THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

BSOMES

KPIs for Lift Maintenance Performance Evaluation

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Prof. Joseph H.K. Lai

Department of
Building Environment and Energy Engineering
建築環境與能源工程學系

Introduction

- A collaborative research project, titled "Establishment of Standard KPIs for Evaluation of Lift Maintenance Performance in Hong Kong" (hereinafter referred to as "the Study") and jointly undertaken by the Building Services Operation and Maintenance Executives Society (BSOMES) and the Hong Kong Polytechnic University (PolyU), was commenced.

- Aim:
  - To develop standard key performance indicators (KPIs) for evaluation of lift maintenance performance in Hong Kong.

Background and objectives of the study

- Objectives:
  1. To review and identify any overseas or local KPIs applicable to lift maintenance performance evaluation in Hong Kong.
  2. To reveal the current practices of lift maintenance performance evaluation in Hong Kong.
  3. To derive KPIs tailored for evaluation of lift maintenance performance in Hong Kong.
  4. To shortlist KPIs for evaluation of lift maintenance performance in Hong Kong.
  5. To validate the applicability of the shortlisted KPIs.

Stage 1: Literature review

- In preparing the proposal for this Study, a search of publications in the public domain has provided some reference materials.

- Upon official commencement of this Study, a further, comprehensive search and review of relevant literature was conducted.

- This review identified any KPIs applicable to lift maintenance performance evaluation in Hong Kong.

Stage 2: Definition and derivation of KPIs

- For each of the KPIs obtained in the preceding stage, the corresponding representation was defined clearly.

- Then, how each of the KPIs can be derived was worked out by devising an appropriate formula.

- To illustrate how such formulas can be used to derive the KPIs, example data was processed and the calculation results of the KPIs were obtained.

Stage 2: Definition and derivation of KPIs

- Built upon the above results, a questionnaire was designed for soliciting the existing ways in which maintenance professionals evaluate lift maintenance performance in Hong Kong.

- This questionnaire was used for the focus group study in the next stage; yet, inputs and comments on the questionnaire were solicited from the representatives of BSOMES (e.g. committee members of the project team). Any suggested improvements for the questionnaire were incorporated.

Stage 3: Focus group study

- The focus group meeting was intended for participation by nominated/invited lift maintenance professionals (e.g. committee members of BSOMES).
- The participants of this meeting were given the questionnaire and facilitated by the convenor (i.e. the Project Leader and assistant(s)) to exchange their views and experiences on various aspects, such as:
  - types of lift maintenance data logged
  - method used to log the data
  - how the logged data are retrieved for lift maintenance performance evaluation

Stage 3: Focus group study

(continued)

- how useful are the performance evaluation results
- any problem with the existing way of lift maintenance performance evaluation
- any suggestion for improvements

- In this meeting, the applicability of the identified KPIs in real-world buildings in Hong Kong were reviewed.

- After deliberation at the focus group meeting, a list of KPIs taking into account the above factors was determined.

Stage 4: Shortlisting of KPIs

- Based on the focus group study's findings, a questionnaire was designed and distributed to the lift maintenance industry in Hong Kong.
- This questionnaire listed the KPIs identified above and request the survey respondents to indicate the importance levels of the KPIs.
- To maximize the extent of participation in this survey, an online version of the questionnaire was prepared for ready distribution through BSOMES to relevant professionals in the lift maintenance industry.
- Survey responses were analysed to yield the importance levels of the KPIs, based on which the most essential KPIs were shortlisted.

Stage 5: Validation and finalization of KPIs

- To ensure that the shortlisted KPIs are fit for use, case studies were conducted.
- In these case studies, empirical lift maintenance data was collected from high-rise buildings in Hong Kong.
- The data, collected through interviews with lift maintenance management professionals, was used to test whether the KPIs are effective for the intended performance evaluation purpose.

Literature review

- Relevant publications were searched from four literature databases, namely, Web of Science, Scopus, ScienceDirect and Emerald.

- In the first round of literature search, keywords including “lift”, “escalator”, “elevator”, “maintenance”, “KPI” and “Performance indicator” were used in combinations. A summary of the search results is shown in Table 1.

Literature review

Database	Search Results								
	lift + maintenance	escalator + maintenance	elevator + maintenance	lift + KPI	escalator + KPI	elevator + KPI	lift + performance indicator	escalator + performance indicator	elevator + performance indicator
Web of Science	908	33	161	4	0	1	6	0	2
Scopus	1274	99	440	38	0	1	78	1	13
ScienceDirect	220	1	21	2	0	0	11	0	4
Emerald	> 2000	207	659	83	12	23	557	49	126
Total Nos.	**> 4402**	**340**	**1281**	**127**	**12**	**25**	**649**	**50**	**145**

Table 1: First round of literature search results

Literature review

- Over 5000 publications were identified from the first round of literature search; after screening, most of them were found to be peripheral to the context of the Study.
- Then, a second round of literature search was done using three groups of keywords, as shown in the Table 2.

Group 1	Group 2	Group 3
• Lift • Elevator • Escalator	• Maintenance	• KPI • Key performance indicator • Performance indicator • Performance index • Performance score

Table 2: Keyword groups used in second round of literature search

Literature review

- Similar to the first round, the second round of literature search was made on the four literature databases, i.e., Web of Science, Scopus, ScienceDirect and Emerald, with the three groups of keywords used in combinations. The search results are summarized in Table 3.

Database	Search Results				
	Lift + Maintenance +				
	KPI	Key performance indicator	Performance indicator	Performance index	Performance score
Web of Science	0	0	0	0	0
Scopus	4	4	7	0	0
ScienceDirect	0	0	0	0	0
Emerald	34	95	185	18	16
Total	38	99	192	18	16

Table 3: Second round of literature search results

Literature review

Database	Search Results				
	Elevator + Maintenance +				
	KPI	Key performance indicator	Performance indicator	Performance index	Performance score
Web of Science	1	0	0	0	0
Scopus	1	1	1	0	0
ScienceDirect	0	0	0	0	0
Emerald	12	37	62	13	4
Total	14	38	63	13	4

Table 3: Second round of literature search results (continued)

Literature review

Database	Search Results				
	Escalator + Maintenance +				
	KPI	Key performance indicator	Performance indicator	Performance index	Performance score
Web of Science	0	0	0	0	0
Scopus	0	0	0	0	0
ScienceDirect	0	0	0	0	0
Emerald	8	18	27	3	2
Total	8	18	27	3	2

Table 3: Second round of literature search results (continued)

Literature review

- In the second round of literature search, around 500 publications were found. After screening, key publications of particular relevance to KPIs for lift maintenance were identified.

Literature review

- To further identify if there are suitable performance indicators in the local lift industry, guidelines of professional bodies (e.g. BSOMES) and government websites (e.g. EMSD) were searched and reviewed.

- Consequently, additional performance indicators were found from the "**Best Management Practices on Operation & Maintenance for Lifts & Escalators**" (BSOMES, 2019).

Literature review

- An inspection on a sample lift log book found that the following lift performance data should be available from a properly-kept lift log book:
  - Call Received by Contractor (Date / Time)
  - Contractor's Representative Arrived at Site (Date / Time)
  - Passenger Released (Date / Time)
  - Service Resumed (Date / Time)

Literature review

- The sample **log book** also shows that there are different types of work:

- Breakdown
- Routine
- Routine Suspended
- Risk Assessment / Supervisory / Quality Check
- Trapping
- Special Maintenance
- Routine Compensated

Literature review

The EMSD's "**Best Practices for Operation and Maintenance Service of Lift and Escalator Installations**", which recommends a basic framework for 15 key attributes important to users such as facility management professionals and relevant stakeholders, covers guidelines that are related to lift maintenance services.

Literature review

- Under the EMSD's **Quality Lift Service Recognition Scheme**, there are three assessment criteria:
  - A) Level of lift modernization
  - B) Record of lift operation
  - C) Performance of RPs in managing lift services

- Points scored under Criteria A, e.g. for the assessment item titled "installed double brake system", reflect the level of lift modernisation. Such items, therefore, could not be taken as applicable performance indicators in the context of the present study.

Literature review

- On the other hand, Criteria B, which is highly relevant to the present study, comprises "duration of service suspension due to failure", "average arrival time for failure related to passenger entrapment" and "average arrival time for failure unrelated to passenger entrapment"; collectively they represent a maximum of 50 points out of the total 150 points.

- The items of the checklist for measuring the performance of responsible persons in managing lift services, under Criteria C, represent another 50 points of the scheme.

Identified performance indicators

- Through the above literature review process and with reference to specific guidelines in the local O&M industry, a number of performance indicators were identified.
- For performance indicators to be useful, they need to be "Specific", "Measurable", "Attainable", "Relevant", and "Time-Bound" (SMART).
- Scrutinizing the above-identified performance indicators against this SMART principle, some of the indicators were found to be not qualified, for reasons such as: they are not specific enough, they could not be quantified, etc. Thus, such indicators were excluded.

Identified performance indicators

- The remaining performance indicators were grouped into four aspects, namely "Financial", "Physical", "Safety" and "Clients' needs & satisfaction", as summarized in Table 4.

Aspect	KPIs	Sources
Financial	(F1) Maintenance cost per area	Lai, J.H.K. and Yik, F.W.H. (2008)
	(F2) Maintenance cost per lift	
	(F3) Outsourced maintenance cost per area	Research Proposal
	(F4) Outsourced maintenance cost per lift	
	(F5) In-house maintenance cost per area	
	(F6) In-house maintenance cost per lift	

Table 4: Shortlisted performance indicators

Identified performance indicators

Aspect	KPIs	Sources
Physical	(P1) Availability	Lai, J. and Yuen, P.L. (2021) / Lai, J.H.K. and Man, C.S. (2018)
	(P2) Maintenance downtime (P3) Maintenance response time (P4) Maintenance repair time	Research Proposal
	(P5) Percentage of attending service calls within 30 minutes (P6) Percentage of attending service calls within 60 minutes (P7) Enquiries response time (P8) Number of complaints from users	BSOMES (2019)

Table 4: Shortlisted performance indicators (continued)

Identified performance indicators

Aspect	KPIs	Sources
Physical	(P9) Number of repair work with duration extended to more than 8 hours (P10) Number of incidents cannot resume operations within specified 4-hour period	EMSD (2022a)
	(P11) Duration of service suspension due to failure (P12) Average arrival time for failure unrelated to passenger entrapment	EMSD (2022b)

Table 4: Shortlisted performance indicators (continued)

Identified performance indicators

Aspect	KPIs	Sources
Safety	(S1) Passenger trap release time (S2) Number of statutory orders (S3) Compliance percentage of statutory orders	Research Proposal
	(S4) No. of passengers injured during operation	BSOMES (2019)
	(S5) Number of cases that the registered lift contractor not able to arrive at the venue of incident within 1 hours (or within 30 minutes if trapped passenger is reported) for all emergency situations.	EMSD (2022a)
	(S6) Average arrival time for failure related to passenger entrapment	EMSD (2022b)

Table 4: Shortlisted performance indicators (continued)

Identified performance indicators

Aspect	KPIs	Sources
Clients' needs & satisfaction	(C1) Implementation of preventive maintenance plan which includes monthly servicing (C2) Daily inspection on the lift buttons, cleanliness, appearance and also function of the lifts (C3) All lifts provided are sufficient and in excellent condition to cater the capacity of the building end-users	Elyna Myeda, N., Nizam Kamaruzzaman, S. and Pitt, M. (2011)
	(C4) RC submitted maintenance reports as required on time (C5) RC is cooperative and understands the client's needs (C6) Spare parts or components can be delivered to the correct properties within the specified hours (e.g. 8 hours)	BSOMES (2019)

Table 4: Shortlisted performance indicators (continued)

Focus group meeting

- Executive members of BSOMES were invited to join a focus group meeting - to shortlist from the performance indicators (identified above) the practicable and essential ones.

- A total of 10 professionals, with work experience from 14 to over 30 years joined the meeting.

- Slides showing the background of this study, a set of guiding questions (to facilitate discussion) and the performance indicators identified above were provided to the participants for their advance information.

Focus group meeting

- In the first part of the focus group meeting, after a briefing by the facilitator (i.e. the study team) the participants referred to the guiding questions and exchanged views on the applicability of the performance indicators identified above.

- With the consent of the participants, the meeting discussion was recorded.

- The recording was transcribed after the meeting for checking against the accuracies of the notes taken during the meeting.

Focus group meeting

- According to the focus group discussion, some performance indicators are not specific, not measurable and/or with no actual data available for assessment purposes.

- The list of performance indicators was revised as in Table 5.

- Some of the original indicators were deleted, some were changed to indicators with better representation/meaning, and some additional indicators were suggested by the participants as essential.

Focus group meeting

Financial		
	Original performance indicators	**Revision after reviewed by participants (with reason)**
(F1)	Maintenance cost per area	Deleted (Represented by F2)
(F2)	Maintenance cost per lift	Preserved
(F3)	Outsourced maintenance cost per area	Deleted (Represented by F2)
(F4)	Outsourced maintenance cost per lift	Deleted (Represented by F2)
(F5)	In-house maintenance cost per area	Deleted (Represented by F2)
(F6)	In-house maintenance cost per lift	Deleted (Represented by F2)

Table 5: Revision of performance indicators

Focus group meeting

Physical		
	Original performance indicators	**Revision after reviewed by participants (with reason)**
(P1)	Availability	Preserved
(P2)	Maintenance downtime	Preserved
(P3)	Maintenance response time	Preserved
(P4)	Maintenance repair time	Preserved
(P5)	Percentage of attending service calls within 30 minutes	Preserved
(P6)	Percentage of attending service calls within 60 minutes	Preserved
(P7)	Enquiries response time	Preserved
(P8)	Number of complaints from users	Preserved
(P9)	Number of repair work with duration extended to more than 8 hours	Preserved

Table 5: Revision of performance indicators (continued)

Focus group meeting

Physical		
	Original performance indicators	**Revision after reviewed by participants (with reason)**
(P10)	Number of incidents cannot resume operations within specified 4-hour period	Preserved
(P11)	Duration of service suspension due to failure	Changed to: Average duration of service suspension due to failure
(P12)	Average arrival time for failure unrelated to passenger entrapment	Preserved
(P13)	Frequency of failures	Proposed by focus group participants

Table 5: Revision of performance indicators (continued)

Focus group meeting

Safety		
	Original performance indicators	**Revision after reviewed by participants (with reason)**
(S1)	Passenger trap release time	Changed to: Average passenger trap release time
(S2)	Number of statutory orders	Preserved
(S3)	Compliance percentage of statutory orders	Preserved
(S4)	No. of passengers injured during operation	Preserved
(S5)	Number of cases that the registered lift contractor not able	Preserved
(S6)	Average arrival time for failure related to passenger	Preserved

Table 5: Revision of performance indicators (continued)

Focus group meeting

Clients' needs / Satisfaction		
	Original performance indicators	**Revision after reviewed by participants (with reason)**
(C1)	Implementation of preventive maintenance plan which includes monthly servicing	Deleted (Not specific)
(C2)	Daily inspection on the lift buttons, cleanliness, appearance and also function of the lifts	Deleted (Not specific)
(C3)	All lifts provided are sufficient and in excellent condition to cater the capacity of the building end-users	Deleted (Not measurable)
(C4)	RC submitted maintenance reports as required on time (e.g. monthly)	Preserved
(C4a)	RC submitted incident reports on time (e.g. 24 hours)	Proposed by focus group participants

Table 5: Revision of performance indicators (continued)

Focus group meeting

Clients' needs / Satisfaction		
	Original performance indicators	**Revision after reviewed by participants (with reason)**
(C5)	RC is cooperative and understands the client's needs	Deleted (Too subjective)
(C6)	Spare parts or components can be delivered to the correct properties within the specified hours (e.g. 8 hours)	Deleted (Not specific, varies with contracts)

Table 5: Revision of performance indicators (continued)

Focus group meeting

- After confirming the performance indicators as above, the participants were facilitated by the study team to vote on whether the indicators should be taken for use in evaluation of lift maintenance performance. Table 6 shows the voting result.

Financial		Agree (No.)	No. of participants	Percentage
(F2)	Maintenance cost per lift	10	10	100%
Physical		**Agree (No.)**	**No. of participants**	**Percentage**
(P1)	Availability	9	10	90%
(P2)	Maintenance downtime	6	10	60%
(P3)	Maintenance response time	7	10	70%
(P4)	Maintenance repair time	9	10	90%

Table 6: Voting result of the performance indicator

Focus group meeting

Physical		Agree (No.)	No. of participants	Percentage
(P5)	Percentage of attending service calls within 30 minutes	7	10	70%
(P6)	Percentage of attending service calls within 60 minutes	2	10	20%
(P7)	Enquiries response time	2	10	20%
(P8)	Number of complaints from users	1	10	10%
(P9)	Number of repair work with duration extended to more than 8 hours	9	10	90%
(P10)	Number of incidents cannot resume operations within specified 4-hour period	3	10	30%
(P11)	Duration of service suspension due to failure	10	10	100%

Table 6: Voting result of the performance indicator (continued)

Focus group meeting

Physical		Agree (No.)	No. of participants	Percentage
(P12)	Average arrival time for failure unrelated to passenger entrapment	8	10	80%
(P13)	Frequency of failures	10	10	100%

Safety		Agree (No.)	No. of participants	Percentage
(S1)	Average passenger trap release time	10	10	100%
(S2)	Number of statutory orders	6	10	60%
(S3)	Compliance percentage of statutory orders	5	10	50%
(S4)	No. of passengers injured during operation	8	10	80%

Table 6: Voting result of the performance indicator (continued)

Focus group meeting

Safety		Agree (No.)	No. of participants	Percentage
(S5)	Number of cases that the registered lift contractor not able	9	10	90%
(S6)	Average arrival time for failure related to passenger	9	10	90%
Clients' needs / Satisfaction		**Agree (No.)**	**No. of participants**	**Percentage**
(C4)	RC submitted maintenance reports as required on time (e.g. monthly)	7	10	70%
(C4a)	RC submitted incident reports on time (e.g. 24 hours)	6	10	60%

Table 6: Voting result of the performance indicator (continued)

Focus group meeting

- Based on the voting results from the focus group meeting, indicators voted by 50% or more of participants were shortlisted.
- Consequently, 18 indicators were shortlisted.

Design Survey Questionnaire

Aspect	KPIs
Financial	(F1) Maintenance cost per lift
Physical	(P1) Availability
	(P2) Maintenance downtime
	(P3) Maintenance response time
	(P4) Maintenance repair time
	(P5) Percentage of attending service calls within 30 minutes
	(P6) Number of repair work with duration extended to more than 8 hours
	(P7) Duration of service suspension due to failure
	(P8) Average arrival time for failure unrelated to passenger entrapment
	(P9) Frequency of failures

Table 7: Shortlisted performance indicators

Design Survey Questionnaire

Aspect	KPIs
Safety	(S1) Passenger trap release time (S2) Number of statutory orders (S3) Compliance percentage of statutory orders (S4) No. of passengers injured during operation (S5) Number of cases that the registered lift contractor not able to arrive at the venue of incident within 1 hours (or within 30 minutes if trapped passenger is reported) for all emergency situations. (S6) Average arrival time for failure related to passenger entrapment
Clients' needs & satisfaction	(C1) Registered Contractor submitted maintenance reports as required on time (e.g. monthly) (C2) Registered Contractor submitted incident reports on time (e.g. 24 hours)

Table 7: Shortlisted performance indicators (continued)

Interim Seminar

- An interim seminar was held on December 20, 2022, with the aim of sharing the work conducted and the findings obtained from Part A.

- The seminar was held both in physical form at the PolyU campus and virtually via Zoom.

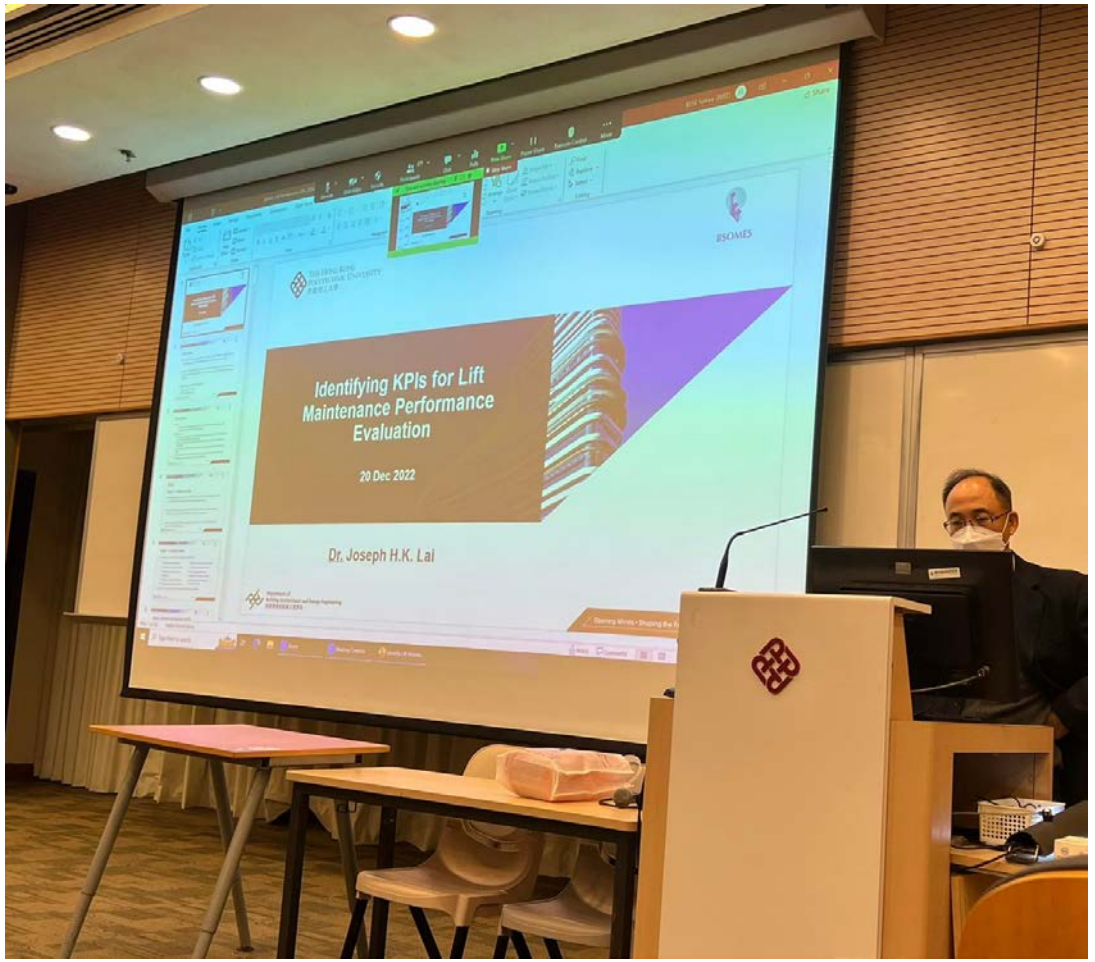


Figure 2: Interim seminar

Design Survey Questionnaire

- An on-line survey by google form was designed and distributed to the lift maintenance industry though the supporting organizations and the interim seminar (Figure 3).

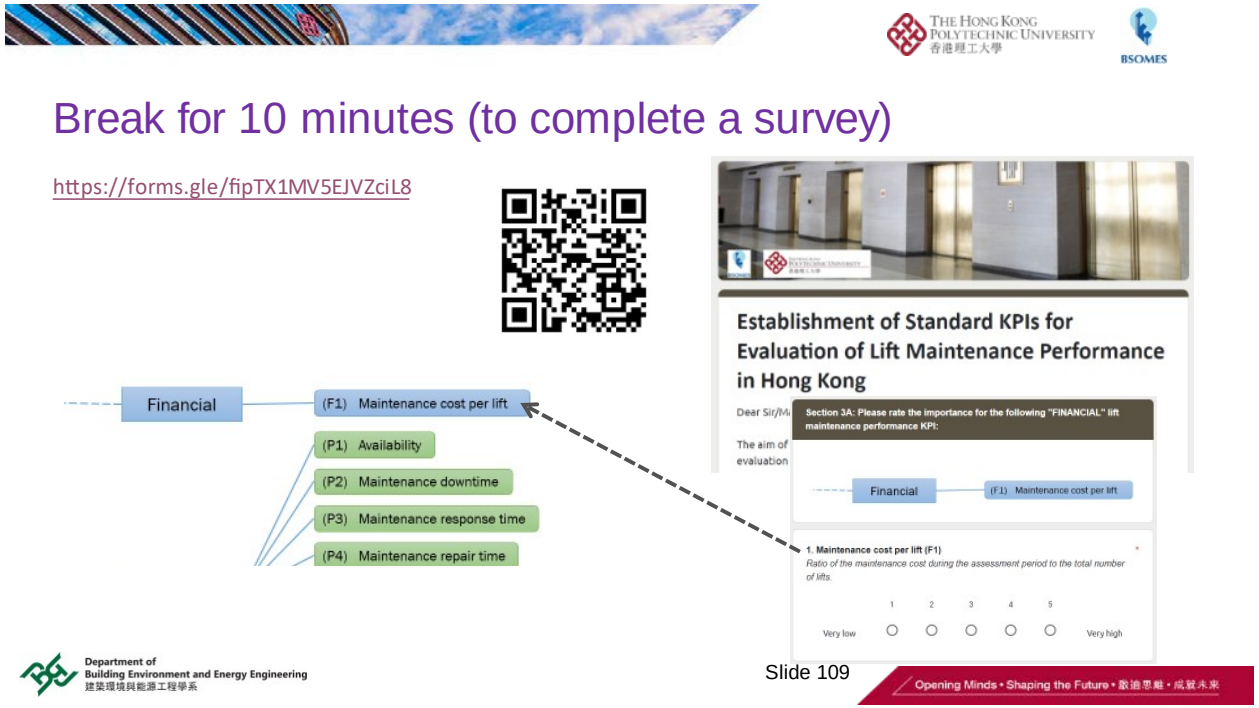


Figure 3: Slide to invite seminar participants to complete the on-line survey

Design Survey Questionnaire

- **Financial**
  - (F1) Maintenance cost per lift
- **Physical**
  - (P1) Availability
  - (P2) Maintenance downtime
  - (P3) Maintenance response time
  - (P4) Maintenance repair time
  - (P5) Percentage of attending service calls within 30 minutes
  - (P6) Number of repair work with duration extended to more than 8 hours
  - (P7) Duration of service suspension due to failure
  - (P8) Average arrival time for failure unrelated to passenger entrapment
  - (P9) Frequency of failures
- **Safety**
  - (S1) Average passenger trap release time
  - (S2) Number of statutory orders
  - (S3) Compliance percentage of statutory orders
  - (S4) Number of passengers injured during operation
  - (S5) Number of cases that the registered lift contractor not able to arrive at the venue of incident within 1 hour (or within 30 minutes if trapped passenger is reported) for all emergency situations
  - (S6) Average arrival time for failure related to passenger entrapment
- **Clients' needs / Satisfaction**
  - (C1) Registered Contractor submitted maintenance reports as required on time (e.g. monthly)
  - (C2) Registered Contractor submitted incident reports on time (e.g. 24 hours)

Design Survey Questionnaire

During the break of the seminar, the attendees were asked to rate the importance level of the 18 performance indicators and provide the following personal particulars via the survey:

- Job level
- Company type
- Work experience
- Number of lifts you look after
- Professional qualification
- Academic qualification level

Design Survey Questionnaire

Figure 4a: Screen shot of the online survey (Personal particulars)

Design Survey Questionnaire

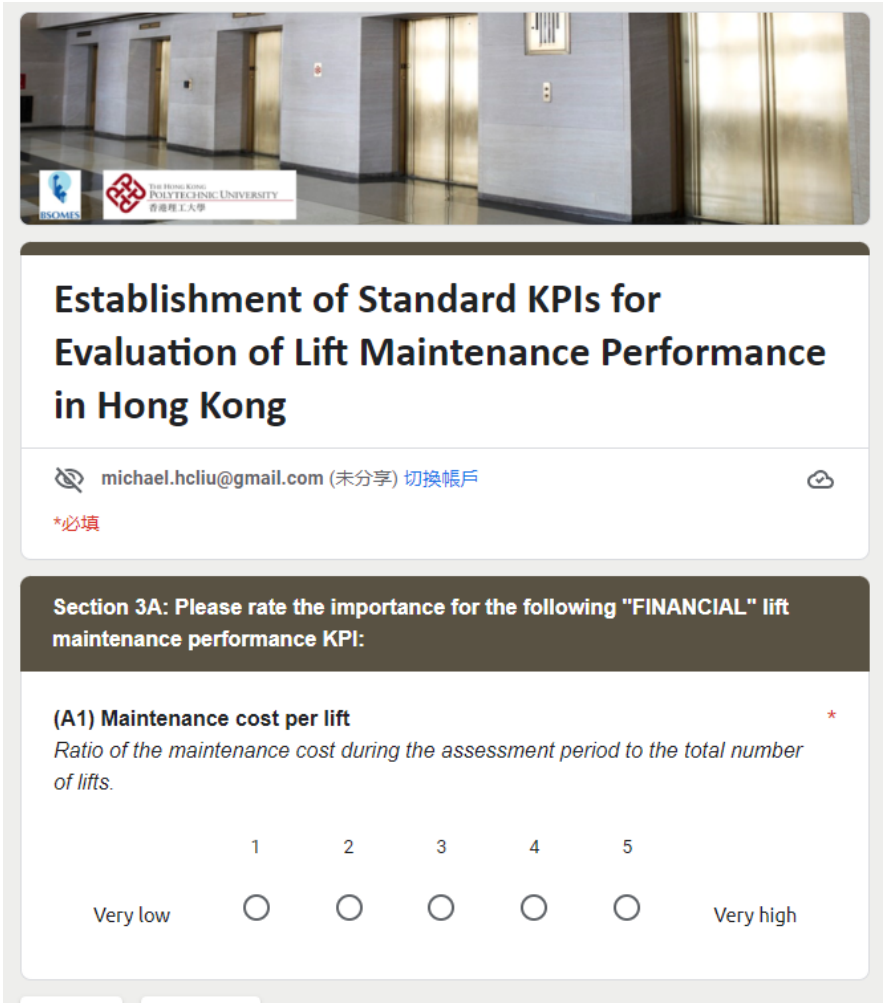


Figure 4b: Screen shot of the online survey (KPI rating)

Survey Questionnaire Results

- Overall, 183 responses to the survey were received. The following is a summary of the survey results:

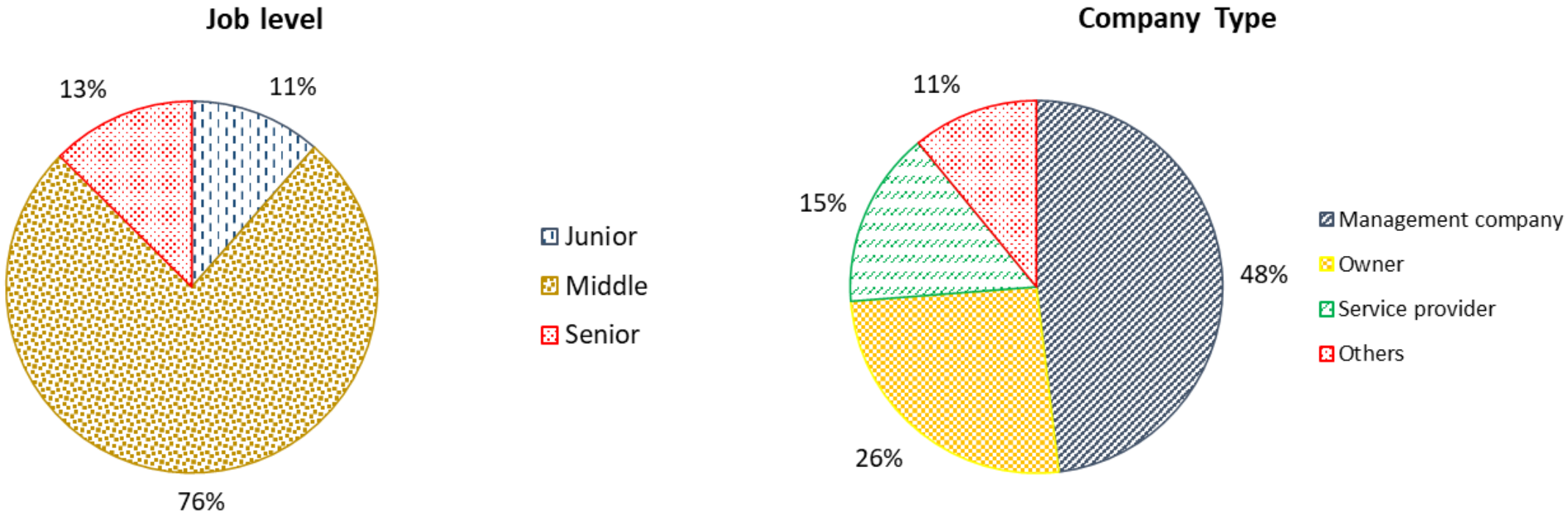
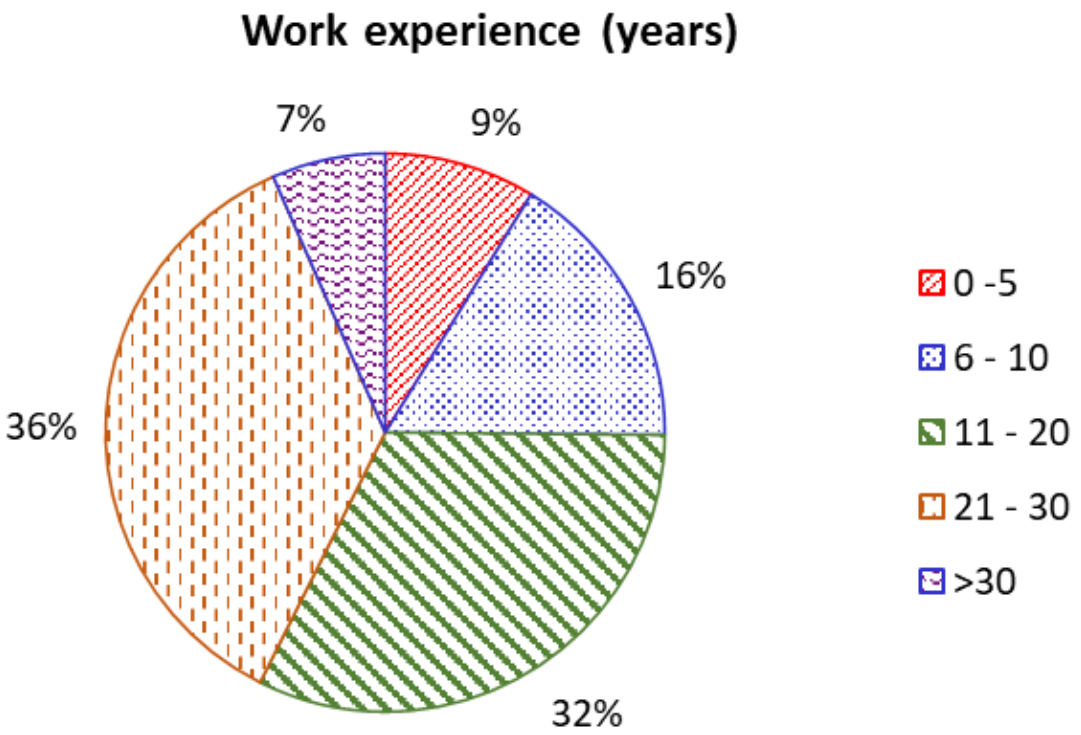


Figure 5a: Summary of respondents' personal particulars

Survey Questionnaire Results



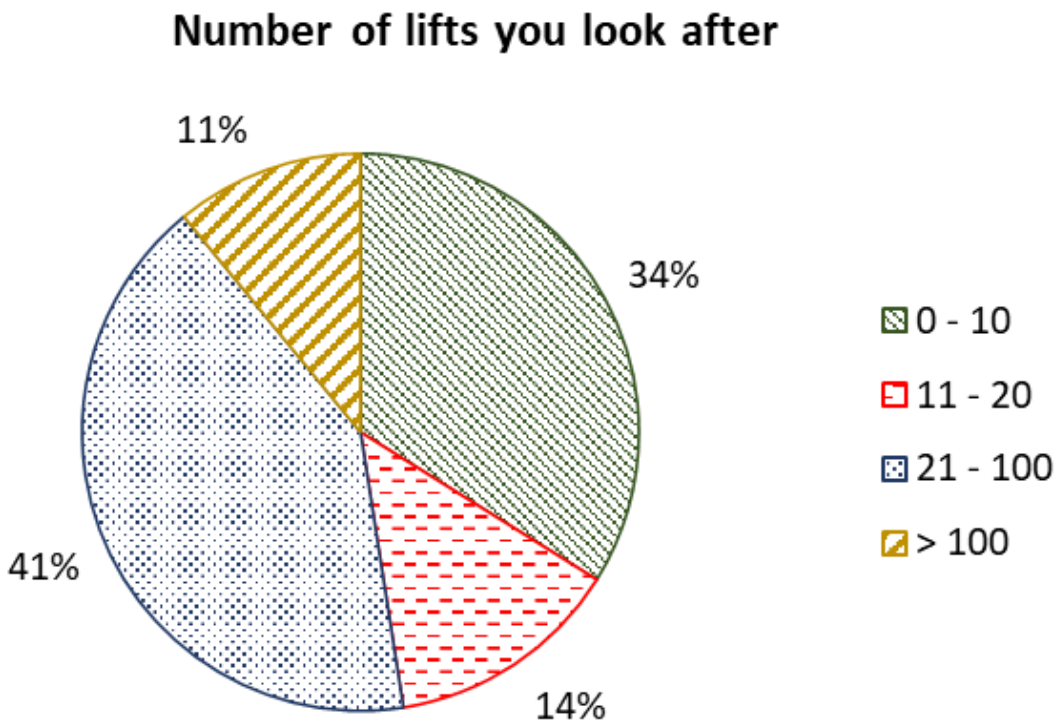


Figure 5b: Summary of respondents' personal particulars

Survey Questionnaire Results

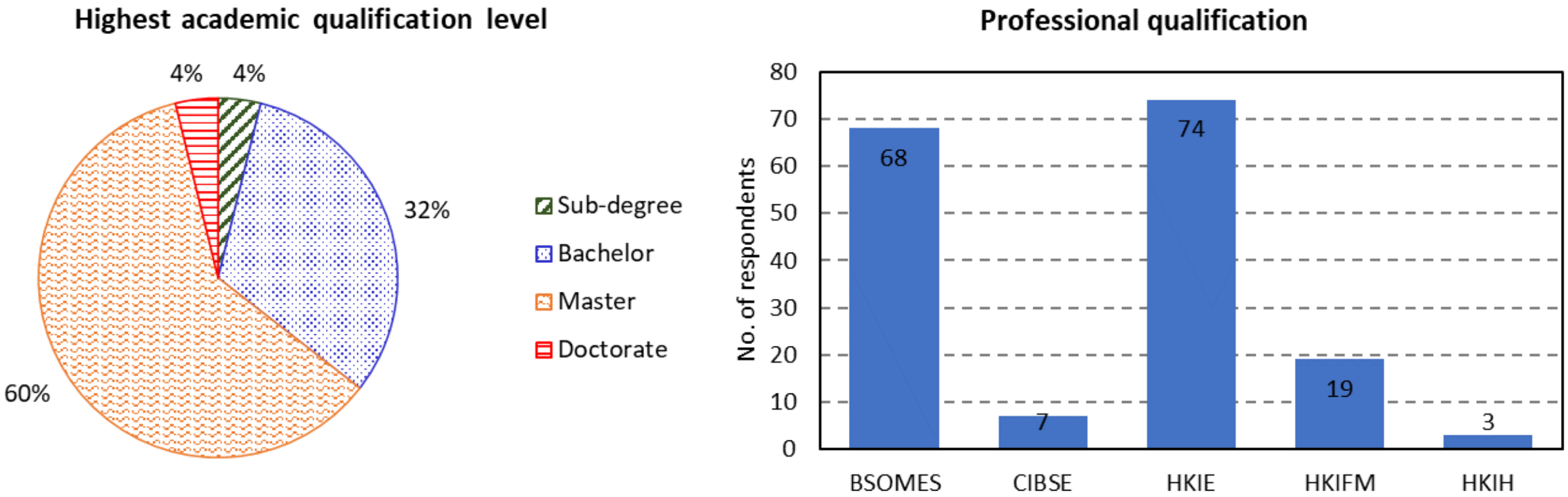
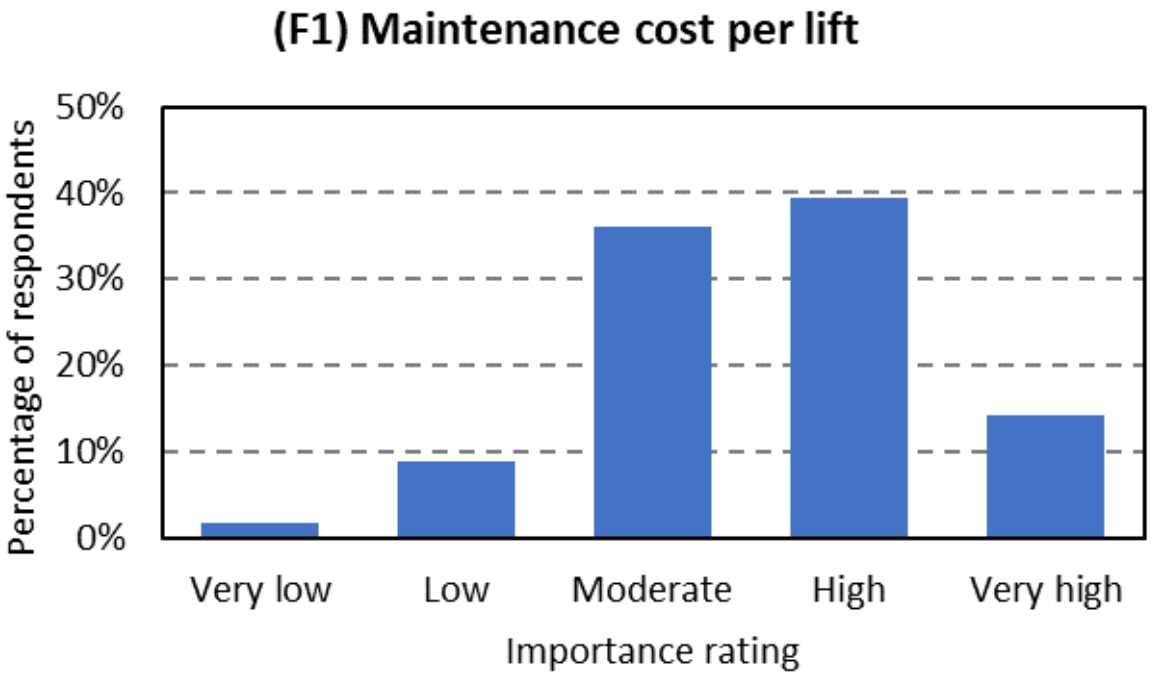


Figure 5c: Summary of respondents' personal particulars

Survey Questionnaire Results



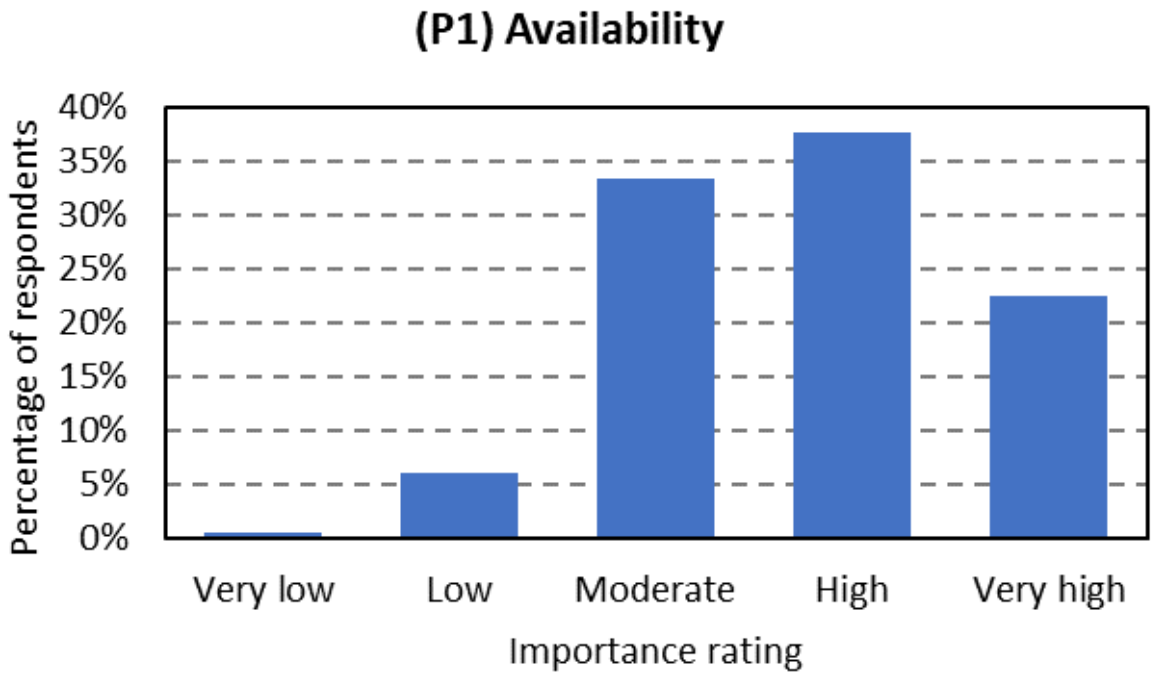
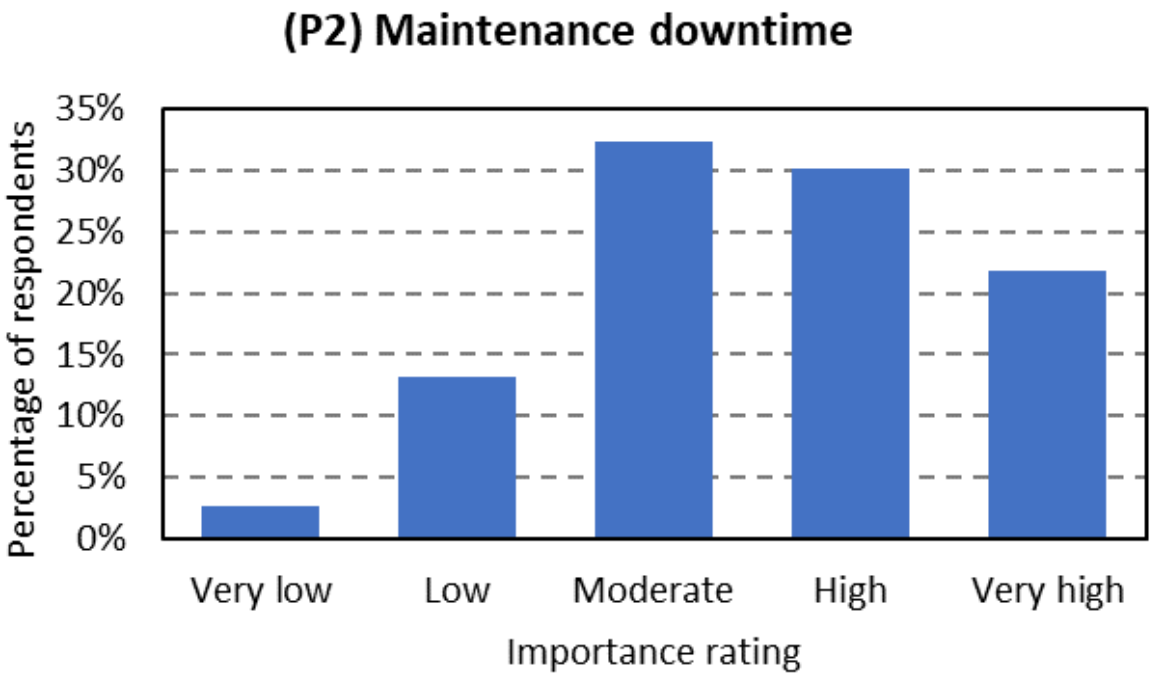


Figure 6a: Summary of importance level of performance KPIs.

Survey Questionnaire Results



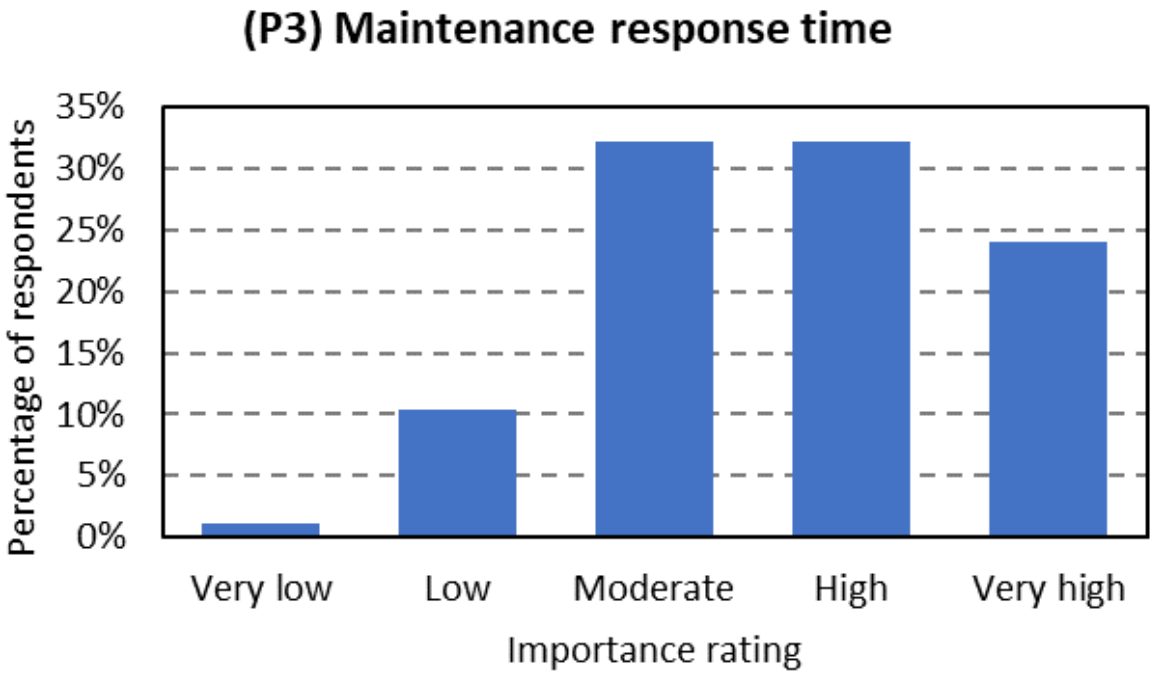
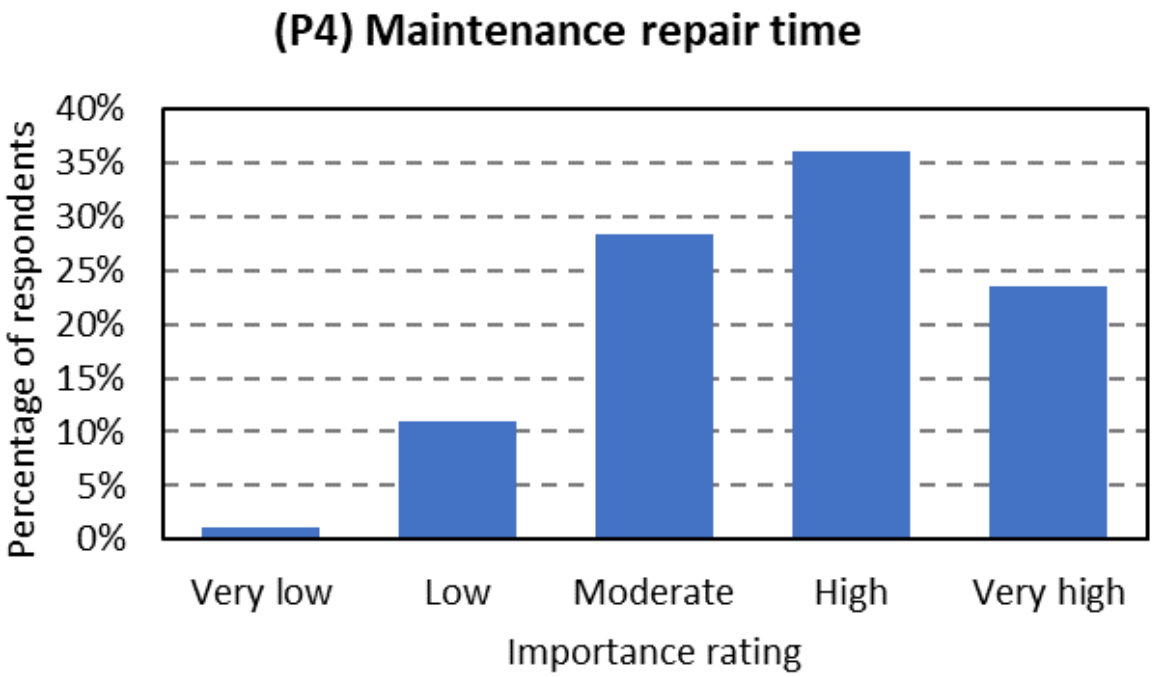


Figure 6b: Summary of importance level of performance KPIs.

Survey Questionnaire Results



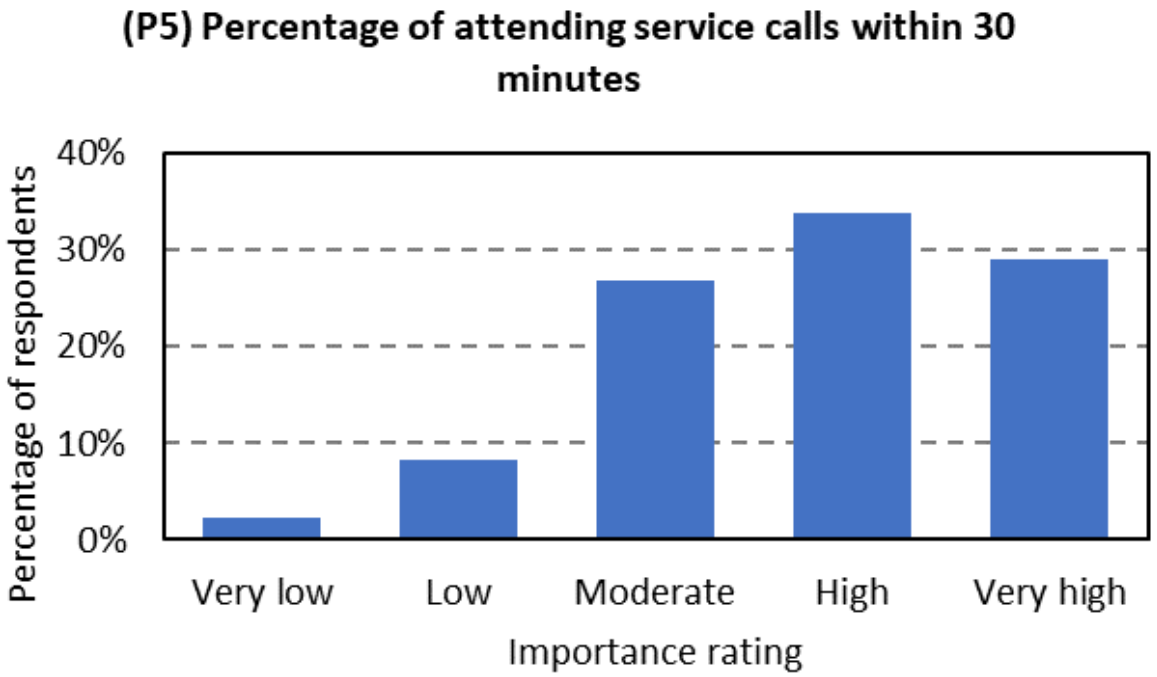
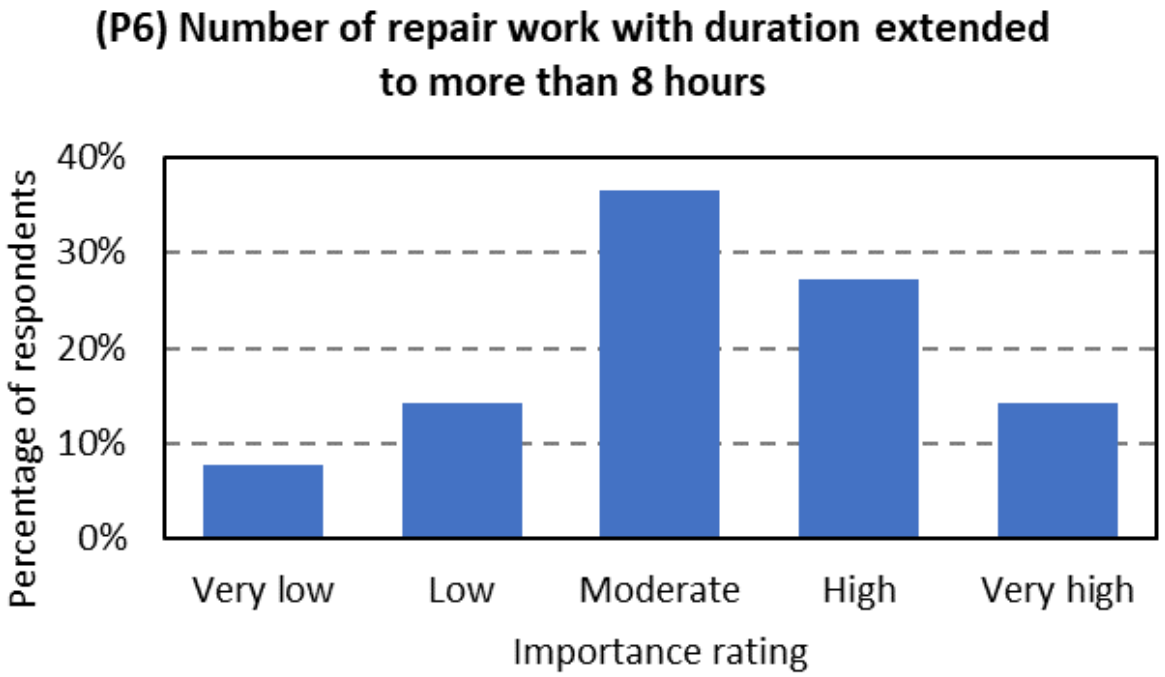


Figure 6c: Summary of importance level of performance KPIs.

Survey Questionnaire Results



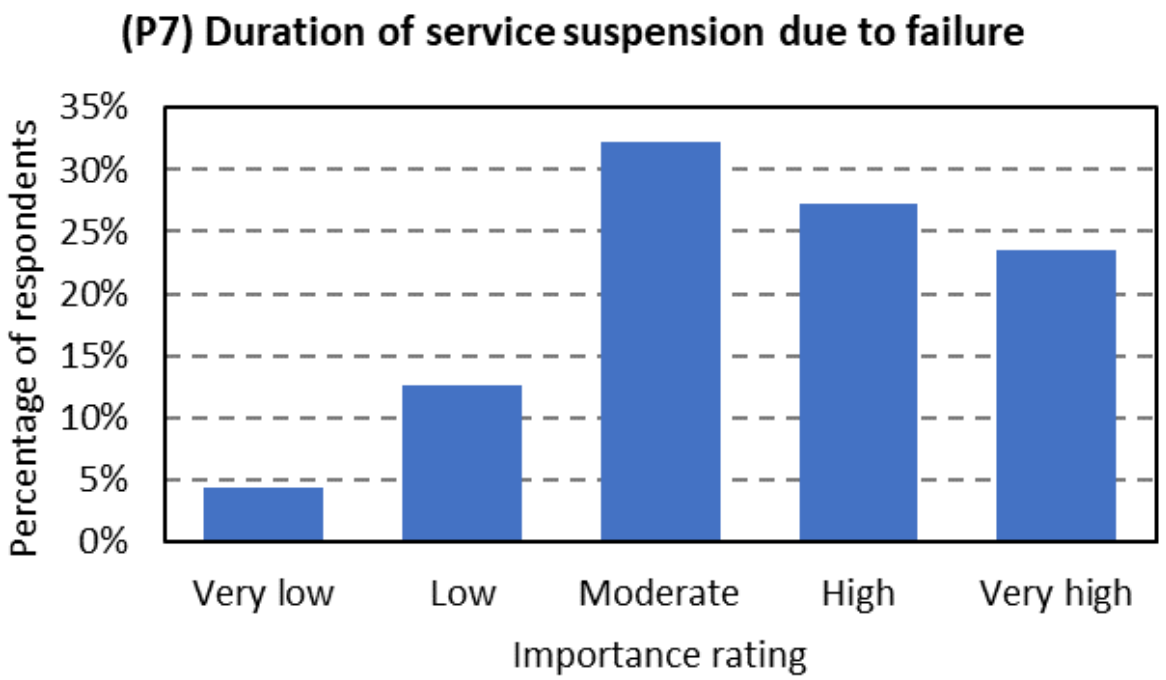
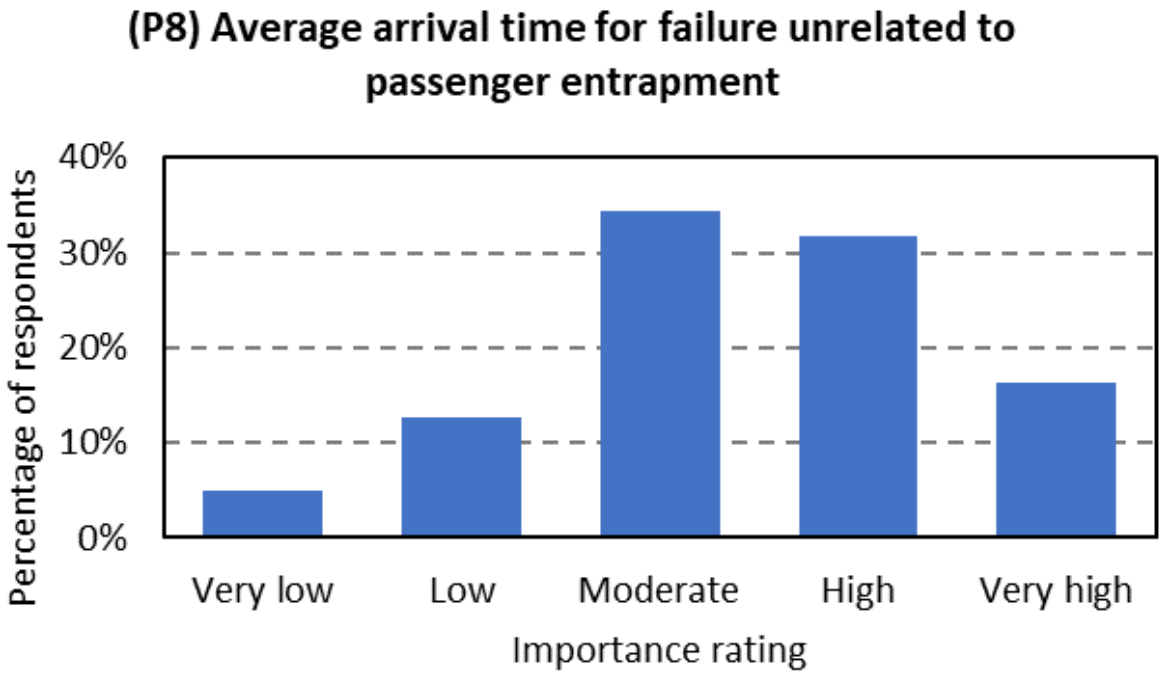


Figure 6d: Summary of importance level of performance KPIs.

Survey Questionnaire Results



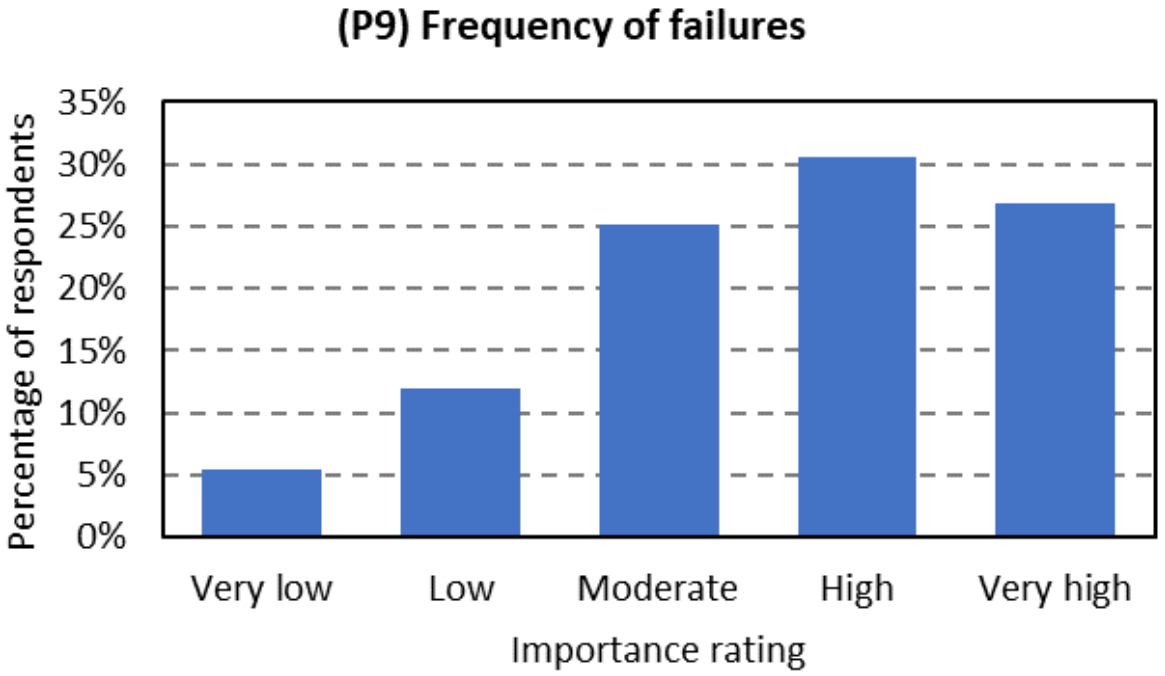
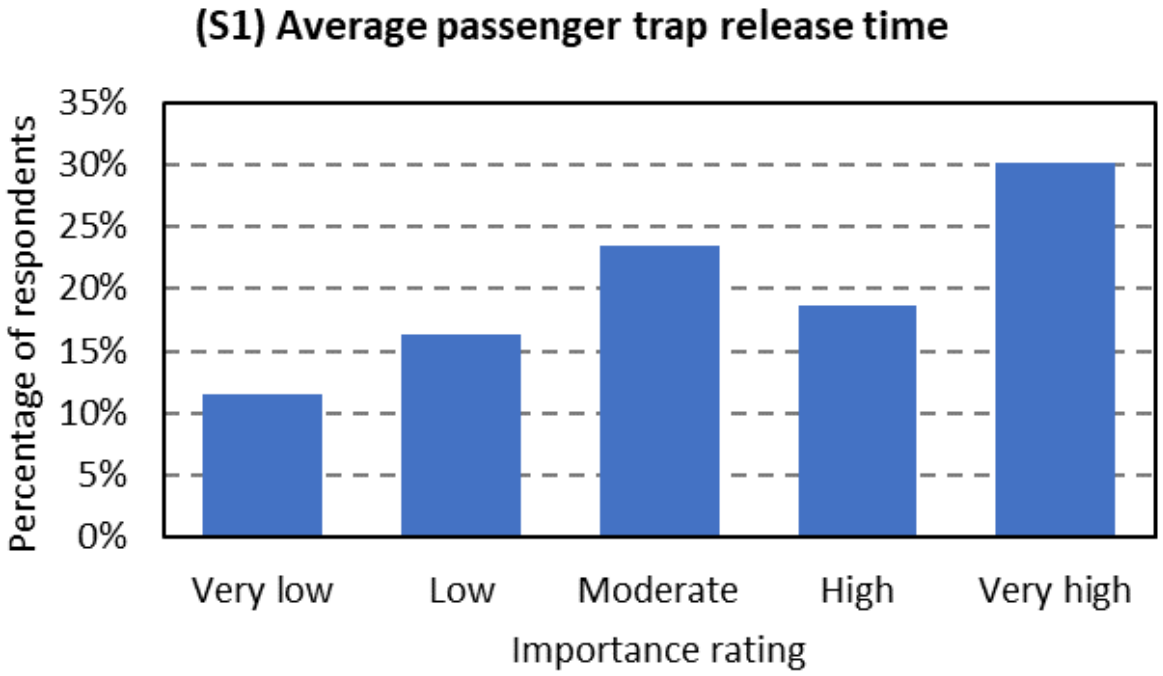


Figure 6e: Summary of importance level of performance KPIs.

Survey Questionnaire Results



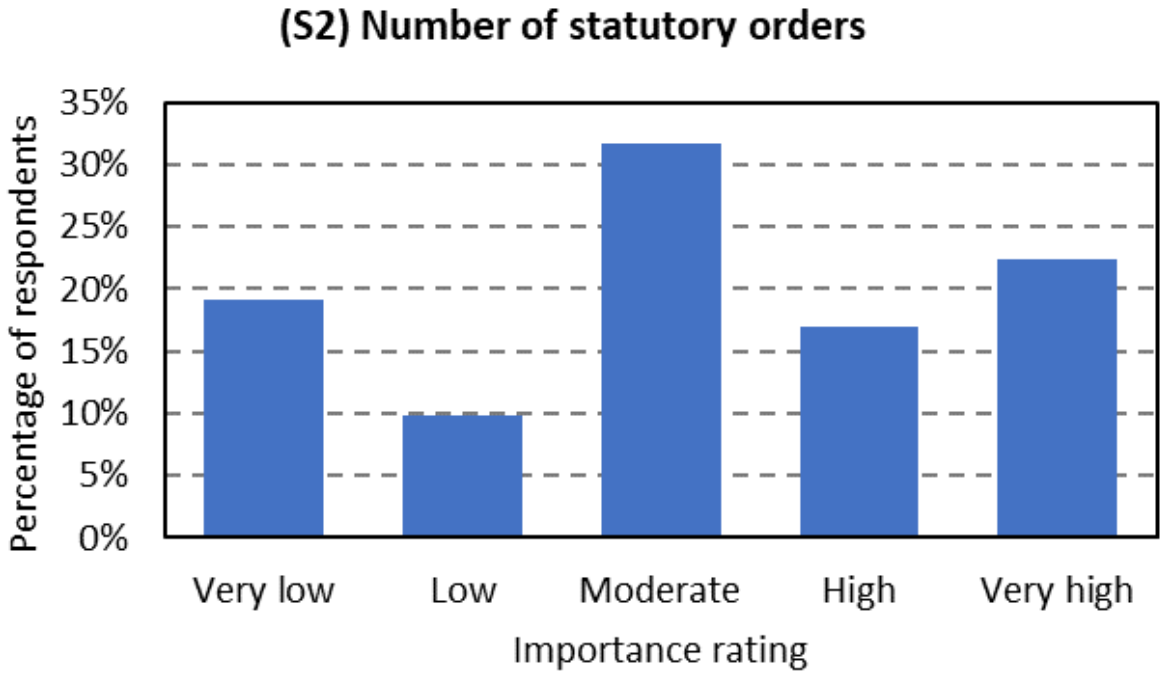
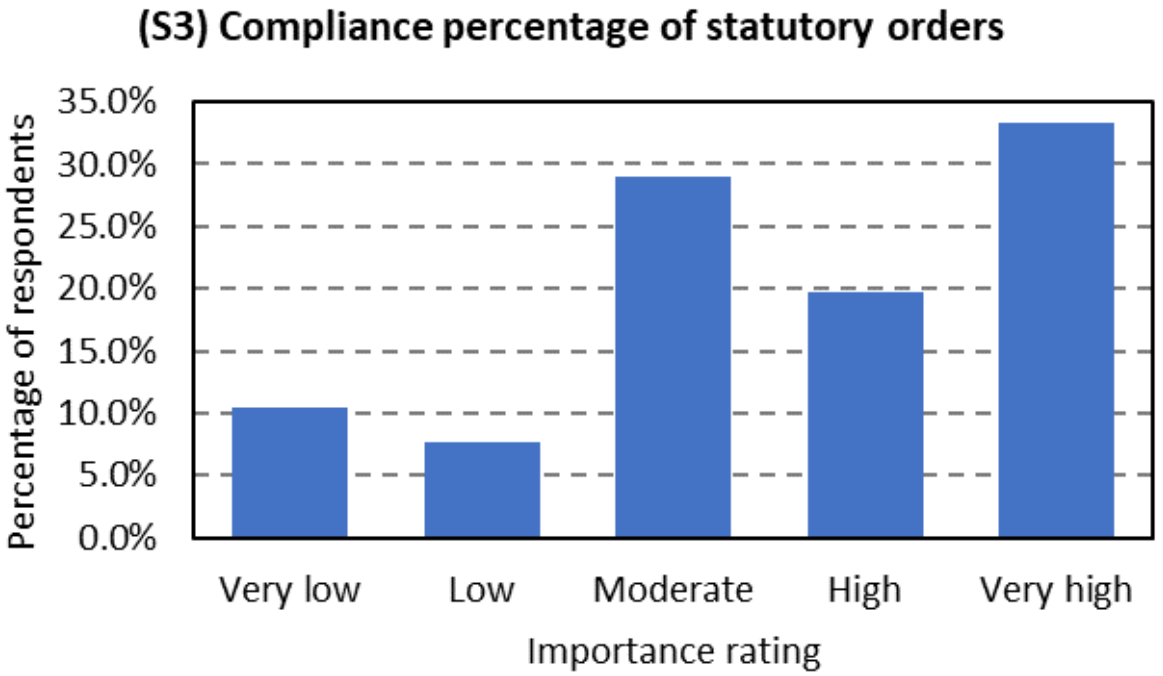


Figure 6f: Summary of importance level of performance KPIs.

Survey Questionnaire Results



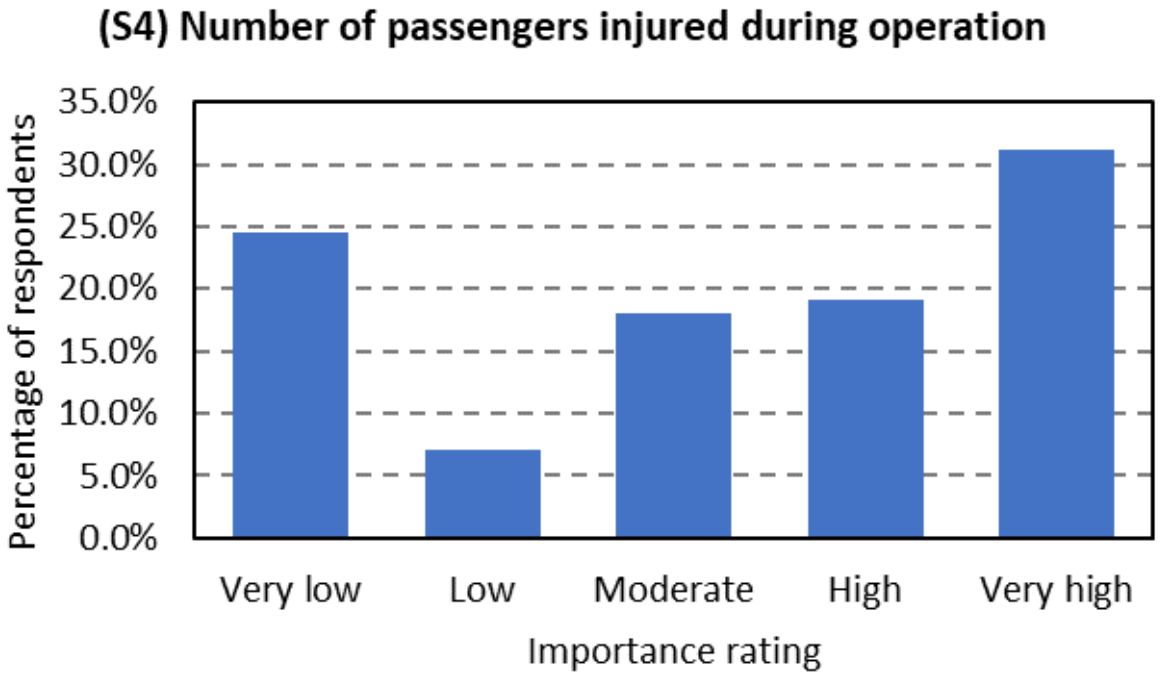
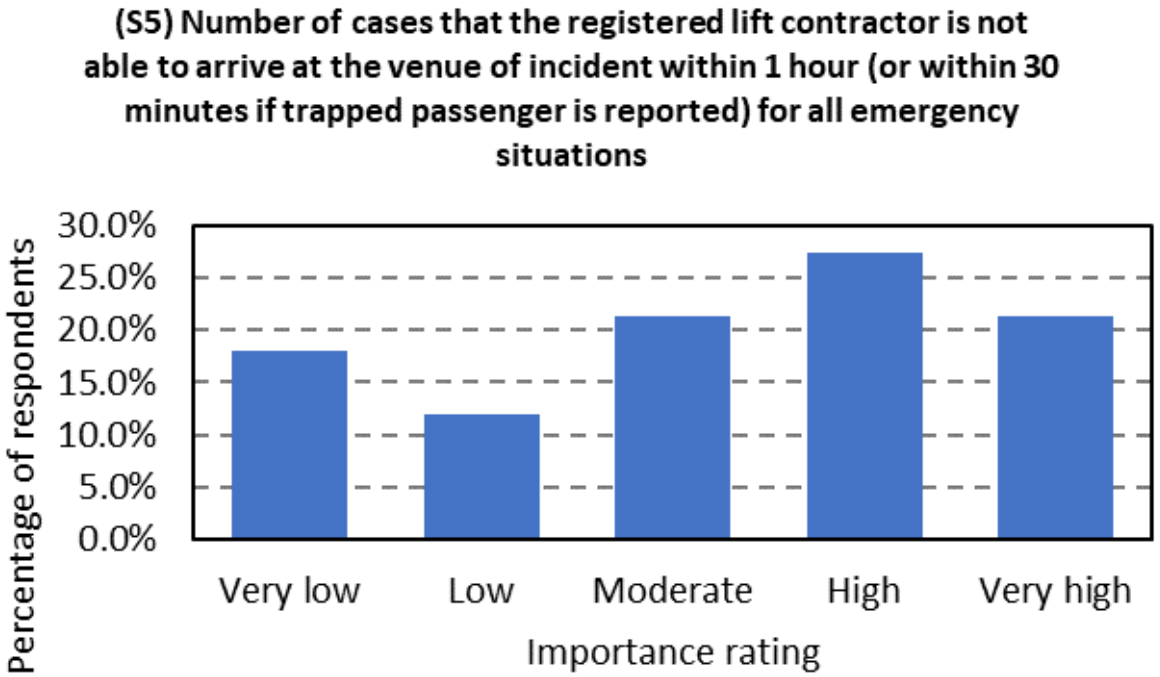


Figure 6g: Summary of importance level of performance KPIs.

Survey Questionnaire Results



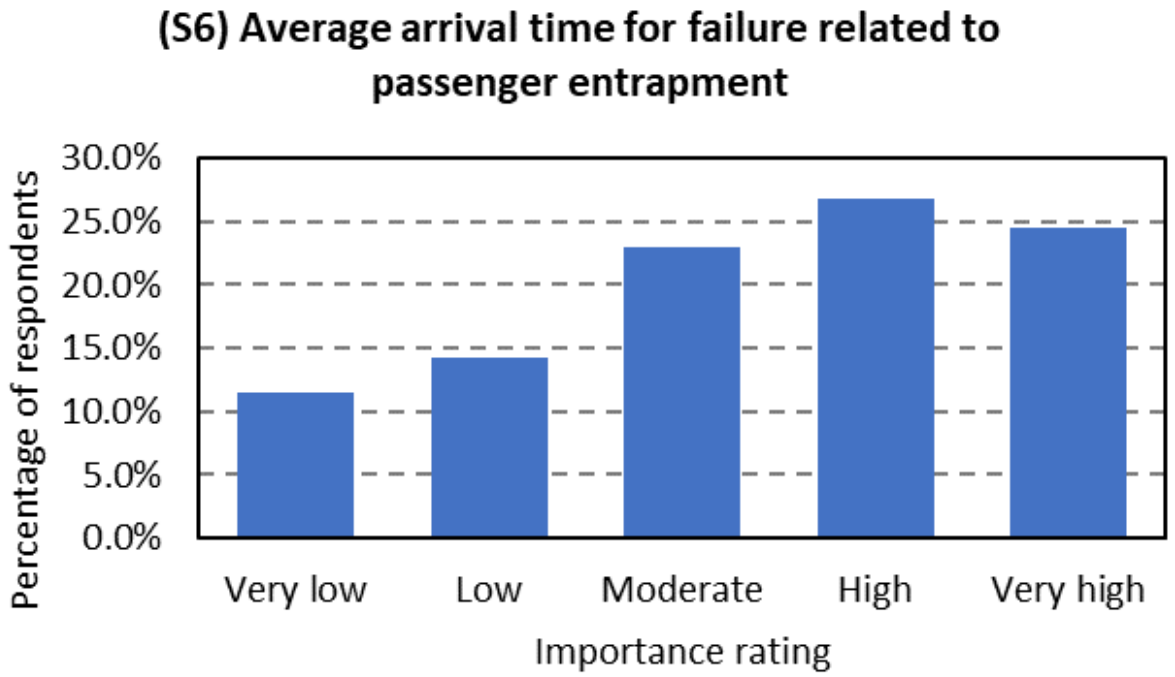
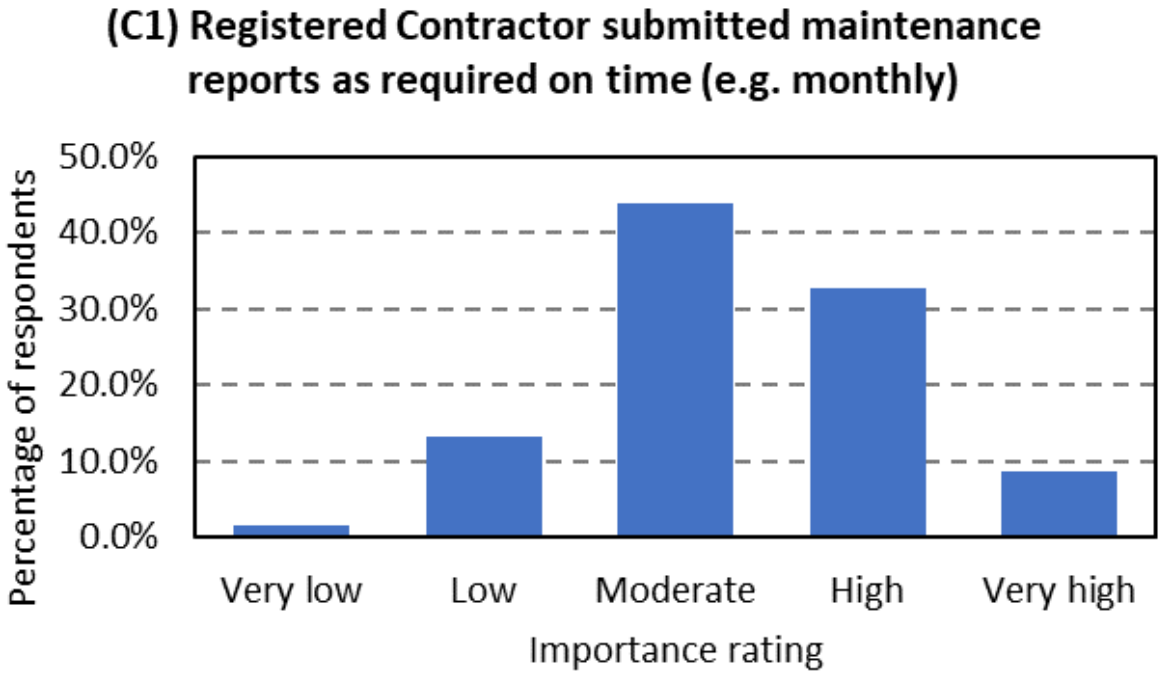


Figure 6h: Summary of importance level of performance KPIs.

Survey Questionnaire Results



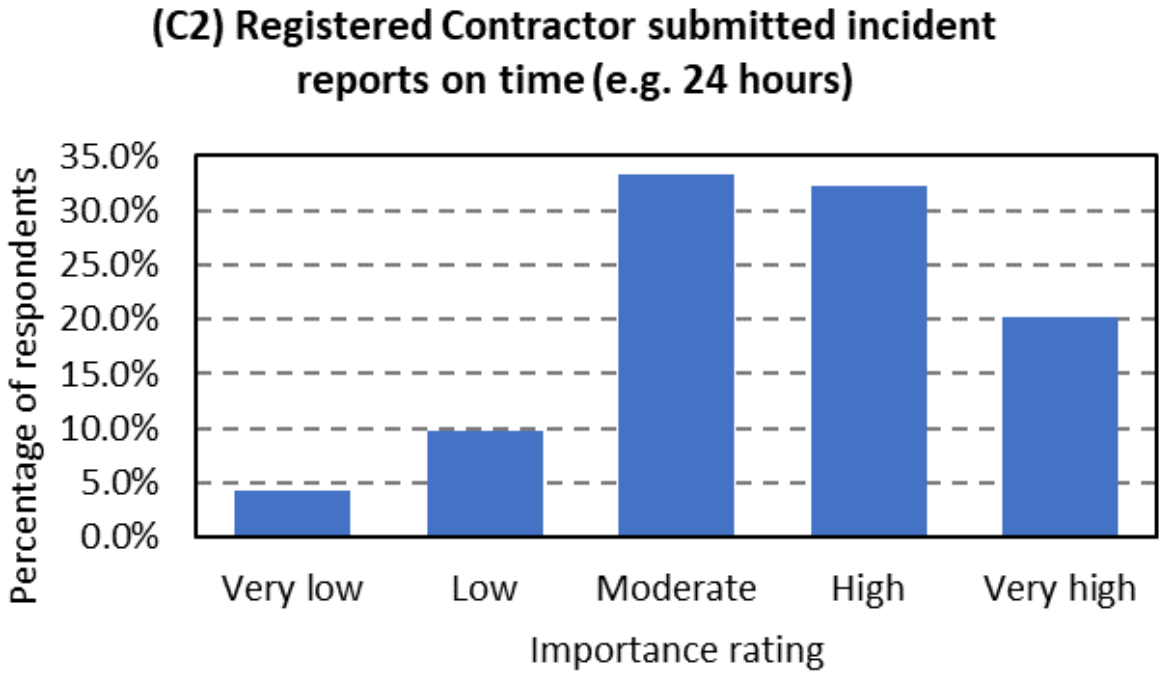
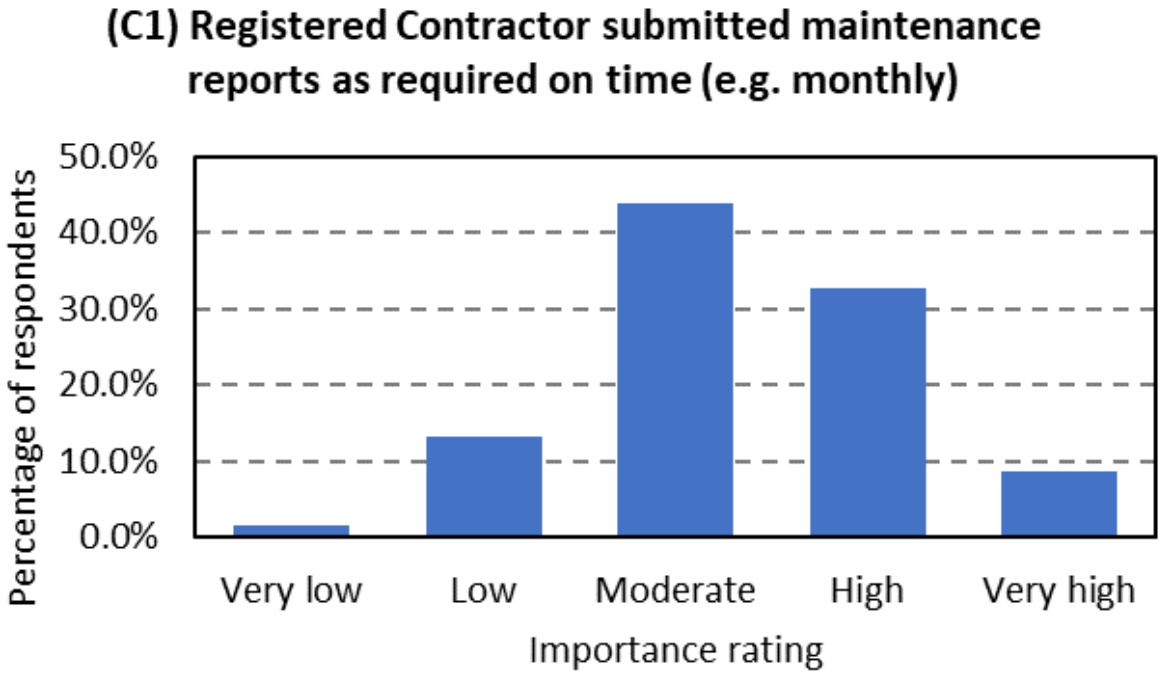


Figure 6i: Summary of importance level of performance KPIs.

Survey Questionnaire Results



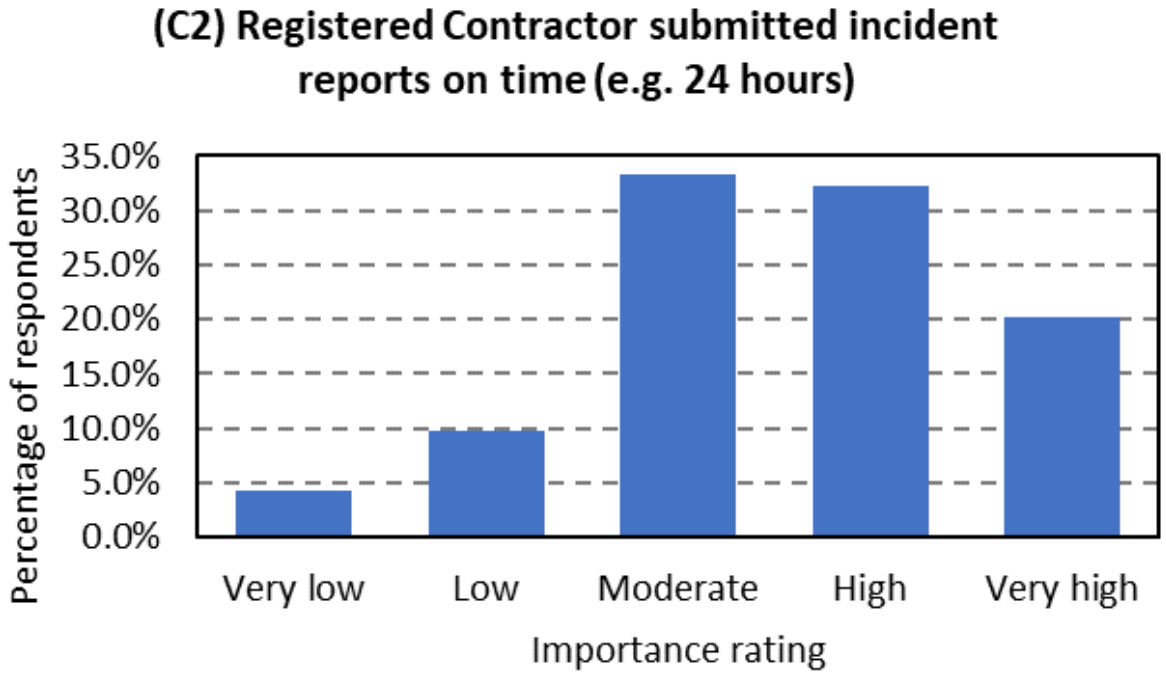


Figure 6j: Summary of importance level of performance KPIs.

Survey Questionnaire Results

- In order to identify and rank the importance level (1: very low, 2: low, 3: moderate, 4: high and 5: very high) of the 18 KPIs, the mean importance rating of each KPI were calculated and their ranks determined (Table 8).

KPIs		Rank
P5	Percentage of attending service calls within 30 minutes	1
P1	Availability	2
P4	Maintenance repair time	3
P3	Maintenance response time	4
P9	Frequency of failures	5
S3	Compliance percentage of statutory orders	6
F1	Maintenance cost per lift	7
P2	Maintenance downtime	8

Table 8: Mean importance ratings of KPIs

Survey Questionnaire Results

KPIs		Rank
C2	Registered Contractor submitted incident reports on time (e.g. 24 hours)	9
P7	Duration of service suspension due to failure	10
P8	Average arrival time for failure unrelated to passenger entrapment	11
S1	Average passenger trap release time	12
S6	Average arrival time for failure related to passenger entrapment	13
C1	Registered Contractor submitted maintenance reports as required on time (e.g. monthly)	14
P6	Number of repair work with duration extended to more than 8 hours	15
S4	Number of passengers injured during operation	16
S5	Number of cases that the registered lift contractor is not able to arrive at the venue of incident within 1 hour (or within 30 minutes if trapped passenger is reported) for all emergency situations	17
S2	Number of statutory orders	18

Table 8: Mean importance ratings of KPIs (continued)

Survey Questionnaire Results

- For those KPIs with a mean importance rating of over 3.5 (i.e. between the moderate and high levels), they were shortlisted.

- A further review of these shortlisted KPIs found that P7 "Duration of service suspension due to failure" could be covered by P1 "Availability".

- As a result, nine KPIs (Table 9), comprising six "Physical" indicators, one "Safety" indicator, one "Financial" indicator and one "Clients' needs/satisfaction" indicator, were finally shortlisted for use in devising the questionnaire for the next phase.

Survey Questionnaire Results

Performance KPIs	
P5	Percentage of attending service calls within 30 minutes
P1	Availability
P4	Maintenance repair time
P3	Maintenance response time
P9	Frequency of failures
S3	Compliance percentage of statutory orders
F1	Maintenance cost per lift
P2	Maintenance downtime
C2	Registered Contractor submitted incident reports on time (e.g. 24 hours)

Table 9: Shortlisted performance indicators

Questionnaire for collecting lift maintenance data

- To assess the practicality of the shortlisted performance indicators, a questionnaire (Figure 7) was developed to gather data for the study.

- Three FM practitioners were invited to participate in a meeting - aimed at demonstrating how to complete the questionnaire and gathering their feedback to refine it.

Questionnaire for collecting lift maintenance data

Questionnaire - KPIs for Evaluation of Lift Maintenance Performance in Hong Kong

With reference to the O&M record of 1 representative (typical) lift of your building in the past 12 months, please complete the 'yellow' rows of Part A and Part B.

(Note: For easy reference, Appendix shows a worked example for calculating the availability of a lift.)

Upon completion, please save this questionnaire in a file and email it to michael.liu@polyu.edu.hk .

For any query, please email (michael.liu@polyu.edu.hk) or call (3400 3599) Mr. Michael Liu.

Part A: Data for KPIs

(1) Maintenance downtime

Total amount of downtime of the lift over the assessment period (12 months).

Total amount of downtime = Downtime due to equipment fault + Downtime due to non-equipment fault	Unit: minutes
Downtime due to equipment fault: minutes	Downtime due to non-equipment fault: minutes
Total amount of downtime: minutes	

Note:

Downtime:

- Time interval (other than that due to scheduled maintenance) throughout which the lift is in a down state, i.e. total downtime due to both equipment faults and non-equipment faults (e.g. human misbehavior).

Downtime due to equipment fault:

- Time interval throughout which the lift is in a down state due to equipment faults.

Downtime due to non-equipment fault:

- Time interval throughout which the lift is in a down state due to non-equipment faults (e.g. human misbehavior).

(2) Maintenance response time

Total amount of response time of the lift over the assessment period (12 months).

Total amount of response time	Unit: minutes
minutes	

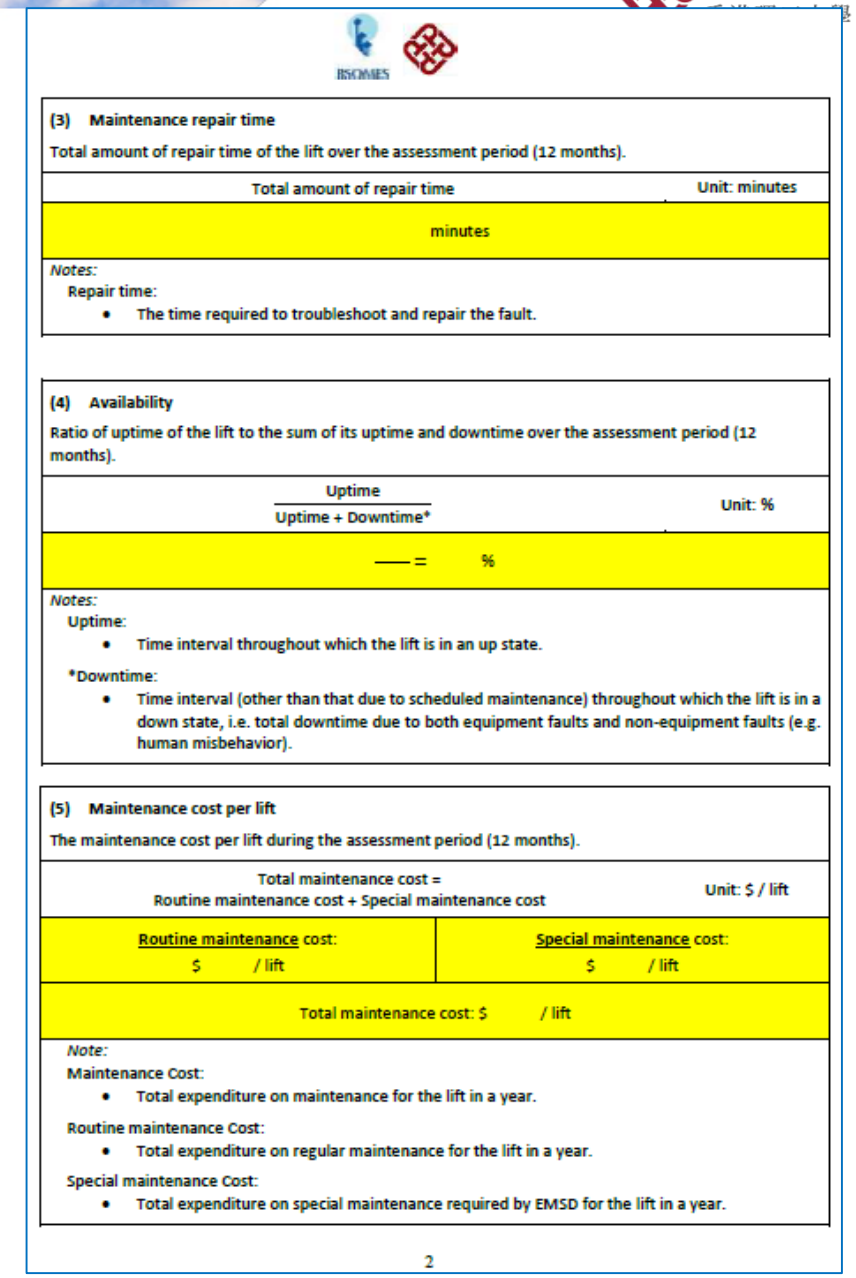
Notes:

Response time:

- The time that elapses between the reporting of a fault and the RC arriving at where the faulty equipment is located.

Figure 7: Questionnaire for collecting lift maintenance data

Questionnaire for collecting lift maintenance data



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(3) Maintenance repair time

Total amount of repair time of the lift over the assessment period (12 months).

Total amount of repair time	Unit: minutes
minutes	

Notes:

Repair time:

- The time required to troubleshoot and repair the fault.

(4) Availability

Ratio of uptime of the lift to the sum of its uptime and downtime over the assessment period (12 months).

$\frac{\text{Uptime}}{\text{Uptime + Downtime*}}$	Unit: %
—— = %	

Notes:

Uptime:

- Time interval throughout which the lift is in an up state.

*Downtime:

- Time interval (other than that due to scheduled maintenance) throughout which the lift is in a down state, i.e. total downtime due to both equipment faults and non-equipment faults (e.g. human misbehavior).

(5) Maintenance cost per lift

The maintenance cost per lift during the assessment period (12 months).

Total maintenance cost = Routine maintenance cost + Special maintenance cost	Unit: $ / lift
Routine maintenance cost: $ / lift	Special maintenance cost: $ / lift
Total maintenance cost: $ / lift	

Note:

Maintenance Cost:

- Total expenditure on maintenance for the lift in a year.

Routine maintenance Cost:

- Total expenditure on regular maintenance for the lift in a year.

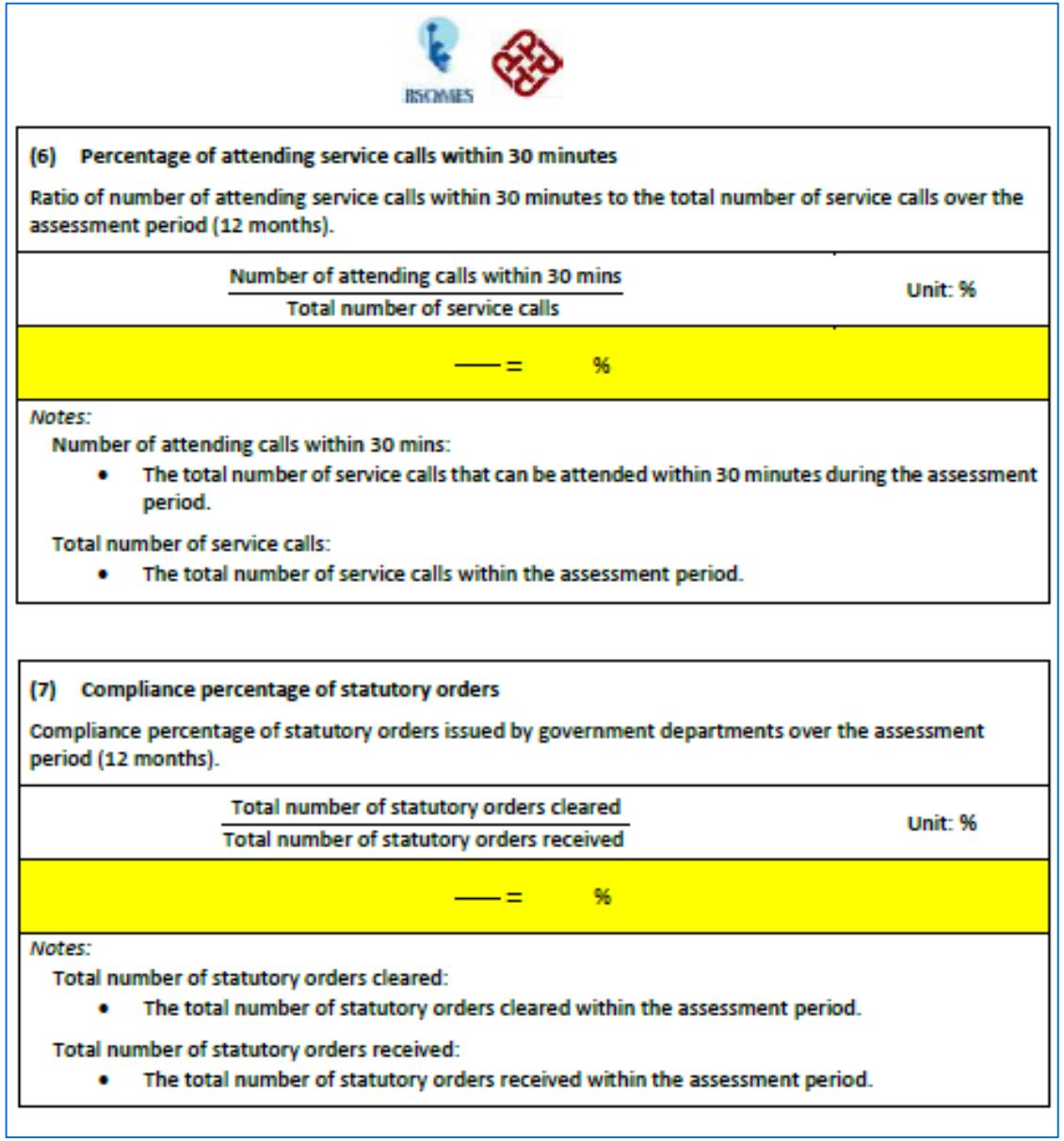
Special maintenance Cost:

- Total expenditure on special maintenance required by EMSD for the lift in a year.

2

Figure 7: Questionnaire for collecting lift maintenance data

Questionnaire for collecting lift maintenance data



(6) Percentage of attending service calls within 30 minutes

Ratio of number of attending service calls within 30 minutes to the total number of service calls over the assessment period (12 months).

$$\frac{\text{Number of attending calls within 30 mins}}{\text{Total number of service calls}} = \quad \%$$

Unit: %

Notes:

Number of attending calls within 30 mins:

- The total number of service calls that can be attended within 30 minutes during the assessment period.

Total number of service calls:

- The total number of service calls within the assessment period.

(7) Compliance percentage of statutory orders

Compliance percentage of statutory orders issued by government departments over the assessment period (12 months).

$$\frac{\text{Total number of statutory orders cleared}}{\text{Total number of statutory orders received}} = \quad \%$$

Unit: %

Notes:

Total number of statutory orders cleared:

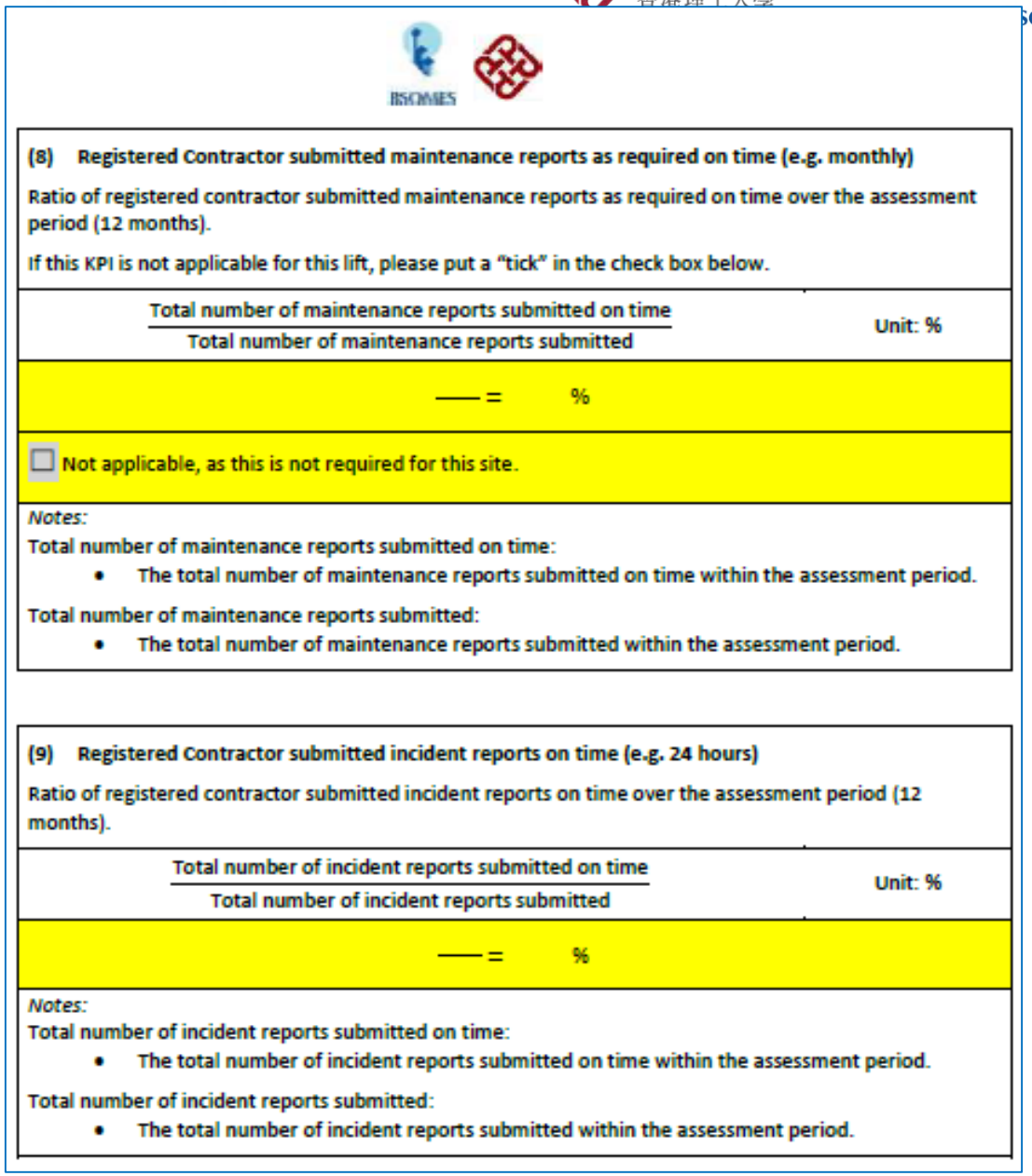
- The total number of statutory orders cleared within the assessment period.

Total number of statutory orders received:

- The total number of statutory orders received within the assessment period.

Figure 7: Questionnaire for collecting lift maintenance data

Questionnaire for collecting lift maintenance data



(8) Registered Contractor submitted maintenance reports as required on time (e.g. monthly)

Ratio of registered contractor submitted maintenance reports as required on time over the assessment period (12 months).

If this KPI is not applicable for this lift, please put a "tick" in the check box below.

$$\frac{\text{Total number of maintenance reports submitted on time}}{\text{Total number of maintenance reports submitted}} = \quad \%$$

Unit: %

☐ Not applicable, as this is not required for this site.

Notes:

Total number of maintenance reports submitted on time:

- The total number of maintenance reports submitted on time within the assessment period.

Total number of maintenance reports submitted:

- The total number of maintenance reports submitted within the assessment period.

(9) Registered Contractor submitted incident reports on time (e.g. 24 hours)

Ratio of registered contractor submitted incident reports on time over the assessment period (12 months).

$$\frac{\text{Total number of incident reports submitted on time}}{\text{Total number of incident reports submitted}} = \quad \%$$

Unit: %

Notes:

Total number of incident reports submitted on time:

- The total number of incident reports submitted on time within the assessment period.

Total number of incident reports submitted:

- The total number of incident reports submitted within the assessment period.

Figure 7: Questionnaire for collecting lift maintenance data

Questionnaire for collecting lift maintenance data

Part B: Building information and personal particulars

About the lift (with data provided above)

Age of the lift (years):
Lift usage (e.g. passenger, passenger (fireman), service, goods, vehicle):
No. of stops:
Size (kg):
Rated speed (m/s):

About the building where the lift is located

Name of building (optional):
Age of building (years):
Type of building (e.g. office, residential, industrial):
No. of storeys:
No. of lifts in the building:

About yourself (the study team will contact you if there are queries on the data)

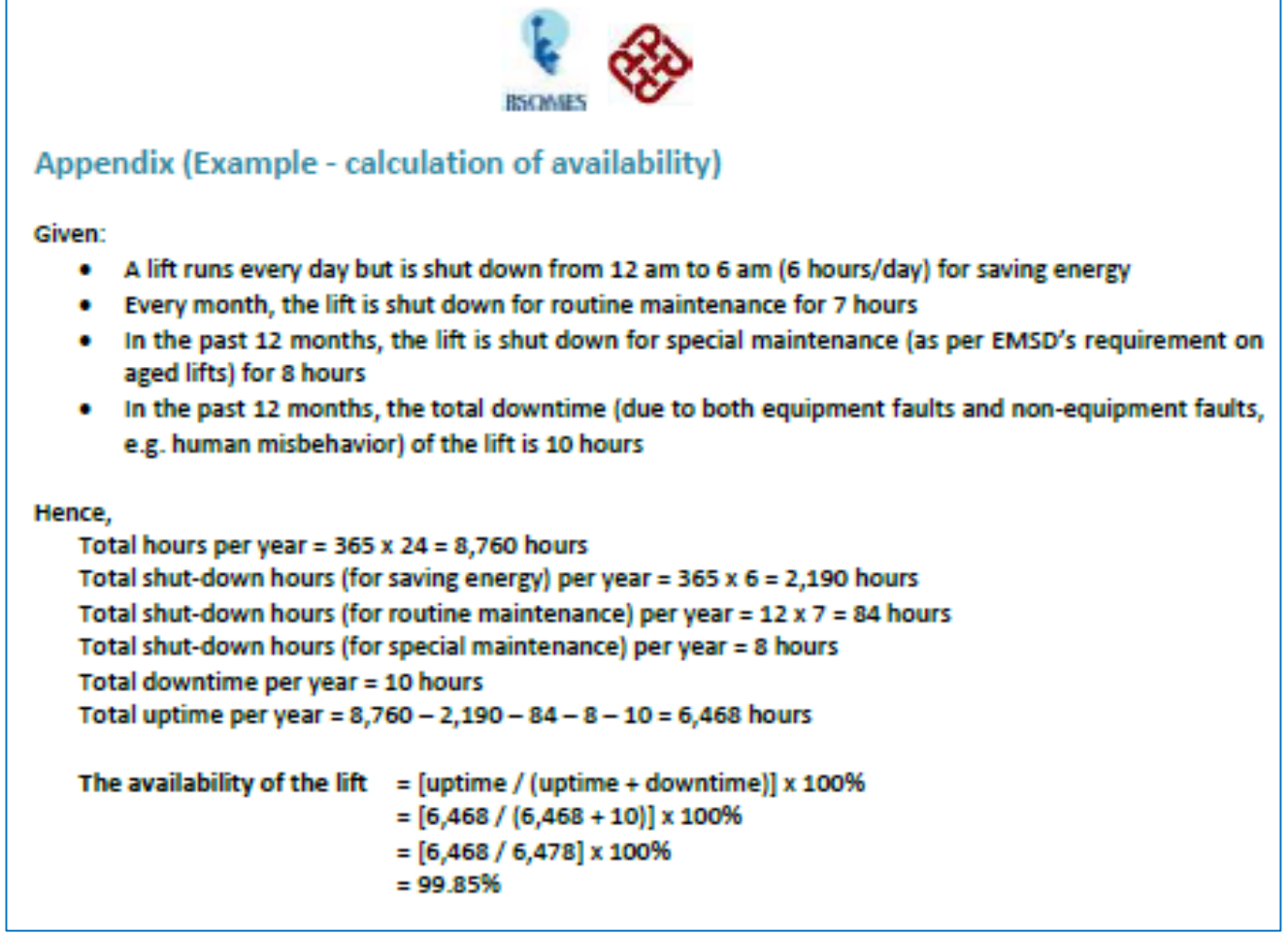
Name:	
Email:	Phone:

*** Thank you very much for your participation ***

Please save this questionnaire in a file and email it to michael.liu@polyu.edu.hk

Figure 7: Questionnaire for collecting lift maintenance data

Questionnaire for collecting lift maintenance data



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Appendix (Example - calculation of availability)

Given:

- A lift runs every day but is shut down from 12 am to 6 am (6 hours/day) for saving energy
- Every month, the lift is shut down for routine maintenance for 7 hours
- In the past 12 months, the lift is shut down for special maintenance (as per EMSD's requirement on aged lifts) for 8 hours
- In the past 12 months, the total downtime (due to both equipment faults and non-equipment faults, e.g. human misbehavior) of the lift is 10 hours

Hence,

Total hours per year = 365 x 24 = 8,760 hours
Total shut-down hours (for saving energy) per year = 365 x 6 = 2,190 hours
Total shut-down hours (for routine maintenance) per year = 12 x 7 = 84 hours
Total shut-down hours (for special maintenance) per year = 8 hours
Total downtime per year = 10 hours
Total uptime per year = 8,760 – 2,190 – 84 – 8 – 10 = 6,468 hours

The availability of the lift = [uptime / (uptime + downtime)] x 100%
= [6,468 / (6,468 + 10)] x 100%
= [6,468 / 6,478] x 100%
= 99.85%

Figure 7: Questionnaire for collecting lift maintenance data

Questionnaire for collecting lift maintenance data

- At the outset of the meeting, the facilitator provided an overview of the background and the specific data required for the performance indicators.

- Subsequently, discussions were held between the study team and the interviewees, during which the practitioners shared their insights and provided comments on the questionnaire. The comments, particularly on the following three KPIs, are as summarized below:

Questionnaire for collecting lift maintenance data

(1) Maintenance cost per lift:

- The maintenance cost should be counted in two components:
  - i. Routine maintenance cost.
  - ii. Special maintenance cost required by EMSD.

(2) Availability and maintenance downtime:

- The downtime of lifts should be counted as follows:
  - i. Downtime due to equipment fault.
  - ii. Downtime due to non-equipment fault (e.g. human misbehaviour).

Questionnaire for collecting lift maintenance data

(3) Registered Contractor submitted maintenance reports as required on time:

- Monthly report is not mandatory under the law. Thus, an option "not applicable" is allowed for this KPI.

- The feedback received from the facility management practitioners during the meeting was taken to revise the questionnaire.
- They agreed to provide empirical data of their lifts for completing the questionnaire. Eventually, a total of 55 completed questionnaires were received from the facility management practitioners.

Questionnaire for collecting lift maintenance data

- Before proceeding to the next stage of analysis, the received data were carefully verified to ensure their accuracy and validity.
- This verification process involved applying predefined rules to identify and address any incorrect data (Table 10).

KPI 1: Downtime	
downtime due to equipment fault (TDef) + downtime due to non-equipment fault (TDnef) ≠ total amount of downtime (Td)	TDef + TDnef ≠ Td

Table 10: Rules used to detect incorrect data

Questionnaire for collecting lift maintenance data

KPI 2 & KPI 3: Response time & Repair time response time (Trs) + repair time (Trp) ≠ downtime (Td)	Trs + Trp ≠ Td
KPI 4: Availability uptime (Tu) <100000 or uptime (Tu) >525600	Tu < 100000 or Tu > 525600
KPI 5: Maintenance cost routine maintenance cost (Cr) < 80000	Cr < 80000
KPI 5: Maintenance cost routine maintenance cost (Cr) + special maintenance cost (Cs) ≠ total maintenance cost (Ct)	Cr + Cs ≠ Ct
KPI 7: Statutory orders statutory orders (Os) > 5	Os > 5

Table 10: Rules used to detect incorrect data (continued)

Questionnaire for collecting lift maintenance data

- After verifying all the 55 questionnaires, only two (Case A and Case B) were found to be completely error-free (or not dubious). Below is a summary of the KPI data of these two cases:

Characteristic of the cases (lifts):

Case	Age	Usage	No. of stops	Size (kg)	Rated Speed (m/s)
A	19	Passenger	47	900	3.5
B	21	Passenger	22	680	1.75

KPI 1 - Downtime (mins):

Case	Equipment fault	Non-equipment fault	Total
A	180	0	180
B	0	139	139
Average	90	69.5	159.5

KPI 2 - Response time (mins):

Case	Response time
A	60
B	44
Average	52

KPI 3 - Repair time (mins):

Case	Repair time
A	120
B	95
Average	107.5

Questionnaire for collecting lift maintenance data

KPI 4 - Availability:

Case	Uptime (min.)	Uptime + Downtime (min.)	Availability
A	525420	525600	99.97%
B	523081	523220	99.97%
Average	524250.5	524410	99.97%

KPI 6 – Attending calls within 30 mins:

Case	Number of attending calls within 30 mins	Total number of service calls	Percentage of attending service calls within 30 minutes
A	1	2	50.0%
B	2	2	100.0%
Average	1.5	2	75%

KPI 5 - Maintenance cost (HK$):

Case	Routine	Special	Total
A	121732.5	0	121732.5
B	96720	0	96720
Average	109226.25	0	109226.25

KPI 7 - Statutory orders:

Case	Total number of statutory orders cleared	Total number of statutory orders received	Compliance percentage
A	0	0	N/A
B	0	0	N/A

Questionnaire for collecting lift maintenance data

KPI 8 - Submitted maintenance reports:

Case	Total number of maintenance reports submitted on time	Total number of maintenance reports submitted	On time percentage
A	0	0	N/A
B	N/A	N/A	N/A

KPI 9 - Submitted incident reports:

Case	Total number of incident reports submitted on time	Total number of incident reports submitted	On time percentage
A	0	0	N/A
B	0	0	N/A

Questionnaire for collecting lift maintenance data

- For the remaining 53 questionnaires filled with suspected error data, we reached out to the facility management practitioners to seek clarifications on some queries. Examples of the queries are as below:

1. KPI 1: The sum of downtime of equipment fault and no-equipment fault was not equal to the total downtime.

Example:	Downtime due to **equipment fault**: 70 minutes Downtime due to **non-equipment fault**: 40 minutes Total amount of downtime: 130 minutes 70 + 40 ≠ 130

Questionnaire for collecting lift maintenance data

2. The sum of response time (KPI 2) and repair time (KPI 3) was not equal to the total downtime (KPI 1).

Example:	Total amount of downtime: 130 minutes Total amount of response time: 780 minutes Total amount of repair time: 60 minutes 780 + 60 ≠ 130

Questionnaire for collecting lift maintenance data

3. Uncertain units were found in the uptime and downtime for the availability (KPI 4).

Example:	$\frac{6465}{6544} = 98.79\ \%$	$\frac{524856}{525600} = 99.86\ \%$
	The unit is hour?	The unit is minute?

4. The uptime and downtime in availability (KPI 4) were found unusually high.

Example:	$\frac{\text{Uptime}}{\text{Uptime + Downtime*}}$
	$\frac{1919396}{1927200} = 99.60\ \%$

Questionnaire for collecting lift maintenance data

5. The total maintenance cost (KPI 5) was found unusually low.

Example:	Total maintenance cost: $ 45000 / lift

6. KPI 5: The sum of routine maintenance cost and special maintenance cost was not equal to the total maintenance cost.

Example:	**Routine maintenance** cost: $ *FORMTEXT* 5043 */ lift* | **Special maintenance** cost: $ *FORMTEXT* 8170 */ lift* Total maintenance cost: $ 4030 */ lift* 5043 + 8170 ≠ 4030

Questionnaire for collecting lift maintenance data

7. KPI 6: Total number of statutory orders was found unusually high.

Example:	$\frac{\text{Total number of statutory orders cleared}}{\text{Total number of statutory orders received}}$ $\frac{12}{12} = 100\ \%$

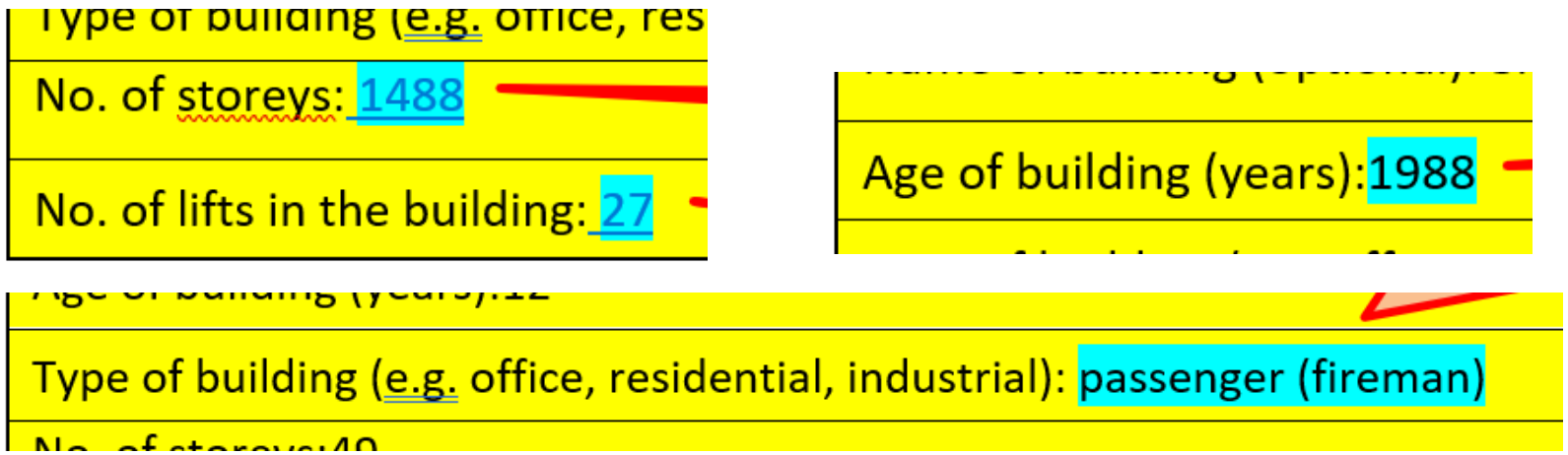
8. Data for more than 1 lift per questionnaire was found.

Example:	Lift usage (e.g. passenger, passenger (fireman), service, goods, vehicle): Passenger x 5, passenger (fireman) x2 No. of stops: (Passenger) 30, passenger (fireman)34

Questionnaire for collecting lift maintenance data

9. Unusually large values or data were found.

Example:



- When the above queries are clarified in the future, the data provided in the corresponding questionnaires would be rectified.
- Further research work could be pursued to analyse such data and conduct performance benchmarking based on the analysis result.

Summary

- When Part A of this Study commenced, an extensive literature review was conducted, leading to the identification of an array of indicators that may be applicable to measuring the performance of lifts.
- After review and with the principles for selection of KPIs taken into consideration, some of the identified performance indicators were excluded.
- The remaining (i.e. shortlisted) indicators were each given a clear definition and the formula for their calculation was also defined.
- The shortlisted performance indicators were grouped into four categories: Financial", "Physical", "Safety" and "Clients' needs/satisfaction".

Summary

- Based on these indicators, a set of guiding questions and presentation slides were prepared to facilitate the focus group discussion.
- With the participation of 10 maintenance experts, fruitful discussion was made during the focus group meeting.
- Referring to the experts' opinions, the list of indicators was refined, with some of the impracticable indicators discarded and some essential indicators added. The resultant indicators fall into 4 aspects: financial (1 indicator), physical (13 indicators), safety (6 indicators), and clients' needs / satisfaction (2 indicators).

Summary

- In the beginning of Part B, the above-shortlisted indicators formed the basis for designing a questionnaire survey.
- Then the survey was conducted on a wide community of maintenance practitioners in Stage 4 (under Part B).
- Responses to the survey were analysed, and eventually a total of nine KPIs (6 "Physical" indicators, 1 "Safety" indicator, 1 "Financial" indicator and 1 "Clients' needs/satisfaction" indicator) were selected as the most essential for evaluation of lift maintenance performance.

Summary

- To ensure that these KPIs are fit for use in the lift maintenance industry of Hong Kong, case studies and interviews were carried out in the final stage (Stage 5).
- Through the interviewees, questionnaires completed with KPI data of 55 lifts were collected.
- Those questionnaires with error-free data were taken to validate the applicability of the KPIs.
- Evidenced by the positive validation results, the nine KPIs can serve as useful lift maintenance KPIs in Hong Kong.

Summary

- With the above KPIs established, in future it is worthwhile to further study how such KPIs could be used to develop a credible lift maintenance performance evaluation scheme.
- When such a scheme is made available
  - management practitioners would be enabled to effectively determine the maintenance performance of the lifts they manage
  - lift maintenance contractors would become clear about the performance level of their maintenance service
  - building owners would be able to understand whether the maintenance services procured for their lifts are value for money

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Further reading

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Thank you very much

Q&A

Prof. Joseph H.K. Lai

Department of Building Environment and Energy Engineering, PolyU

Email: bejlai@polyu.edu.hk

Webpage: https://www.polyu.edu.hk/beee/people/academic-staff/ir-professor-lai-hung-kit-joseph/