For 18 September 2007

Legislative Council Panel on Economic Services

Report on Ngong Ping Skyrail Cabin Dislodgement Incident

Purpose

This paper informs Members of the findings of the investigation into the falling of a cabin from the cable car system on 11 June 2007 and outlines the rectification and other arrangements to be implemented.

Background

2. Since its opening to the public on 18 September 2006, Ngong Ping cable car has received more than 1.5 million passengers in its first nine months of operation. This has already exceeded the average of 1 million visitors per year to the area in the past. The Electrical and Mechanical Services Department (EMSD) has been closely monitoring the operation of Ngong Ping Skyrail as **safety is always our top priority**. It has provided advice to MTR Corporation Limited (MTRCL) and Skyrail-ITM (Hong Kong) Limited (Skyrail) on the operation and maintenance of the cable car system as and when required to enhance its smooth operation and service reliability. During the first nine months of operation, EMSD has conducted regular and random inspections to enforce safety requirements in operation and maintenance for the cableway.

3. There were, however, occasional service interruptions that raised concerns on the reliability of the ropeway system. With advice of the EMSD and in the light of experience, improvements have been made. Before the 11 June incident, the cable car system achieved an overall reliability rate of 98.8%.

4. From 5 to 7 June 2007, Skyrail closed the cable car system in order to facilitate a rope shortening exercise. This is a regular maintenance procedure. Upon completion of the exercise, Skyrail reopened the cable car system for public service on 8 June 2007.

5. Separately, Skyrail commenced a series of tests on 7 June 2007 to satisfy the requirement under the Aerial Ropeways (Safety) Ordinance (Cap. 211) (the Ordinance). Under the Ordinance, the first annual examination of the ropeway has to be completed no later than 14 months from the date of approval to operate, and thereafter every 12 months. In the case of the Ngong Ping cable car system, the first annual examination was due to be completed by 26 July 2007. To meet this statutory requirement, a series of tests had been scheduled during the non-operating hours of the ropeway for about one week to ascertain the effectiveness of different system components.

6. On 11 June 2007, in the course of conducting a brake test, as part of the first annual examination, after the ropeway was closed to the public, a cabin fell to the ground at around 8:00 p.m. In view of the seriousness of the incident, EMSD immediately ordered the MTR Corporation Limited (MTRCL), owner of the ropeway, to close the ropeway, and asked MTRCL to submit a report on the incident. In parallel, the Government also appointed an Expert Panel[1], comprising two renowned independent overseas experts on ropeway incidents and systems and the Assistant Director of Electrical and Mechanical Services, to —

(a) identify the cause of the incident (paragraphs 7-10 refer);

(b) review the management, design, operation and maintenance of the cable car system (paragraphs 11-20 refer) ; and

(c) identify remedial measures and recommend prerequisite requirements for re-opening of the cable car system for use by the public (paragraphs 21-25 refer).

The Incident

7. According to the Expert Panel's findings, the brake tests conducted in the evening of 11 June 2007 were part of the annual examination of the ropeway.

[1] The Expert Panel was chaired by Prof. Dr. Gàbor Oplatka, past President and Honourary Member of the International Organisation for the Study of the Endurance of Wire Ropes (OIPEEC) of the International Organisation for Transportation by Cables (OITAF), with Prof. Dr. Josef Nejez, Chairman of the Austrian Standards Committee on Ropeways, as Deputy.

The test schedule was set out by the independent surveyor[2] appointed by Skyrail, while the manual operation of the brake system for the test was undertaken by the maintenance personnel of Skyrail. Under normal operation, the service brakes function automatically under computer control. The aim of the test is to ascertain the effectiveness of the brakes by simulating partial failure of the deceleration control.

8. In parallel, the Government has conducted a criminal investigation into the incident. The Government's investigation reveals that a person appears to have contravened Section 23A of the Ordinance, which reads "no person shall wilfully or negligently do or omit to do anything in relation to an aerial ropeway if such act or omission is likely to render the ropeway unsafe for persons using, operating, or being in the vicinity of, the ropeway".

9. The Judiciary served three summonses on 17 September 2007 setting out the following information —

(a) [name], on 11 June 2007, in Hong Kong, did negligently omit to consult or clarify with the manufacturer of the Ngong Ping Ropeway before [he] performed a brake test in relation to the ropeway which was neither stated nor required in the Operation and Maintenance Manual of the manufacturer of the ropeway and such negligent omission was likely to render the ropeway unsafe for persons being in the vicinity of the ropeway;

(b) [name], on 11 June 2007, in Hong Kong, did negligently do an act, namely, performing a brake test negligently during the annual examination of the "Tung Chung Cable Car", which was likely to render the ropeway unsafe for persons being in the vicinity of the ropeway; and

(c) [name], on 11 June 2007, in Hong Kong, did negligently do an act, namely, negligently supervising [his] assistant to perform a brake test during the annual examination of the "Tung Chung Cable Car", which was likely to render the ropeway unsafe for persons being in the vicinity of the ropeway.

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[2] Under the Aerial Ropeways (Safety) Ordinance (Cap. 211), the owner of an aerial ropeway shall ensure that an annual examination is carried out by a surveyor who is registered with EMSD. In the case of Ngong Ping Skyrail, "owner" refers to MTRCL or the operator, Skyrail, under the Ordinance. In the current case, the surveyor was appointed by Skyrail.

10. The case has entered the *sub judice* phase. This is now a matter for the court. Therefore, the Government is not in a position to discuss the case or release any information relating to the cause of the incident. A sanitised copy of the Expert Panel's report is at Annex. Certain parts of this report are removed upon the Department of Justice's advice in order not to prejudice the legal proceedings under the Ordinance.

Review of Operation, Management and Maintenance of the System

11. ***Regulatory regime***. EMSD exercises regulatory control under the Ordinance to ensure the safe operation of the ropeway. It performs its regulatory functions through approval of design and installation of ropeways to ensure that they comply with safety requirements. Besides, it also specifies the types and frequency of tests and checks, as well as the maintenance schedule to ensure cable car safety. The international experts have confirmed with us that the current regulatory regime is in line with prevailing international practice. EMSD will continue with this framework to ensure the safety of the cable car system.

12. ***Design of the cable car system.*** Having reviewed the Ngong Ping cable car system, the Expert Panel has confirmed with us that the design of the ropeway is in line with the prevailing international standards and practices.

13. ***Previous incidents.*** Since the formal opening of the cable car system, there had been 21 incidents[3] which led to service disruptions. After reviewing the management, operation and maintenance of the cable car system, the Expert Panel considers that of these incidents, three were caused by component imperfection, such as water-proofing enclosure of an equipment item failing to protect the electronic parts from ingress of water; and eleven related to operation issues, including inadequate works co-ordination, poor workmanship, inadequate operation awareness, and unsatisfactory maintenance and stock management. The remaining seven were due to adverse weather conditions and initial system setting. The Expert Panel advises us that these various instances had affected the reliability of the system but did not compromise its safety.

[3] These incidents exclude the incident on 11 June 2007. They had resulted in suspension of service for 15 minutes to 6 hours 20 minutes.

14. ***On-going improvements***. During the nine months since the Ngong Ping Ropeway commenced operation on 18 September 2006, EMSD conducted over 130 regular and random inspections, and issued 47 advisory notices on improvement measures identified through these inspections. To ensure prompt and effective implementation by MTRCL and Skyrail, EMSD held monthly meetings with MTRCL and Skyrail to closely monitor the progress. As at 11 June 2007, 42 of these 47 improvement measures have been effectively implemented.

15. In view of the less than satisfactory performance of the Ngong Ping Skyrail, EMSD completed a performance review of the Ngong Ping Skyrail and forwarded its recommendations to MTRCL in January 2007. It urged MTRCL to conduct a timely and independent review of the cable car system with regard to the following —

(a) design standard, quality and reliability of major equipment/parts and the cable car system as a whole;

(b) the current operation and maintenance management including fault prevention, recording, diagnosis and recovery procedure;

(c) performance benchmarking with overseas cable car systems of similar design; and

(d) improvement measures for minimising service interruption and thus enhancing system reliability.

16. Subsequently, MTRCL commissioned a consultancy review. Findings of the review were submitted to EMSD for vetting on 31 May 2007. EMSD responded with additional suggestions for implementation.

17. The actions to improve the performance of the cable car system mentioned in paragraphs 14-16 above are summarised in the table below —

Date	EMSD's Action	Follow-up Action taken by MTRCL and Skyrail
September 2006 to 11 June 2007	• conducted 130 regular and random inspections • issued 47 advisory notices on improvement	• 42 out of 47 suggested improvements were completed by Skyrail • the remaining five items are in progress
January 2007	• completed a performance review of the Ngong Ping Skyrail and asked MTRCL to conduct an independent review of the ropeway	• MTRC subsequently commissioned TÜV SÜD to conduct an independent review
31 May 2007	-	• MTRC submitted the consultancy report completed by TÜV SÜD to EMSD
8 June 2007	• responded with additional improvement items	-
11 June 2007	• issued a closure order and commenced investigations into the cabin falling incident	-

18. The Expert Panel has reviewed and endorsed the on-going improvement measures recommended by EMSD before the incident on 11 June 2007.

19. ***Need for further improvement***. The Expert Panel considers that there is further room for improvement in the management, operation, and maintenance of the cable car system. These include the following improvement measures —

(a) training for operators and maintenance staff;
(b) maintenance and operation procedures and work instructions;
(c) spare parts and materials inventory control;
(d) planned preventive maintenance;
(e) quality management;
(f) human resources management; and
(g) procurement practices.

20. These improvements will enhance the maintenance and operation of the cable car system. They will help restore public confidence in the Ngong Ping cable car system. In fact, as mentioned in paragraphs 14 and 15 above, many of the improvements have been undertaken by MTRCL and Skyrail in response to problems identified from instances of service disruption. The Expert Panel considers that a more structured and systematic management approach would help ensure a reliable and efficient ropeway operation.

Pre-requisites for Re-opening

(a) Technical Remedies and Improvements

21. Upon completion of on-site investigations by EMSD, MTRCL and Skyrail have conducted a thorough inspection of the entire cable car system to identify components, parts and equipment which require repair and replacement. During the service suspension, all damaged and worn components have been repaired or replaced as necessary. To ensure satisfactory performance and rebuild the community's confidence in the system, for the re-opening of the system to the public, the Expert Panel considers that —

(i) all the repaired or replaced component parts should be certified by the ropeway manufacturer. This is currently in progress;

(ii) the system should be tested and commissioned as if it were a new build; and

(iii) a full annual examination of the system in accordance with the Ordinance should be conducted.

22. The Expert Panel also considers it necessary for the ropeway owner to implement a quality management system, such as ISO 9000, to enhance management system and work procedures. This will help ensure a more comprehensive compilation of maintenance procedures and work instructions, proper implementation of a stocking/inventory system for spare parts and provision of continued training to all operation and maintenance staff.

(b) A New Management Regime

23. In light of the Expert Panel's recommendations and having reviewed the experience gained in operating the cable car system, MTRCL has informed the Government that it will change the current cable car management. A subsidiary company will be formed by MTRCL to take up the management and operation of the system. The new company will be led by an international management team comprising MTR engineers and experienced cable car professionals. It will strengthen the management approach by implementing ISO 9000 and transferring recognized best practices in safety and quality to further raise professional standards. MTRCL will introduce the new management team to the public when it is in place.

(c) Retraining of Operation and Maintenance Staff

24. MTRCL advises us that the new management will keep virtually all existing operation and maintenance staff. They will receive refresher training to enhance their safety awareness and technical competence. Re-assessment of the ropeway staff and qualified technical personnel will be conducted by MTRCL to ensure the quality of the workforce. They will be further evaluated by EMSD.

(d) Rigorous Trial Run Programme

25. After the above process has been implemented and MTRCL has demonstrated to EMSD that the cable car system is safe and robust, EMSD will require the system to go through a comprehensive dummy load test for at least 7 days, achieving a reliability level of 98% or above. Only upon satisfactory completion of the dummy load test will MTRCL conduct trial runs.

26. The transfer of management control, re-testing of the ropeway, staff re-assessment, a comprehensive dummy load test and trial runs will take some time. MTRCL will announce a re-opening date for commercial operation after all aspects of the recovery programme have been satisfactorily completed and it has obtained the requisite statutory approval from EMSD.

Ngong Ping Village, Trade and Community Engagement

27. The Government understands the difficulties that the tenants at the Ngong Ping Village have faced during the cable car suspension period, and has urged MTRCL to continue to liaise closely with Ngong Ping Village tenants by arranging further rental concessions and promotions. MTRCL will also work jointly with Hong Kong Tourism Board and the travel trade in re-establishing Ngong Ping 360 as a popular tourist attraction.

28. Members are invited to note the series of measures the Government and MTRCL, as owner of the system, will take to ensure smooth re-opening of the cable car system and rebuild its popularity as a must-visit tourist attraction in Hong Kong. We will keep Members, concerned parties and the general public informed of progress made in implementing these measures.

Commerce and Economic Development Bureau
September 2007

As advised by the Department of Justice, in order not to prejudice the legal proceedings under the Aerial Ropeways (Safety) Ordinance, (Cap. 211), certain parts of this report are removed from public viewing.

Report from the Expert Panel

on the

Cabin Falling Incident

occurred on 11 June 2007

at the

Ngong Ping Ropeway

(Prof. Dr. Gabor Oplatka)	(Prof. Dr. Josef Nejez)	(Ir. Frank Chan, JP)
Chairman	Deputy Chairman	Member

Date : 30. Juli 2007

CONTENTS **Page**

PART 1

CAUSES OF THE INCIDENT, AND RECOMMENDATIONS TO PREVENT RECURRENCE OF SIMILAR INCIDENT IN FUTURE

PART 2

ASSESSMENT OF

THE DESIGN, OPERATION, MAINTENANCE

AND

MANAGEMANT OF THE ROPEWAY

PART 2 - ASSESSMENT OF THE DESIGN, OPERATION, MAINTENANCE AND MANAGEMANT OF THE ROPEWAY

Approach of the Assessment

25. The approach adopted by the Expert Panel in conducting the assessment is outlined as follows :

25.1 Conduct on-site inspection and audit of the ropeway by overseas expert.

25.2 Review the previous service disruption incidents and the performance of the ropeway operating company in this regard since the ropeway was opened for public use on 18 September 2006.

25.3 Review the observations and findings arising from the random inspections conducted by EMSD.

25.4 Review operation records of the ropeway, including fault log, duty roster, training and overtime record of staff.

25.5 Inspect and examine maintenance schedule, procedures, work instructions, service log and related records.

25.6 Review record of interview and information given by concerned staff members of Skyrail, representatives of the ropeway manufacturer and owner, as regards operation and maintenance of the ropeway.

25.7 Examine the ropeway performance review reports previously conducted by EMSD in January 2007 and TÜV SÜD in May 2007.

25.8 Review spare part inventory and management system of the ropeway operating company.

On-site inspect and audit of the ropeway by overseas expert

26. During the investigation of the incident, the overseas expert also

conducted on-site inspection and audit of the Ngong Ping ropeway. Some observations and findings are given in Appendix 3.

Review of previous service disruption incidents

27. Since the opening of the Ngong Ping ropeway for public use in September 2006, there were altogether twenty-two major incidents leading to frequent service interruptions. Those incidents resulted in out-cry from dissatisfied passengers, and drew public attention on the reliability of the ropeway system.

28. Discounting those interruptions due to adverse weather conditions and initial system incorrect settings, there were :

- three major incidents which were found to be caused by component design imperfection, and

- eleven major incidents which were found to be caused by operation blunders, poor works coordination, poor workmanship, inadequate operation awareness, poor maintenance and stock management.

29. Paragraphs 30 to 38 below give an assessment of the Expert Panel on the design, operation, maintenance and management of the ropeway.

Review of the incidents relating to design of the Ngong Ping ropeway

30. Table 1 below gives an account of three service interruption incidents which were caused by component design imperfection.

Table 1

Ref No.	Date & Duration of Service Disruption	Brief Description
D1	8.10.06 58 minutes	Inadequate clearance between the hauling rope and the shaft of the rope catcher at the tower, ground fault alarm was activated due to touching of the two.
D2	15.10.06 55 minutes	Premature failure of an electrical part in the control system, causing intermittent service interruption.

D3	6.2.07 15 minutes	Mis-count of the number of cabin inside cabin storage area during cycling-on operation, causing delay in service.

31. Having studied the operation of the ropeway, its physical layout and construction, control arrangement, safety provisions, design philosophy in respect of selecting the bi-cable option, the Expert Panel is of the opinion that the design of the Ngong Ping ropeway is in line with the prevailing international standards and practices for meeting the various parameters in the design intent, including passenger flow, topographical constraints, wind speed resistance and environmental consideration.

32. On the other hand, the Expert Panel noted that certain components of the ropeway system, including v-belt pulleys in stations, track ropes, and connection pins between hangers and the cabins showed signs of rusting which would not be expected for a system that was put into service for one year (figures 17, 18 and 19). Signs of rusting also existed on the spare parts inside the cabin storage area. Those components should be treated for corrosion protection, or replaced with better quality ones that are suitable for the humid environment of Hong Kong, especially in the north Lantau area.

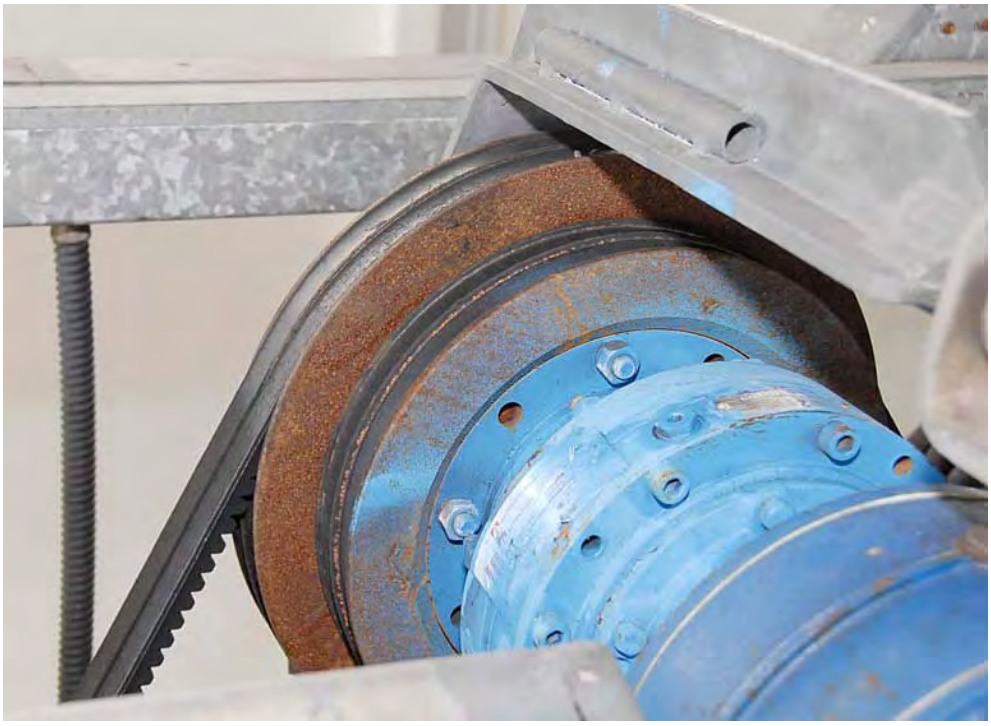


Figure 17 – Close up view on the rusty v-belt pulley

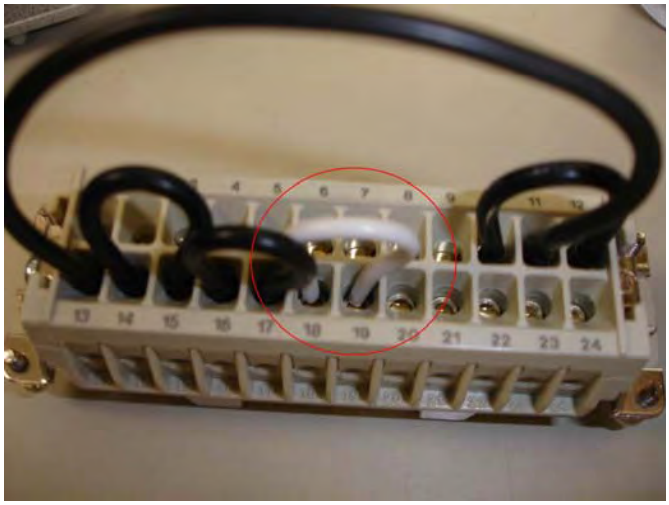
Figure 18 – Close up view on the track rope with rust

Figure 19 – Spare parts stored inside cabin storage area with sign of rust

Review of the incidents relating to operation, maintenance and management of the Ngong Ping ropeway

33. Table 2 below gives an account of the eleven service disruption incidents which were caused by operation blunders, poor works coordination, poor workmanship, inadequate operation awareness, poor maintenance and stock management, and led to prolonged service disruptions.

Table 2

Ref. No.	Date & Duration of Service Disruption	Brief Description
OM1	30.9.06 51 minutes	An incorrect control function plug was used at Tung Chung Terminal, leading to improper functioning of the control system which subsequently tripped the system operation.  Figure 20 - A jumper (in red circle) was found missing from the plug
OM2	15.10.06 59 minutes	The maintenance work conducted at night caused improper cabin spacing resulting in the ropeway system not ready for operation on time in the morning of 15.10.06.

OM3	27.10.06 4 hours 20 minutes	A drive sprocket in the cabin storage area was jammed and one of the teeth was damaged. There was no spare sprocket in stock, and therefore requiring repair of the damaged sprocket, leading to service interruption for over 4 hours.  Figure 21 - Drive sprocket with one of the teeth damaged
OM4	28.11.06 23 minutes	One of the friction belts was found loosen, causing improper cabins separation and resulting in tripping of the system. Frequency of checking and adjustment of belt tension was considered inadequate.
OM5	1.1.07 1 hour 12 minutes	A friction tyre deflated during operation, resulting in tripping of the system. Frequency of checking and maintaining the tyre pressure was considered inadequate.

OM6	3.1.07 1 hour 18 minutes	Water ingressed into an electronic encoder at Airport Island Angle Station, causing tripping of the system. Encoder electronics parts are not well insulated from moisture and dirt.  Figure 22 - Malfunctioned encoder with position where water and oil like dirt found was circled in red
OM7	17.1.07 6 hours 20 minutes	Dirty station rollers trapped moisture, resulting in "grounding fault" warning signal and tripping of the system. Checking and cleansing of station rollers was considered inadequate.
OM8	7.2.07 26 minutes	One of the friction belts was found loosen, causing slippage in the belt drive and resulting in tripping of the system. Frequency of checking and adjustment of belt tension was considered inadequate.
OM9	9.4.07 51 minutes	One of the friction belts was found loosen, causing slippage in the belt drive and resulting in tripping of the system. While adjusting the belt tension, the maintenance technicians over-tightened an adjustment bolt thus causing damage to the bolt threads. Subsequent replacement of the tensioning bolt caused extended service interruption.

OM10	11.5.07 2 hours	A spring-loaded damping roller was damaged during operation, resulting in tripping of the system. The shaft of the damping roller showed heavy surface abrasion, a sign of inadequate routine checks and maintenance.  Figure 23 - Close up view on the shaft with heavy surface abrasion
OM11	11.6.07 from 19:52, 11.6.07 onwards	

34. EMSD has been closely monitoring the safety performance of Ngong Ping ropeway since its public opening. During the past nine months, EMSD has provided guidance and advice to Skyrail with a view to enhancing reliability of the ropeway. The causes for advice can be grouped into two categories, namely, arising from observations during the investigation of the various service disruption incidents and during random inspections conducted by EMSD. It is evident from tables 3 and 4 below that EMSD has also covered detail operation and maintenance of ropeway on top of its regulatory role.

Table 3 – Advice on Improvement arising from EMSD's Investigation of Service Disruption Incidents

*(* denotes those improvement items that have been completed by Skyrail, with close monitoring by EMSD)*

Ref. No.	Incident Date	Advices given to / Actions taken by Skyrail
OM1	30.9.06	● Ensure all function plugs for remote control console are with proper connections. * ● Document and implement engineering changes properly. *
D1	8.10.06	● Provide nylon sleeves to the shafts of rope catchers at Tower 3, as an interim measure. * ● Follow-up with Leitner for new design of rope catcher to allow additional clearance between the rope catcher shaft and the hauling rope. * ● Re-arrange positions of CCTV on Tower 3, 4 & 7 with a view to improving the monitoring of the ropeway conditions at and around the towers. *
OM2	15.10.06	● Implement proper method for lubricating the track rope such that resumption of operation of the ropeway system could be effected on time the next morning. *
OM3	27.10.06	● Stock spare sprocket of chain #4. * ● Source sprocket locally, as an alternative supply. * ● Seek confirmation from Leitner that the cabin conveying system is of suitable duty grading and the parts are of appropriate specification for the design application. * ● Provide motor torque limiting device for the cabin conveyors. * ● Provide a manual override to the computerized operation of the cabin conveyors. * ● Add a display of running current of the conveyors into the SCADA (Supervisory Control and Data Acquisition) system. * ● Request Leitner to investigate the cause of rope cross-over during cycling, and appropriate improvement measures. * ● Conduct laboratory test on the chemical and mechanical properties of the deformed sprocket, and action if necessary. * ● Review the conveyor system of the cabin storage area for enhancing service availability. *

OM5	1.1.07	● Establish a marking system to identify leaky friction tyres. * ● Design and provide inspection facility for tyre leakage. * ● Incorporate tyre pressure gauge for all friction tyres. * ● Adopt measures to prevent rusting on the bolts of tyre hubs. * ● Review constantly pressure setting for friction tyre. * ● Examine if there is correlation between the warning signal "Collision of Vehicle" following by signal "Minimum Grip Force", in the event of tyre losing pressure. *
OM6	3.1.07	● Increase maintenance frequency for encoders & other electronic devices which are used in outdoor environment. * ● Review suitability of enclosure protection for equipment used outdoor. * ● Develop measure for preventing condensation inside encoder. *
OM9	9.4.07	● Improve record system for logging daily maintenance activities. * ● Enhance the frequency of checking of mounting bolts of spacer and use appropriate measure (e.g. thread glue, etc.) to prevent loosening of the mounting bolts. * ● Arrange refreshment course to equip the maintenance team with correct recovery procedure. * ● Provide lock nuts and lining to the adjustable bolts for the spacer. *
OM10	11.5.07	● Check alignment and working condition of all spring-loaded damping rollers. * ● Ensure availability of enough stock for spring-loaded damping rollers. ● Regular apply lubrication and conduct inspection on the moving parts of the spring-loaded damping roller and other similar mechanisms.

Table 4 – Advice on Improvement arising from Random Inspections by EMSD

*(* denotes those improvement items that have been completed by Skyrail, with close monitoring by EMSD)*

Ref. No.	Date	Observation / Advice given to Skyrail
1	31.7.06	**Observation :** Newly employed maintenance technician was found working alone to attend fault during ropeway operation.

		Advice given : Strengthening the on-site supervision of the maintenance activities to ensure effective fault rectification. *
2	2.8.06	**Observation :** Outer wires of the track rope were found to be dislocated. **Advice given :** Close monitoring the condition of the track rope with dislocated wires to ensure rope integrity. *
3	17.9.06	**Observation :** Rusting was found on the actuator for cabin door lock. **Advice given :** Replacement of the original actuator for cabin door lock by unit made of stainless steel. *
4	10.10.06	**Observation :** A fault involving the encoder of main motor occurred during operation and there was no spare encoder for replacement. **Advice given :** Ensure adequate stock and timely replenishment of spare encoder for main motor. *
5	15.10.06	**Observation :** Repeated cabin spacing faults since public opening. **Advice given :** Recording and analyzing the spacing distance of the cabins for improving the software for anti-collision alarm. *
6	15.10.06	**Observation :** Serious corrosion was found at the connection port of the proximity switch. **Advice given :** Use of longer cable for proximity switches so as to eliminate the use of plug and socket which are prone to corrosion. *
7	16.10.06	**Observation :** The last cabin with passengers was not correctly reported by an operator, risking to have passengers trapped on line after operation. **Advice given :** Reminding all controllers & operators to follow the proper procedure of "Reporting Last Cabin". *
8	3.11.06	**Observation :** Replacement of rusty pulleys were being conducted by Leitner, with little input from Skyrail. **Advice given :** - Closely monitor of replacement of rusty pulleys in all terminals and angle stations. - Examine if there is excessive wear of the belts and pulleys. * - Addition of tensioning device for the belts in the deceleration/acceleration systems in the terminals and angle stations. *

9	16.11.06	**Observation :**	Anemometer at Tower 4 was found out of function.
		Advice given :	Restoring the proper functioning of the anemometer at Tower 4 which provides essential wind speed measurement. *
10	Early Jan 07	**Observation :**	Skyrail has implemented a software management system, namely FRACAS (Failure Reporting Analysis, Corrective Action System), but not making good use of it.
		Advice given :	Skyrail to conduct regular fault analysis by using FRACAS so as to identify measures to minimize service interruption. *
11	5.1.07	**Observation :**	One of the bolts for engaging/disengaging rescue drive from the bull wheel was found to be broken. The bolt was suspected to have broken earlier. Some staff noticed the defect but not reported to the management.
		Advice given :	- Develop appropriate measure for checking the disengagement of bull wheel coupling with the main shaft. * - Enhance fault recording & reporting system. *
12	March 07	**Observation :**	Replacement of rusty connection pins were being conducted by Leitner, with little input from Skyrail.
		Advice given :	Remind Skyrail to closely monitor the replacement works with a view to identifying if there is any abnormality. *
13	30.4.07	**Observation :**	A station roller was found with its rim seriously damaged. Investigation revealed that a mounting bolt for station roller was broken during ropeway operation.
		Advice given :	Regularly check and replace all mounting bolts for station rollers in view of observed corrosion.

35. While the ropeway operating company is responsible for the safety and reliability of the Ngong Ping ropeway, the same applies to the ropeway owner, namely the MTR Corp. Ltd. (MTRCL). In early 2007, it became evident that the performance of the Ngong Ping ropeway warranted close scrutiny from its owner. EMSD therefore compiled a paper (Appendix 4), outlining the observations derived from repeated incidents as well as its random inspections, and recommended MTRCL to conduct performance review of the ropeway, among other things.

36. Subsequently, MTRCL contracted TÜV SÜD to conduct an independent review and submit a report in May 2007 (Appendix 5). While "the reliability of the Ngong Ping ropeway during its initial operating period is considered to be in line with the best practice of comparable systems", the report outlined a number of areas that required improvement actions. Comparing to an independent audit of the ISO 9000 Quality Management System, some of those deficiencies would be classified as non-conformances.

37. Deriving from the observations by EMSD during the process of investigation of the service disruption incidents and during random inspections conducted by EMSD as described in tables 3 and 4, the overall performance concerning operation, maintenance and management of the ropeway were considered to have room for improvement.

38. The Expert Panel therefore considers that improvement is required in the following areas :

38.1 Training for operators and maintenance staff

Refresher training for the operation and maintenance staff is needed to enhance their technical know-how, and to upkeep the ropeway to maintain a highly reliable ropeway service to meet public expectation. In particular, enhancement of emergency preparedness and response to scenarios such as inclement weather, unexpected stoppages and happenings, as well as timely fault attendance and rectifications, is considered essential. Furthermore, communication, understanding and cooperation between operation team and maintenance team should be strengthened so that observations from the operation team could be reflected timely to the maintenance team, and vice versa.

38.2 Maintenance and operation procedures and work instructions

While operation and maintenance manuals are made available by the manufacturer, detailed procedures and work instructions are essential for operation and maintenance staff and should be developed to provide clear procedures and works instructions for all daily operation and maintenance routines. These documents should make cross reference to the relevant sections of the O&M manual, and shall be

prepared and distributed to all staff concerned. Where appropriate, these procedures and work instructions should be written in Chinese for easy understanding by the staff. The documentation control system should be in line with the requirements of ISO 9000, or equivalent.

38.3 Spare parts and materials inventory control

The existing stock level of essential spare parts and materials should be reviewed, and a systematic inventory management system should be established by taking into account the lead time for delivery of spare parts and its consumption rate, such that adequate stock level of all spare parts/materials will be maintained. Furthermore, the keeping of spare parts at each terminal/station should be reviewed, for improving the response time to fault attendance and rectification.

38.4 Planned preventive maintenance

Planned preventive maintenance should be enhanced, as varying degrees of corrosion appeared in many parts of the system, for example brake discs, track rope, station pulleys, and cabin carriages. In addition, frequency of routine checks and maintenance to system components should be increased to avoid failure of components leading to prolonged service interruptions.

Another observation was that the average monthly running time of the ropeway system stands at 420 hours, which is higher than the ceiling of 250 hours per month recommended by the manufacturer, which used this ceiling as the basis for providing the recommended maintenance schedule. Therefore, with the increased usage, the maintenance frequency should be rescheduled in consultation with the manufacturer to take account of the increased running hours.

38.5 Quality management

As at end July 2007, there is no quality management system in place, risking inconsistency in operation and maintenance practices. This has resulted in repeated minor operation blunders and substandard quality of work in a number of occasions affecting the service reliability

of the ropeway. The establishment and implementation of a structured quality management system would help ensure a safe and reliable ropeway operation.

38.6 Human resource management

Operation and maintenance staff is constantly on a 12-hour daily shift roster. On top of that, they are frequently required to work overtime, and prolonged working hours would invariably cause deterioration in the quality of work. For example, in April 2007, the total overtime of the maintenance team was 580.5 hours which resulted in having an effective 14-hour shift for each maintenance staff.

It should be pointed out that overhaul of the cabins has yet to be conducted as one of the routine activities. The manpower shortage problem of the maintenance team will become more acute when the overhaul programme of the cabins is going to start.

Since the ropeway system was put into operation in September 2006, four key personnel in the maintenance team (total of twenty-seven staff) left the company. It is considered that the retention of knowledge and skills in the maintenance team would need to be constantly reinforced.

38.7 Procurement practices

Procurement of services, tools, materials and spares has not been given priority, leading to delays in maintenance works and thus affecting the service reliability of the ropeway. Examples of long processing time for procurement are given in table 5. A review of the procurement practices is required, with management commitment and priority given to enable the maintenance team to have timely acquisition of services, tools, materials and spares. Besides, sourcing of alternative supply of spares and materials should also be explored.

Table 5

Description of Item	Processing Time	Consequence
1. Repair of CCTV at towers	Outstanding since March 07	Any deropement at towers could not be effectively monitored and checked.
2. Procurement of spare shaft of the spring-loaded station roller	Outstanding since May 07	Incident on 11.5.07 could have been avoided if the damaged shaft was replaced as the damage was observed before the incident.
3. Procurement of working platform for works at height inside stations	About 3 months	Work at height could not be effectively conducted prior to delivery of the platform.
4. Procurement of grip force tester	Outstanding for more than 6 months	Overhaul of cabins could not be carried out timely.
5. Procurement of V-belt tensioners	About 1 month	Fault recovery could not be timely conducted prior to delivery of the tensioners.

PART 3

PREREQUISITE REQUIREMENTS

FOR

RE-OPENING OF THE ROPEWAY

FOR USE BY THE PUBLIC

PART 3 - PREREQUISITE REQUIREMENTS FOR RE-OPENING OF THE ROPEWAY FOR USE BY THE PUBLIC

39. Having reviewed the falling of cabin incident on 11 June 2007, prevailing legislations, international standard and practices, inputs from independent surveyors, and also the operation and maintenance of the ropeway since September 2006, the Expert Panel recommends the following prerequisite requirements prior to the re-opening of the ropeway for use by the public :

39.1 Examination of all damaged parts of the ropeway arising from the falling incident, repair and replace where necessary, certification by the manufacturers of the respective systems/components, including:

(a) track rope by the rope manufacturer;
(b) hauling rope by the rope manufacturer;
(c) tower structure by a Registered Structural Engineer and tower alignment;
(d) replaced components on Tower 2B by the ropeway manufacturer.

39.2 Examination of the ropeway system, in accordance with regulation 20(3) of the Aerial Ropeways (Operation and Maintenance) regulations, on:

(a) all ropes, including gauging the circumference, visual examinations over the whole length and defectograph readings over the entire length of the hauling rope and track rope;
(b) the car hangers and grips, including the actuating and checking mechanisms;
(c) the sheave trains, sheaves, bushes, pins and beams located on trestles;
(d) the sheaves, bushes and pins at the incoming and outgoing trains located at stations;
(e) the main, auxiliary and stand-by drives and braking systems;
(f) all electric circuits, controls, switchgear and earthing arrangements;
(g) car door locking devices and cars for deformation, broken or loose windows and size of apertures;
(h) trestles and foundations, including torque loaded bolts on trestle heads;

(i) car carriage and rope speed synchronizing equipment; and
(j) any other apparatus, device or machinery as may be required by EMSD.

39.3 Testing and commissioning of the following parts and operation procedures of the ropeway as if it was a new build,
(a) all the cabins, including the grips, door mechanism, carriage and its rollers, and structural parts;
(b) drives, brakes, rope tensioning devices;
(c) all control systems, safety devices, sensors and alarms;
(d) cycling on and off systems, cabin conveying and storage system; and
(e) CCTV and all other monitoring systems.

39.4 Implementation of all necessary improvement measures identified by the Independent Review Report prepared by TÜV SÜD, for enhancing system reliability.

39.5 A proposal on the management, operational and maintenance organization, to outline how the new management will effectively operate the ropeway to meet the safety and reliability requirements, as well as the expectation of the public.

39.6 Implementation of a quality management system, such as ISO 9000, PAS 55, or equivalent, for the operation and maintenance of the ropeway. The system shall be put in place with necessary training for staff duly completed. Particular attention should be paid in the following areas :
(a) compilation of maintenance procedures and work instructions, operation checklists, activities log and to ensure their effective implementation;
(b) implementation of a proper spare parts stocking/inventory system; and
(c) Provision of focused, or refresher training to all competent persons, controllers, operators, and maintenance technicians, as well as for all new recruits. A training plan should also be submitted to ensure regular training will be provided for all the operation and maintenance staff.

- END -

The Expert Panel
on the Investigation of the Falling of a Cabin from the Ngong Ping Ropeway
Government of the Hong Kong Special Administrative Region
30 July 2007

Appendix 1

FORENSIC EXAMINATION RESULT

BY

THE GOVERNMENT LABORATORY

Appendix 2

INPUT FROM PROF. DR. OPLATKA AND PROF. DR. NEJEZ

ON ANALYSIS OF BRAKE TEST ON 11 JUNE 2007,

AND

DYNAMIC BEHAVIOUR OF THE ROPES

Appendix 3

INPUT FROM PROF. DR. NEJEZ

ON

THE DESIGN, OPERATION AND MAINTENANCE

AND

HOUSEKEEPING OF THE NGONG PING ROPEWAY

2nd Input to Report of Expert Panel

Ngong Ping Skyrail 360
Technical Problems

Author:

Prof. Dr. Josef Nejez

2nd Input to Report of Expert Panel

Ngong Ping Skyrail 360
Technical Problems

Requested by:

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Date of report: 22nd of July 2007
Number of pages: 6

1. Introduction

During my stay in Hong Kong in connection with the investigation of the incident of 11 June 2007 I was asked by EMSD to have a look at the ropeway and point out further technical problems, which may impair the availability and/or safety of the installation in the future. As agreed upon there was undertaken a random survey throughout the installation only. This survey is not to be considered as an investigation.

2. Findings

During the survey no defects were determined, which could at present represent a danger for the ropeway. Problems, which may impair the availability and/or safety of the installation in the future or at least affect the appearance of the ropeway, are the following:

2.1 In the course of the survey it turned out that many construction units show indications of rust, which one does not expect with a so recent installation. Figures 1 to 11 show such construction units.

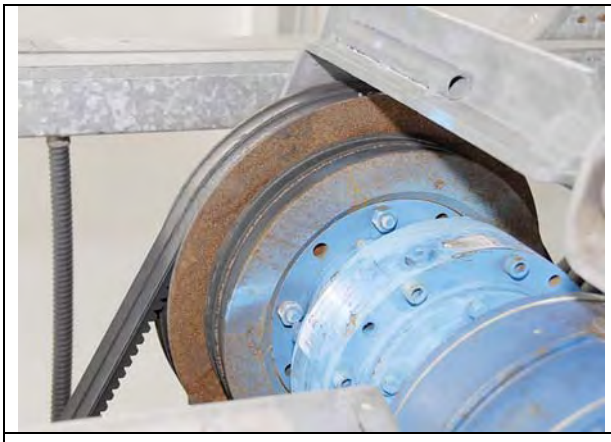

Fig. 1: Rusty V-belt pulleys at the driving motor of the conveyer systems

Fig. 2: Rusty V-belt pulleys at the conveyer systems

Fig. 3: Rusty V-belt pulleys at the conveyer systems (detail)

Fig. 4: Rust and peeling coat of paint at the coupling rails

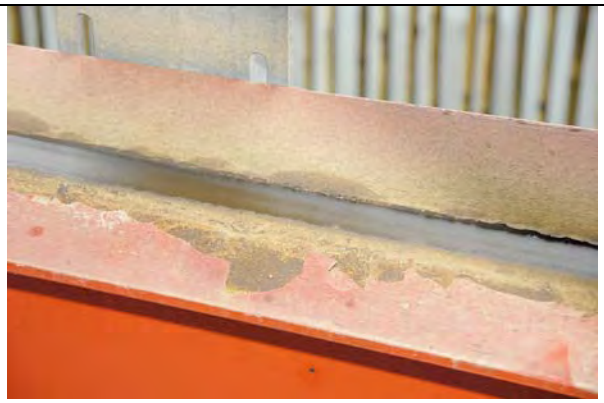

Fig. 5: likewise

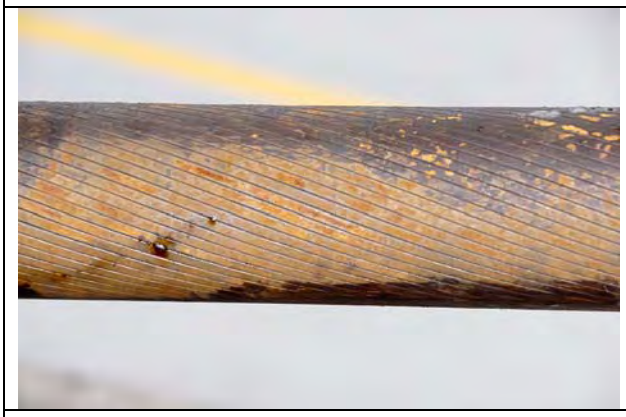

Fig. 6: Rust at the carrying rope within the range of Nei Lak Shan Angle Station

Fig. 7: likewise

Fig. 8: likewise

Fig. 9: likewise

Fig. 10: Rusty axles of the connection of suspension and cabin

Fig. 11: Even the new axles of the connection of suspension and cabin show traces of rust.

2.2 Within the range underneath the mobile platform in Tung Chung Terminal and Ngong Ping Terminal water was found, which can damage the drive of the mobile platform (electrical and mechanical parts under water). Figures 12 and 13 show that range underneath the platforms.

Fig. 12: Water within the range underneath the movable platform in Tung Chung Terminal

Fig. 13: Water within the range underneath the movable platform in Ngong Ping Terminal

2.3 At some anchor drums the outer layer of z-wires of the carrying rope show structural problems (e. g. Fig. 14 and 15). As Prof. Oplatka has told me Fatzer (manufacturer of the ropes) already took care of the problem.

Fig. 14: Structural problems of the carrying ropes in the outer layer of z-wires

Fig. 15: likewise

2.4 During the visit of the ropeway it turned out, that vehicle loading and unloading of the line takes a long time because of fault stops because of spatial displacements of cabins. It was said that because of this reason the cabins usually stay on the line during the nighttime and are not stored up in the garage in Tung Chung Terminal. This causes unnecessary stress of the vehicles and the ropes.

3. Recommendations

3.1 Rust protection should be generally improved.

3.2 The range underneath the mobile platforms in Tung Chung Terminal and Ngong Ping Terminal should be drained.

3.3 It should be clarified weather the structural problems of the carrying ropes on some of the anchor drums may cause problems in the future (e. g. at the time of relocation of the carrying ropes).

3.4 Loading and unloading procedure of the ropeway should be improved. The vehicles should usually be stored up in the garage at Tung Chung Terminal during the nighttime.

Vienna, 22nd of July 2007

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(Prof. Dr. Josef Nejez)

Appendix 4

PERFORMANCE REVIEW ON NP360 BY EMSD

PERFORMANCE REVIEW OF NGONG PING 360 CABLE CAR SYSTEM

Purpose

This paper reviews the performance, reliability and underlying causes of major incidents of Ngong Ping 360 (NP360) cable car system since its opening on 18 September 2006, outlines the associated findings and recommends way forward to enhance system reliability and to regain public confidence.

Background

2. There were all together 11 major incidents since the opening of NP360 for public use since 18 September 2006. These incidents have drawn intense public and media attention on the reliability of the cable car system.

The incidents

3. Among the 11 incidents, 3 were due to poor weather condition, 1 was due to inappropriate operation and maintenance and 7 were due to equipment/part failure. A summary of these incidents is given in **Annex 1**.

4. In response to these incidents, we have advised and Skyrail (the operator of NP360) has taken remedial and improvement measures including enhancement of operation and maintenance procedures, increase in manpower, better equipped with tools and spares, addition of monitoring devices and fine-tuning of the cable car system.

Areas of Concern

5. EMSD has closely monitored the progress of the remedial and improvement measures, as well as performance of the system. These measures aim to enhance system reliability and shorten the recovery time should system stoppage occur. However, it appears that some of the equipment/part failures were related to the quality of the equipment of which routine maintenance may not be able to prevent. For example, moisture was found inside the defective speed encoder that caused the stoppage incident on 3 January 2007.

6. In addition to the findings given by Skyrail in their investigation reports, our own incident investigation and on-site monitoring inspection revealed various problems in the system. For example, some of the metallic parts start getting rusty under the misty environment in North Lantau area. As these parts should have been designed to withstand local operation environment, the observed rate of deterioration and the high failure rate of components have nonetheless arouse concern.

7. Deriving from our on-site observations, a number of areas where improvement measures are required were made clear to Skyrail. A summary of the improvement measures recommended in the past and their associated progress is given in **Annex 2**. The information given in Annexes 1 and 2 indicate inadequacies in various areas and the possibility of recurrence of stoppage incident is likely. Furthermore, timely and systematic fault diagnosis is essential to efficient and speedy service recovery. However, the diagnostic software and procedure provided by the cable car manufacturer have apparently rooms for improvement. In view of the aforesaid, there is a need to review the design standard and quality of these equipment/parts with a view to enhancing overall system performance.

Recommendations

8. We are of the view that the design standard and quality of equipment, as well as the effectiveness of the diagnostic software and procedures have contributed to the repeated occurrence of incidents during the past months.

9. We recommend that an independent review of the cable car system should be conducted with regard to the following aspects :-

(a) design standard, quality and reliability of major equipment/parts and the cable car system as a whole;

(b) the current operation and maintenance management including fault prevention, recording, diagnosis and recovery procedure;

(c) performance benchmarking with overseas cable car system of similar design; and

(d) improvement measures for minimizing service interruption and thus enhancing system reliability.

10. In view of the potential risk of repeated equipment failure and hence system stoppage, we recommend the review to be completed within four weeks.

11. As MTRCL is the ultimate owner of the cable car system, it is recommended that MTRCL to engage an independent party to conduct the above-mentioned review as soon as possible.

Electrical and Mechanical Services Department
12 January 2007

Annex 1

Summary of major incidents occurred since the soft opening of NP360 for public use from 18/9/2006

Date	Impact	Stoppage Time	Cause	Underlying Problem
Sep 23, 2006	Stop boarding of passenger	10:00 – 10:15 (15 min) stop boarding of passenger, no stoppage of system	Strong wind	-
Sep 24, 2006	Stop boarding of passenger	13:24 – 13:56 (32 min) stop boarding of passenger, no stoppage of system	Strong wind	-
Sep 30, 2006	Stop boarding of passenger	9:00 – 9:39 (39 min) stop boarding of passenger, no stoppage of system	Strong wind	-
	Suspension of Service	10:35 – 11:26 (51 min) stop boarding of passenger; 10:35 – 11:13 (38 min) stoppage of system	Equipment failure (defective plug)	Operation blunder (poor engineering change management)
Oct 8, 2006	Suspension of Service	16:48 – 17:46 (58 min) stop boarding of passenger; 16:48 – 17:21 (33 min) stoppage of system	Equipment failure (insufficient clearance for haul rope)	Design imperfection
Oct 15, 2006	Service could not be started on schedule	10:00 – 11:06 (66 min) no service	Delay in maintenance work causing system not ready for operation on time	Poor operation and maintenance coordination
	Intermittent Stoppage	18:05 – 19:00 (55 min) intermittent stoppage	Equipment failure (poor contact of cable connector)	Poor design standard/ quality of component
Oct 27, 2006	Service could not be started on schedule	10:00 – 14:20 (4 hr 20 min) no service	Equipment failure (defective component on conveying system in Cabin Storage Area)	Design imperfection/ workmanship imperfection/ inappropriate torque limit setting
Nov 28, 2006	Suspension of Service	12:22 – 12:45 (23 min) stoppage of system	Equipment failure (friction belt not enough tension)	Poor maintenance strategy

Date	Impact	Stoppage Time	Cause	Reflected Problem
Jan 1, 2007	Intermittent Stoppage	16:14 – 17:26 (1 hr 12 min) stop boarding of passenger 16:29 – 16:35 (6 min) stoppage of system	Equipment failure (Air leakage on friction tire)	Poor quality of inner tube of tire and poor maintenance strategy (repeated tire failure)
Jan 3, 2007	Suspension of Service	18:20 – 19:38 (1 hr 18 min) stoppage of system	Equipment failure (Defective speed encoder)	Poor design standard/ quality of component

Annex 2

Summary of improvement items recommended and the associated progress

Date	Observation	Measures Recommended	Underlying Problem	Progress
July 31, 2006	Maintenance technician worked alone to attend fault	Strengthening of on-site supervision of maintenance activities	Poor maintenance system	Completed with satisfactory results
Aug 2, 2006	Dislocation of outer wires at the terminals of track ropes was observed	Monitoring of the condition of wire dislocation on track ropes at terminals	Inadequate awareness	On-going with close monitoring the condition via maintenance
Sep 17, 2006	Recurrence of stoppage due to "Cabin door not closed/locked" appeared	Replacement of original actuator for cabin door lock by stainless steel actuator	Poor design standard and quality of component	Completed with satisfactory results
Oct 10, 2006	The last motor speed encoder was used	Ordering of spare motor speed encoder	Poor stock management	Completed with satisfactory result
Oct 15, 2006	Proximity switch was found not function properly	Use of connector with better design standard and quality on sensors	Poor design standard and quality of component	Trial in progress
Oct 15, 2006	Recurrence of intermittent stoppage due to the activation of "Collision of Vehicle" alarm	Enhancement of operation procedures and improvement of software for controlling anti-collision alarm	Operation imperfection	Completed and performance being closely monitored
Oct 16, 2006	The last cabin with passenger was not properly reported	Reminding all controller and operators to follow the proper arrangement of "Reporting Last Cabin"	Poor operation	Completed with satisfactory result
Nov 3, 2006	A large amount of pulleys in synchronization system were found rusty after opening for use for a short period of time	Replacement of rusty pulleys	Poor design standard and quality of component	Replacement work in progress

Date	Observation	Measures Recommended	Underlying Problem	Progress
Nov 3, 2006	Excessive wear of belts and pulleys was found after opening for use for a short period of time	Study causes of excessive wear of belts and pulleys and strengthen maintenance	Poor design standard and quality of component	Study in progress while maintenance has been strengthened
Nov 3, 2006	Elongated tension belt with good condition needs replacement	Addition of tensioning device for tension belts in synchronization system	Poor design	Trial in progress
Nov 16, 2006	Malfunction of the anemometer at Tower 4 was encountered	Restoring the proper functioning of anemometer at Tower 4 due to connection problem	Poor design standard and quality of connection	Completed with satisfactory result
Jan 5, 2007	One of the three bolts for engaging/ disengaging rescue drive was found broken but was not reported/recorded	a) Replacement of bolt for engaging/ disengaging rescue drive	Poor maintenance management	Completed with satisfactory result
		b) Developing appropriate tools/gauge for checking the movement of engaging/ disengaging rescue drive	Poor maintenance system	Improvement work in progress
		c) Enhancing fault recording, reporting, tracking and analysis system	Poor maintenance system	Improvement work in progress

A ppendix 5

REPORT OF THE INDEPENDENT REVIEW

CONDUCTED BY TÜV SÜD