour conditions, language and other factors is in itself risky. In the case of the European suppliers, Hong Kong is very remote and very different from their normal sphere of operations. The contractor will recognise these risks and expect to be paid for them. Contractors have indicated that they are able to take on the operation and maintenance, but that this would have to be funded; they are not willing to carry revenue risk.

12.2.8 The operator should be perfectly capable of setting up an appropriate organisation, given proper support from the supplier during the initial period of operation. The question is simply one of cost, and the best strategy that the operator could adopt would be to include operations and/or maintenance as an option when tendering. This would allow the prices quoted by suppliers to be compared against the estimated cost of setting up and running an in-house organisation.

12.2.9 This option must be included at the tendering phase to ensure that the best prices are obtained. Subsequent to award of contract, the supplier will know that there is no competition and will not price keenly. This means that a specification, including performance targets and payment mechanisms for the operating phase must be developed in parallel with the system specification.

Preparation of a Draft Documentation

12.2.10 On completion of this aspect of the study, sufficient documentation needs to be available for the operator to be able to invite tenders from potential suppliers (should the feasibility study recommend that the project should proceed).

12.2.11 Whilst this activity is not due to be delivered until later on in the study, some progress has been made towards its accomplishment. This activity is evolving throughout the study. All information will be collated based upon the knowledge and expertise of similar tendering activities, making a judgement concerning its adequacy and this will form the draft documentation.