二零零七年九月十八日會議

立法會經濟事務委員會

昂坪纜車車廂墜下事件調查報告

目的

本文件旨在告知議員在2007年6月11日纜車系統一個車廂墜地事故的調查結果，並扼述所需的補救措施和其他安排。

背景

2. 昂坪纜車自2006年9月18日啟用以來，在運作的九個月期間，已接載150多萬名乘客，人數超越以往平均每年遊覽該區的100萬人次。**安全向來是我們的首要考慮**。機電工程署(機電署)在昂坪纜車啟用後，一直密切監察纜車運作情況，並因應需要，就管理和保養問題向地鐵公司和Skyrail-ITM(香港)有限公司(Skyrail)提出意見，從而令纜車系統運作更加暢順可靠。在昂坪纜車啟用後的九個月期間，機電署透過定期及突擊巡查，確保纜車在運作和保養方面均符合安全規定。

3. 不過，纜車服務多次中斷，令人關注纜車系統的可靠性。其後，纜車系統已按照機電署的意見和運作經驗作出改善。在6月11日的事故發生前，纜車系統的整體可靠程度達到98.8%。

4. 在2007年6月5日至7日，Skyrail因要為纜車進行纜索縮短工作而暫停接載乘客。縮短纜索是定期保養程序之一。在有關工作完成後，纜車系統於2007年6月8日重開為公眾提供服務。

5. 另一方面，Skyrail根據《架空纜車(安全)條例》(第211章)(有關條例)，由6月7日起為纜車進行測試。按照該條例，纜車須於獲准運作當日起計的14個月內進行首次年檢，其後每12個月檢驗一次。依照法例規定，昂坪纜車的首次年檢，須於2007年7月26日之前完成。為符合上述規定，

Skyrail 為昂坪纜車安排了一連串測試，在停止載客後進行，以查驗各系統組件的性能。整套測試為期大約一星期。

6. 在 2007 年 6 月 11 日，纜車在停止接載乘客後，進行制動系統（下稱剎車系統）測試，這是首次年檢的一部分。期間，一個車廂在晚上 8 時左右墜落地面。鑑於事態嚴重，機電署即時飭令纜車擁有人（即地鐵公司）停止纜車服務，並就事件提交報告。政府亦隨即委任專家委員會[1]，由兩位國際知名的獨立纜車專家與機電工程署助理署長組成。委員會負責——

(a) 查明肇事原因（參閱第7-10段）；

(b) 檢討纜車系統的管理、設計、運作和保養（參閱第11-20段）；和

(c) 定出補救措施，並提出重開纜車系統予公眾使用的先決條件（參閱第21-25段）。

隧車事件

7. 根據專家委員會的調查結果，2007 年 6 月 11 日晚上進行的剎車系統測試是纜車年檢程序的一部分。測試項目是由 Skyrail 聘請的獨立檢測員[2]訂定，並由 Skyrail 的保養人員在測試期間以人手操作剎車系統。在正常運作時，剎車系統的操作和減速由電腦控制。測試目的是透過模擬減速控制系統局部失效，查驗剎車系統的性能。

8. 在專家委員會就事件進行調查的同時，政府亦進行刑事調查。政府的調查顯示有人涉嫌違反有關條例第 23A 條，該條例列明「任何人不得故意或疏忽地作出或不作出任何與架空纜車有關的事情，而該等作為或不作為是相當可能使架空纜車對使用架空纜車、操作架空纜車或在其附近的人構成不安全的。」

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[1] 專家委員會主席由 Gàbor Oplatka 教授擔任，他是國際纜索運輸協會（OITAF）屬下國際纜索耐力研究協會（OIPEEC）前主席及榮譽會員；副主席是奧地利纜車標準委員會主席 Josef Nejez 教授。

[2] 根據有關條例，架空纜車擁有人必須確保年檢由已向機電署註冊的獨立檢測員主理，"擁有人"包括地鐵公司和營運商 Skyrail。負責今次年檢的獨立檢測員是由 Skyrail 聘請的。

9. 司法機構在9月17日就以下三項違法行為將傳票送達有關人士——

(a) [姓名]於2007年6月11日，在香港進行有關架空纜車剎車測試前，疏忽地不向「東涌吊車」的製造商諮詢或澄清，而該測試並沒有在架空纜車的製造商之運作及維修手冊內列出或要求。該疏忽不作為是相當可能使架空纜車對在其附近的人構成不安全的；

(b) [姓名]於2007年6月11日，在香港疏忽地作出事情，即在「東涌吊車」的每年檢驗期間，疏忽地進行剎車測試，而該作為是可能使架空纜車對在其附近的人構成不安全的；和

(c) [姓名]於2007年6月11日，在香港疏忽地作出事情，即疏忽地監督[他]的助理，在「東涌吊車」的每年檢驗期間進行剎車測試，而該作為是可能使架空纜車對在其附近的人構成不安全的。

10. 現時案件已進入司法程序，已交由法庭處理。根據律政司指示，政府不能討論事件，或提供涉及事故起因的資料。律政司的意見按專家委員會報告（只有英文版本）部分內容已被剔除，並載於附件。

就系統管理、運作和保養的檢討

11. ***規管制度：***機電署根據有關條例實施規管，確保纜車系統安全運作。透過批核設計和安裝，機電署確保纜車符合安全要求。此外，機電署也會規定纜車須通過的測試的範疇和次數，和維修安排。委員會的國際專家向我們確定，現行的規管制度與國際做法一致。機電署會繼續透過現行架構確保纜車系統安全。

12. ***纜車系統的設計：***在檢視過纜車系統，專家委員會確定纜車的設計符合現行的國際標準和守則。

13. ***過往事故：***自昂坪纜車正式啟用以來，一共發生了 21 宗[3]導致服務中斷的事故。在檢討纜車系統的管理、運作和保養後，專家委員會認為：這些事故之中，有 3 宗是由於組件有瑕疵所致，例如某項設備的防水外殼未能保護電子零件免受滲水影響；有 11 宗出於操作失誤，包括工程協調不足、施工質素欠佳、操作警覺不足，以及保養和存貨管理不善；其餘 7 宗事故則與天氣惡劣和初期系統設定有關。專家委員會指出，這些事故影響系統的可靠程度，但不會危及纜車安全。

14. ***持續改善：***自昂坪纜車在 2006 年 9 月 18 日開始操作至今的九個月期間，機電署進行了 130 次常規和隨機檢查，並且發出了 47 項勸告通知書，通知地鐵公司和 Skyrail 須作出的改善工作。為確保這些工作能適時及有效地實施，機電署每月與地鐵公司和 Skyrail 召開會議，從而密切監察進度。直至 2007 年 6 月 11 日，其中 42 項改善措施已確切落實。

15. 由於昂坪纜車的表現未符理想，機電署於 2007 年 1 月為昂坪纜車作出整體表現評估，及將有關建議通知地鐵公司。機電署更敦促地鐵公司聘用顧問，就以下各個範疇為纜車系統作出檢討——

(a) 整體纜車系統及主要機件和零件的設計標準、質量和可靠性；

(b) 現時的操作和保養安排，包括預防失靈的措施、運作紀錄、系統診斷和復修程序；

(c) 與設計相若的海外纜車系統的表現作比較；和

(d) 建議改善措施，以減少服務中斷情況，提高系統的可靠性。

16. 其後，地鐵公司聘請顧問進行研究，並於 5 月 31 日向機電署提交報告。機電署已就報告建議向地鐵公司提出意見。

[3] 這些事故並不包括在 2007 年 6 月 11 日發生的事故。上述事故導致的服務中斷時間由 15 分鐘至 6 小時 20 分鐘不等。

17. 上述第 14-16 段所提及的行動表列如下—

時序	機電署的行動	地鐵公司和Skyrail的跟進工作
2006年9月至2007年6月11日	• 進行了130次常規和隨機檢查 • 發出了47項勸告通知書	• 已落實42項改善措施 • 其餘5項仍在進行
2007年1月	• 為昂坪纜車作出整體表現評估，並敦促地鐵公司聘用顧問為纜車系統作出檢討	• 其後，地鐵公司聘用TÜV SÜD公司進行獨立評估
2007年5月31日	-	• 地鐵公司向機電署提交由TÜV SÜD完成的顧問評估報告
2007年6月8日	• 提出其他改善建議	-
2007年6月11日	• 由於發生車廂墜下事故，飭令纜車停止運作	-

18. 專家委員會已檢討及認許機電署於 2007 年 6 月 11 日事故發生前所建議的改善措施。

19. ***進一步的改善措施：***專家委員會認為系統在管理、運作和保養方面仍可進一步提升，包括——

(a) 操作和保養人員的培訓；

(b) 保養、操作程序及工作指示；

(c) 零件和物料的存貨管理；

(d) 定期進行預防性保養；

(e) 品質管理；

(f) 人力資源管理；和

(g) 採購模式。

20. 這些改善措施可改善纜車系統的保養和運作，並有助重建公眾對昂坪纜車系統的信心。事實上，正如上文第 14 和 15 段所述，地鐵公司和 Skyrail 已針對每次導致服務中斷的原因落實多項改善措施。然而，專家小組認為有必要施行更有系統和全面的管理模式，以助加強纜車系統的操作效率和可靠性。

纜車重開的先設條件

（a） 技術補救和改善措施

21. 在機電署完成實地調查後，地鐵公司和 Skyrail 已全面檢查整個纜車系統，以找出需要修理和更換的組件、零件和設備。在纜車停駛期間，已完成修理和更換所有毀壞和耗損的組件。為確保纜車系統操作暢順，以及恢復市民的信心，在纜車服務重開前，專家委員會有以下建議——

(i) 所有經過修理或更換的配件均須經由纜車製造商驗證。這方面的工作正在進行；

(ii) 纜車系統須如剛落成一樣，重新接受測試和檢驗；及

(iii) 須按照有關條例對纜車系統進行全面的年度檢查。

22. 此外，專家委員會亦建議纜車系統擁有人應實施品質管理，如國際標準化組織指引第 9000 條（ISO 9000），以提升營運制度和工作程序。此舉有助營運商編製全面的保養程序和工作指示、妥善推行零件存貨／倉存制度，並為所有操作和保養人員提供持續訓練。

（b） 新的管理層

23. 鑑於專家委員會的建議和操作纜車的實際營運經驗，地鐵公司已知會政府，將會撤換現時的纜車公司的管理層。地鐵公司會成立附屬公司，接管纜車系統的管理及營運工作。新公司會由國際級的管理團隊領導，成員來自地鐵的工程人員和資深的纜車專業人仕。地鐵公司會加強纜車管理，並會實施ISO 9000和採納最佳安全及品質管理作業模式，從而提升纜車系統的專業水平。新管理層就位後，地鐵公司便會向公眾介紹。

（c） 重新訓練操作及保養人員

24. 地鐵公司告知我們新管理層會保留絕大部分的現職操作及保養人員。他們會接受重溫訓練，以提升他們的安全意識和技術專長。地鐵公司會重新評核有關員工的技術水平，確保工作團隊稱職勝任。機電署也會進一步評估這些人員。

（d） 嚴格試運計劃

25. 在地鐵公司落實上述程序，以及向機電署證明纜車系統穩妥後，機電署會要求系統進行為期最少七日的全面負載測試，並以達到可靠程度起碼98%為目標。在負載測試圓滿完成後，地鐵公司才可進行試運。

26. 移交管理權、重新測試纜車、重新評估員工、全面負載測試，以及纜車試運都需要時間。地鐵公司會在圓滿完成復原計劃的各個部分，再取得機電署根據法例發出的批准後，才公布纜車重開的日期。

昂坪市集、業界和社區參與

27. 政府非常明白昂坪市集的商戶在纜車停駛期間所面對的困境，並已敦促地鐵公司繼續與其在昂坪市集的租戶保持緊密接觸，為他們提供進一步的租金優惠和加強宣傳。地鐵公司也會與香港旅遊發展局和旅遊業界攜手合作，致力令昂坪 360 再次成為受大眾歡迎的旅遊景點。

28. 上文載述政府和地鐵公司（纜車系統擁有人）計劃推出的連串措施，以確保纜車系統順利重開，並再次成為香港廣受歡迎的必到景點。請議員省覽。我們會就實施這些措施的進度向議員、各有關方面和公眾提供最新資料。

商務及經濟發展局
2007 年 9 月

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

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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.

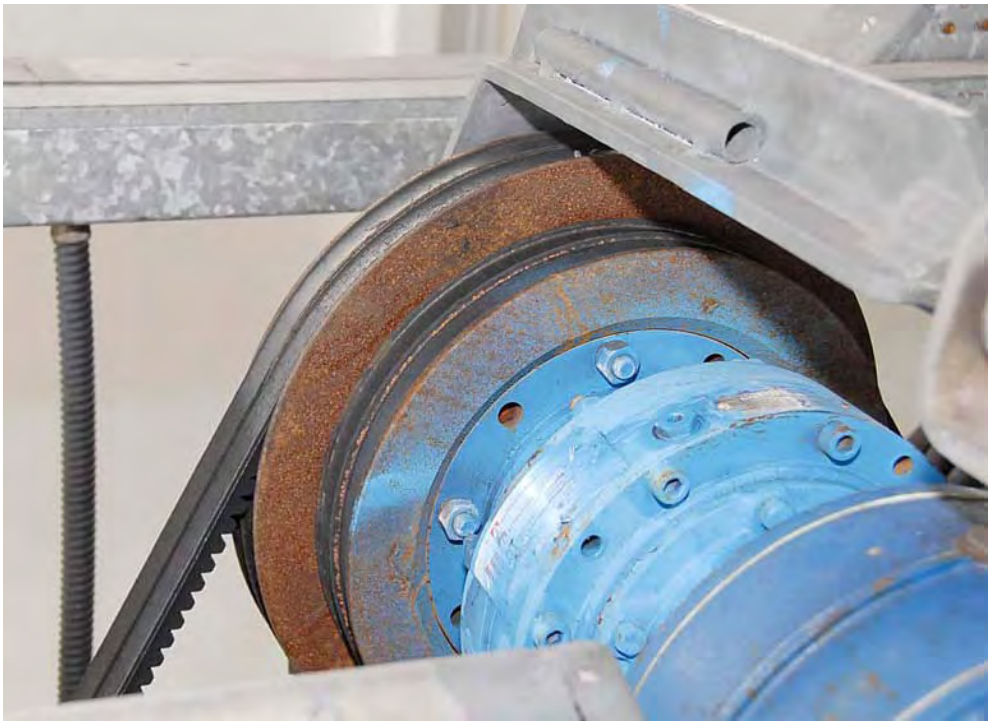


Figure 17 – Close up view on the rusty v-belt pulley

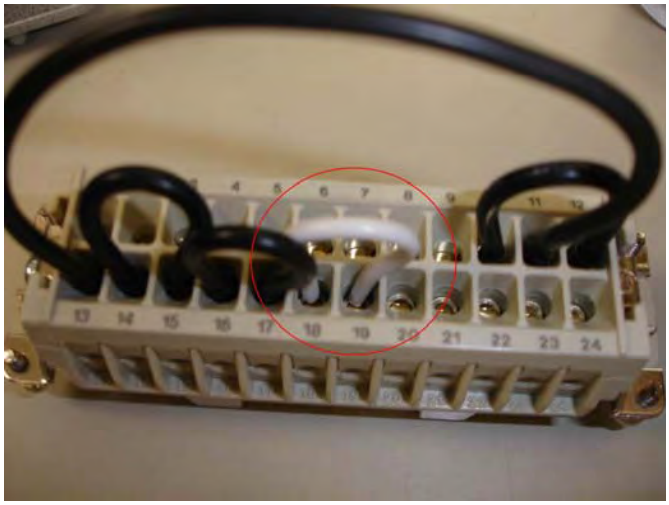
Figure 18 – Close up view on the track rope with rust

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.

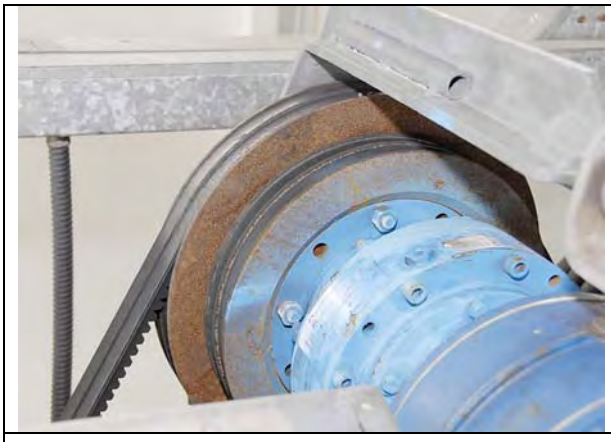

Fig. 1: Rusty V-belt pulleys at the driving motor of the conveyer systems

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

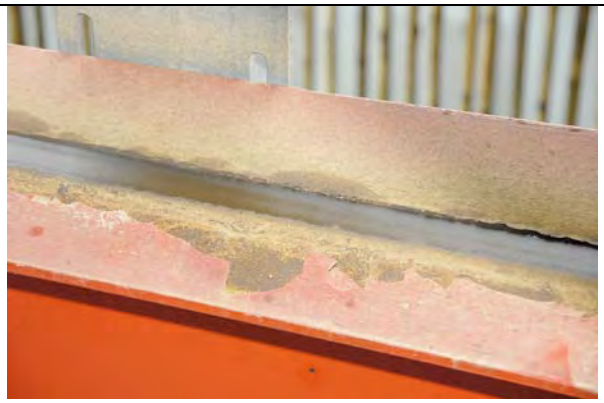

Fig. 5: likewise

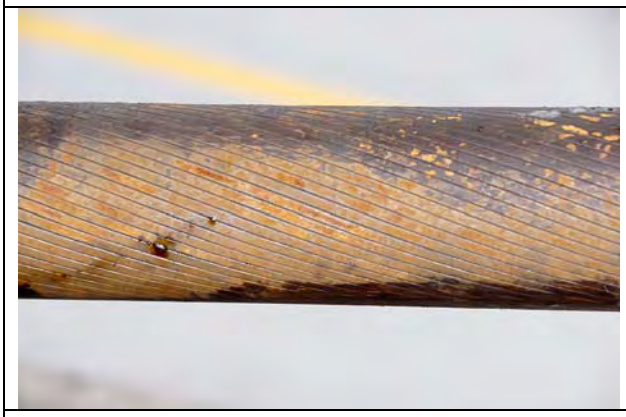

Fig. 6: Rust at the carrying rope within the range of Nei Lak Shan Angle Station

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