ANNEX J: RISK ANALYSIS

1. The Importance of Risk Analysis

1.1 Key to any comparison of different forms of private sector involvement, including PPP, is how risk and uncertainty are shared between the public and private sector, how that risk is managed and how risks are allocated to the party best able to manage them. Some risks, such as legislative risks are best handled by the public sector, but where the private sector is better at handling some risks such as general commercial and business risks they will require compensation for taking on these greater risks. The risk analysis used in the financial assessment for the WKCD develops measures of risk that reflect the different risk profiles of different forms of procurement. This measure, called the risk premium, is the expected value of deviations from the estimated base case.

1.2 This approach provides a more sophisticated estimate of risk than the simple method of adding a fixed contingency percentage to the base costs to cover uncertainties. The risk analysis goes further by analysing the sources of uncertainties and estimating the expected costs of risks for different allocations between public and private sectors. The resulting risk premiums therefore better reflect the type of procurement arrangement adopted.

2. The Nature of Project Risk

2.1 Within any development project there is always potential for unforeseen events to result in a different outcome to that anticipated, both during the construction and operation phases. Such risks include for example revisions to project scope, the selection of inappropriate companies during the selection process and the failure to obtain approval for building plans or to meet required standards. For a project of the size, status and complexity of WKCD, there are then additional risks to take into consideration - which increases the degree of uncertainty - and hence the greater the risk that costs and revenues will deviate from their base case estimates. Should any of these risks materialise then there will be implications for delay, costs and possibly safety, for which suitable up front provision should be made.

2.2 However, it should be recognised that risks are not one-sided: unforeseen events could have either positive (lower costs or higher revenues) or negative impacts (higher costs or lower revenues) so it is always possible that project costs fall below estimates as well as exceed them and that revenues exceed expectations as well as fall below them. A correct assessment of risk will take these positive possibilities into account, as well as the negatives.

3. Objectives and Approach

3.1 The focus of the risk assessment is the expected value of the risk of each of the CACF facilities, or its risk premium. This premium is the weighted probability cost of events turning out better or worse than the base case and should be sought to be minimised so as to maximise a project's financial outcome. The public sector may seek to minimise their exposure to risk by transferring risk to the private sector, in return for which the private sector would expect to be suitably compensated. In order to assess whether a transfer of risk is beneficial in any particular case, the concept of the Public Sector Comparator (PSC) has been devised (see Annex N) and the risk of procurement alternatives under the PSC and the PSI have been assessed.

3.2 The risk analysis therefore:

- Estimates the expected value of the costs of uncertainty, or risk assessment, for different allocations of risk and alternative procurement options involving both the private and public sectors in implementation
- Contributes to the comparison of private sector procurement alternatives with the PSC so as to help identify the financial consequences of different ways of transferring risks and responsibilities from Government to the private sector
- In addition to the calculation of the expected values of the costs of risk, provides an indication of the likely range of values for the procurement alternatives

3.3 The approach uses expected value techniques to differentiate between the various procurement options in terms of how they would deal with a divergence from the base case. This is done by first breaking down the construction and operation of the CACF into a series of discrete stages, charting each of the facilities right through from the first appointment of consultants to final fit-out of the interior and subsequent operation. Each of these discrete stages has the potential to turn out differently from that anticipated under the base case calculation. By assigning to each of these stages first a probability that events may turn out differently, then an anticipated cost under that different outcome, it is possible to generate risk premiums that differ from one procurement option to the next due to the way they handle risk.

3.4 When undertaking the risk assessment, reference has been made to international best practice including that from the UK, Canada and Australia such that the focus has been on those risks that will materially affect the costs (or revenues) being quantified:

"It would generally be inappropriate to devote excessive time and resources to valuing minor or less sensitive risks." Partnerships Victoria, Public Sector Comparator, Technical Note, Guidance Material, June 2001.

3.5 For this reason the risk analysis has focused on the construction and operating risks of the CACF [1]. It should be noted that unlike risk assessments for conventional public infrastructure facilities which are not revenue generating, the nature of operating risks for cultural facilities such as PA venues is also associated with demand risk. The risk is also substantially affected by the relationship between operating costs and revenues. The FA has adopted similar approaches to assessing the risk associated with capital construction and operating risks albeit applied in different ways as described below.

4. Construction Risks

4.1 For construction, relevant risks have been estimated for each of the alternative procurement options of each scenario including the PSC procurement alternatives. The expected values of the risks have been calculated using simple probability valuation techniques. In brief, the expected value of an individual risk event is the product of the probability of the event occurring and the cost if it does occur.

4.2 The sequence of steps in the estimation of the expected value is as follows:

[1] The risk assessment provides valuations of risk and also provides a measure of the potential cost ranges for sensitivity tests on the financial analysis. This approach provides a more sophisticated estimate of contingencies than the simple approach of adding a fixed percentage to a base cost estimate and better reflects the type of procurement arrangement. This detailed risk assessment has only been applied to CACF facilities however. The standard approach of adopting a 15% contingency is used for non-CACF, communal and other engineering facilities in line with the principle of not devoting "time and resources to valuing minor or less sensitive risks".

- Identify each activity associated with the construction of the project (e.g. appointment of design consultants, prepare tenders, etc)
- For each activity, identify possible events that would lead to costs which differ from base costs (e.g. change of scope, delay in award, etc)
- Identify the consequences of the event, if it occurred (e.g. a delay of 'x' months, amendment to the design, etc)
- Assign a probability of the event occurring – low, medium, high – and for each of these probabilities, assign a percentage to each of the following:
    - 'no change' from base cost
    - 'minimum' and 'maximum' difference from base cost
    - 'most likely' change from base cost

4.3 In the cases of the low, medium and high probability of the event occurring, the percentages assumed are as shown in Table 1 below.

Table 1: Risk Probability Matrix

Probability	No change from base costs	Minimum	Most Likely	Maximum
Low probability of the event occurring	50%	10%	30%	10%
Medium probability of the event occurring	20%	10%	60%	10%
High probability of the event occurring	5%	10%	75%	10%

- For each event, identify the cost of the event occurring at the minimum, maximum and most likely levels
- Calculate the expected value of the costs of the risk of each event occurring by multiplying the probability of a change from base costs by the costs if the event does occur, and summing over the percentages. Finally, sum over all the events to generate the expected risk costs

4.4 The analysis is performed for each procurement option (i.e. DB, DBO, BOT etc). This is because the probability of any event occurring varies with the method of procurement.

5. Construction Risks and Categorisation

5.1 The relevant risks associated with the construction of the CACF under each procurement mode have been identified at each stage (design, review, tender, construction, etc.) of the construction process together with the activities required at each stage. The analysis has analysed the nature of the risk in accordance with the sequence of steps described in the approach, above.

5.2 Exhibit 1 at the end of this Annex lists the activities associated with construction activities events that could occur within each activity that would lead to a change in the base costs. The assumptions made in Exhibit 1 relate to a detailed example of the risk calculation. Different assumptions for the alternative procurement scenarios and similar tables have

been prepared. The resulting expected values of the risks, or the 'risk premiums' for each of the alternative procurement modes used in the scenarios are summarised in Table 2.

5.3 The risk premiums associated with construction of the CACF have been summarised under the following headings:

- Project management risk, including tender preparation, the appointment of consultants (i.e. their ability to design and supervise the project), invitation to tender (including the number of competent contractors available) and the timely award of contracts
- Functional risk, including change of scope and the approval of specialist works by relevant authorities
- Approval risk, including the risk of delays in approval of the Master Layout Plan, General Building Plan, Foundation Plan, Drainage Plans, etc. by relevant authorities and non-compliance with statutory requirements for Testing and Commissioning, Occupation Permits etc
- Underground conditions risk – specifically deviation from founding strata indicated at site investigation
- Construction and Completion risks including the risk of delays in site investigation, foundations, superstructure, services, fitting out and setting up of exhibits in museums

5.4 It should be noted that financing risks are excluded from the risk analysis in this form as they are measured by the level of the weighted average cost of capital (WACC) adopted and is itemised separately in the financial analysis.

6. Expected Construction Risk Calculation – An Example

6.1 To enable a better understanding of the methodology for calculating the various probabilities and values, an example of the detailed calculation of one risk is set out below - in this case (referring to Table 2 below and Exhibit 1 at the end of this Annex) illustrating how the premium of **12.6%** for the "**Project Management**" risk under the "Design and Build (DB)" procurement mechanism has been arrived at.

6.2 The calculation can be followed by referring to Exhibit 1 (which calculates all risks for the DB Procurement Option) at the end of this annex – specifically referring to the first row of this Table, labelled "Appointment of Consultants". The risks associated with this activity are calculated by reference to the columns "Possible Risks" through to "Possible Consequences" in the following steps:

6.3 **Step 1**: By reference to the "Possible Risk", the "Category of Risk" and the "Risk/Changes" (identified by the "Expert Panel" – see below), the probability of the occurrence of the possible risks in this case has been assigned as "medium". As the Risk Probability Matrix Table above indicates, "Medium" probability of occurrence is taken to mean that there is:

- a 20% chance that there will be no deviation from the base case costs for this item
- a 10% chance that the actual costs will be at the lower limit of costs from base costs
- a 60% chance that the actual costs will be at the most likely cost difference (see below)
- a 10% chance that the actual costs will be at the outer upper limit of cost

Note that these chances sum to 100%, so all possibilities are covered.

6.4 **Step 2**: Referring back to Exhibit 1 at the end of this Annex, the assumed possible consequences in the event that the costs differ from base costs have been assessed by reference to the factor listed in the "Possible Consequences" column and were valued as a percentage of total estimated base costs at:

- -2.0% of estimated costs at the lower limit (10% chance – from above)
- +3.5% of estimated costs at the most likely cost difference from base costs (60% chance – from above)
- +8.0% of estimated costs at the upper limit (10% chance - from above)
- The possible consequence in terms of cost difference from base costs when there is no deviation from base costs is zero (20% chance – from above).

6.5 **Step 3**: The "Expected % Value of Consequence" in terms of estimated costs of the consequence of the risk is given by:

{(-2.0 * 10%) + (+3.5 * 60%) + (+8.0 * 10%) + (zero * 20%)} = 2.7% of estimated costs

6.6 **Step 4**: From Exhibit 1 at the end of this Annex, the "estimated costs" in this formulation are "construction costs for arts and cultural works". These estimated costs (base costs) are equal to $12,541million[2]. So the expected value of the risks in this case are given by:

2.7% * $12,541 million = $338.61 million

6.7 **Step 5**: To derive the total cost of risk attributable to the "Project Management" risk category, the individual costs for the four items of Project Management risks listed in the "Category of Risk" column are summed - refer to the column "Expected Value of Consequence $m..." in Exhibit 1 at the end of this Annex. This total cost of Project Management risk is therefore: {$338.61 million + $778.76million + $159.29 million + $955.75 million = $2,232.41 million}, summed for all the four Project Management items. The total costs of risk for Project Management – at $ million - have then been summarised as a percentage of base costs of construction - i.e. **12.6%** of $17,699 million[3] - In Table 2 below.

6.8 Although evidence has been used as far as possible, in some cases the estimates are based on professional judgment rather than an evidential basis. In the absence of formal designs, there is no evidence that can be easily quoted for the estimates which have been derived, other than the application of reasonable assumptions based on professional judgment. Likewise for the costs of risks; there is no statistical evidence which is available to be used to provide estimates for the costs of risk for a project such as WKCD.

6.9 The approach adopted for the risk analysis is in line with best practice in international risk analysis – and specifically uses the technique of employing an Expert Panel to make group judgements on these values. Two meetings of this panel – drawn from members of the local and international FA team – were held in Hong Kong and London.

6.10 It should be noted that the costs of risk vary with procurement method. The differences between procurement methods in this regard derive from varying only those risk

[2] best estimate of CACF construction costs used at the time of risk analysis

[3] best estimate of total construction costs used at the time of risk analysis

assumptions which would change depending on the allocation of risk between public and private sectors. Again, the assumptions used are those of the Expert Panel.

7. Expected Construction Risk – Results

7.1 Exhibit 1 attached to this Annex provides the details of the calculation of the expected value of risks for the detailed example, which is principally implemented under the Design and Build (DB) method of procurement.

7.2 In this case, the risk premium is estimated to be 23.0% of the construction costs. That is, the best estimate of the costs of a CACF facility after allowing for uncertainties is 123% of estimated construction costs using the DB procurement method.

7.3 Table 2 below provides the breakdown of the 23.0% figure for the DB approach according to the broad classification of the risks. The table shows the corresponding results for six alternative procurement options used for some CACF in alternative PSI scenarios.

7.4 In the case of DB, the greater proportion of the risk is calculated to be attributable to project management activities. This includes appointment of contractors and tendering. Second in significance is the functional risk, which includes changes to scope and overall Government approval of the approach. The third most significant risk is delay and dislocation that may arise from the approval process, including relevant authority approvals as a result of unexpected delays by the approving agency and the competency of the project manager in dealing with the approval process. Other risks relating to construction itself, such as uncertainty about ground conditions and the impact that they may have on costs, are relatively slight in terms of risk costs since the relevant risks are well understood in this case and the additional costs associated with them are already included in the estimates of base costs.

Table 2 Summary of Construction Risk Premiums for CACF Facilities by Procurement Method

	Procurement Method						
	ASD + C	Design Competition + DB	DB	DBFM	DBO	BOT	BOO
Total risk percentage	28.4%	34.7%	23.0%	29.5%	20.8%	20.8%	20.8%
Project Management	17.7%	19.5%	12.6%	19.1%	10.4%	10.4%	10.4%
Functional	6.0%	10.5%	6.0%	6.0%	6.0%	6.0%	6.0%
Approval	2.6%	2.7%	2.5%	2.5%	2.5%	2.5%	2.5%
Underground conditions	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%
Construction and Completion	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Non-CACF	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%

Note: Finance risks are not included in the Table as they are calculated separately in the financial analysis

7.5 The resulting risk premiums on construction of the CACF vary between 20.8% and 34.7% according to procurement method. The greatest variation arises from project management risks. Procurement modes which separate the design from the building stages and add additional project management risks (e.g. of delay, or change of scope) increase the level of risk significantly. This includes procurement modes such as a design competition or, as in the case of DBFM, those which include the maintenance role in the construction

contract, and separate it from other operating and management functions. Similarly, even the separation of design carried out by ASD from the construction role of an outside contractor, will increase project management risks – though not as much as a design competition or a DBFM. Only those procurement methods which provide a clear output specification to bid against and integrate the development, finance and ultimate operation process under the responsibility of one contractor, such as DBO, BOT and BOO, reduce these risks and provide more cost effective solutions.

7.6 It should be noted that, compared with other international experience, the range of risk premiums is not as great as has been experienced in, for example the UK PFI programme. Greater savings might be expected for whole life PSI approaches such as BOT and BOO compared with the DB mechanism already widely used for public procurement. In Hong Kong this is clearly different because – and the risk analysis has taken account of the fact that – the DB approach used by the public sector already incorporates most of the gains, in terms of reduction of risk, from participation by the private sector.

8. Minimum and Maximum Construction Risk Calculation Tables / Results

8.1 The probability ranges used in the capital risk assessment methodology also allows maximum and minimum risk premiums to be estimated which were used to test the risk and sensitivity of the financial analysis. This is done by assuming the minimum cost for each event to establish the least cost, and the maximum cost for each event to establish the greatest cost. In each case the minimum and maximum values are the absolute outer limits of the risk costs for the assumptions that have been used.

8.2 Table 3 (corresponding to Table 2 above) provides the results of the risk analysis for the minimum and maximum risk costs. In each case the best and worst scenarios from the point of view of cost for all the activities, events and probabilities associated with construction have been assumed.

Table 3 Summary of Minimum and Maximum Construction Risk Premiums for CACF Facilities by Procurement Method

	ASD + C	Design Competition + DB	DB	DBFM	DBO	BOT	BOO
MINIMUM VALUES							
Total risk percentage	-8.2%	-10.8%	-7.0%	-8.0%	-6.7%	-6.7%	-6.7%
Project Management	-3.9%	-4.2%	-2.9%	-4.0%	-2.6%	-2.6%	-2.6%
Functional	-2.7%	-5.0%	-2.7%	-2.7%	-2.7%	-2.7%	-2.7%
Approval	-1.1%	-1.2%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
Underground conditions	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
Construction	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
Completion	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
MAXIMUM VALUES							
Total risk percentage	55.6%	65.3%	44.1%	54.2%	41.1%	41.1%	41.1%
Project Management	30.1%	32.9%	22.0%	32.1%	19.0%	19.0%	19.0%
Functional	10.8%	17.5%	10.7%	10.7%	10.7%	10.7%	10.7%
Approval	11.4%	11.4%	8.2%	8.2%	8.2%	8.2%	8.2%
Underground conditions	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%
Construction	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Completion	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%

8.3 Table 3 demonstrates that there could be modest cost **savings** (i.e. a reduction of base costs) of around 7% of base costs (minimum risk costs) in the DB case, and slightly more than a 7% saving for other procurement methods which have more Government involvement, and slightly less savings for the private sector methods of procurement. This represents a 30 percentage point reduction in minimum risk over the expected risk. Most of the saving would arise from project management, which emphasises the importance of getting the best quality managers for the project.

8.4 At the other limit (i.e. maximum risk costs) the costs of risks could be increased over the 23% expected cost of risk in the DB procurement method. In the worst case risk scenario, the DB costs could be 44% higher than base costs - a 21 percentage point increase in maximum risk over the expected risk. And likewise, the costs could be substantially greater than base costs for other procurement methods, rising to over 65% above base costs if the design competition approach is used. Costs in these cases arise primarily from the project management classification of risk.

9. Operating Risks

9.1 Estimation of appropriate operating risks for the performing arts venues, the Exhibition Centre and the M+ is based on the same theory but applied in a slightly different way. The key risk in operating a facility is demand risk – the possibility that demand and attendance will be higher or lower than assumed for the base costs. The manner in which such changes in demand are handled are then estimated to differ dependent upon whom is operating the facility – Government, private commercial company or not-for-profit organisation.

9.2 The operating risk premium is calculated as the weighted average of three potential demand outcomes: the base case, a more positive outcome, a more negative outcome, and the relative probabilities of that outcome occurring. The FA has prepared a positive case and a negative case for each facility, which determine the individual cost and revenue line items based on varying assumptions.

9.3 For the performing arts venues, these assumptions reflect possible changes in the utilisation rate, hire charges, attendance, ticket prices, sponsorship, rental and merchandise sales income, and operating costs. The outcome is found to differ considerably between the 15 venues (excluding the tea house type venue), even under quite similar assumptions. Tables 4 and 5 below present the difference in assumptions under the base, optimistic and pessimistic case scenarios for two selected venues. Large venues, the Mega Performance Venue in particular, are particularly sensitive to changes in demand – utilisation, ticket price, hire charges and attendance etc. By contrast, smaller venues are not so sensitive to changes in demand given that the hire charge is often based on basic rates rather than a profit (and risk) sharing arrangement, and that lower utilisation generally means fewer programmes that require subsidy since the savings in programming costs offset the reduction in rental income. The operating risk premium for large performing arts venues is therefore greater than for smaller ones.

Table 4 Assumptions under Base / Optimistic / Pessimistic Cases – Mega Performance Venue (PSI Scenario)

	Base Case	Optimistic Case	Pessimistic Case	
Utilisation Rate	90	95	80	%
Average Ticket Price	$300	$350	$250	per performance
Attendance Rate	72	82	62	%
Basic Rate (per session per seat)	$8	$9	$7	per session per seat
Merchandise Sales				
Average Spending	$175	$175	$145	per person
Rentals				
Cafes / Restaurants (smaller than 500 sq.m.)	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
Cafes / Restaurants (500 sq.m. or above)	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
Retail Shops	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
VVIP Facilities	$6,000	$6,500	$5,000	per sq.m. NOFA per annum
Resident Company Space	$2,000	$2,500	$1,500	per sq.m. NOFA per annum
Sponsorship as % of Earned / Venue Income	6	7	4	%
Cleaning and Security Costs	$208	$229	$187	per sq.m. GFA per annum
Electricity	$281	$309	$253	per sq.m. GFA per annum
Water	$36	$40	$32	per seat

Table 5 Assumptions under Base / Optimistic / Pessimistic Cases – Medium Sized Theatre 1 (PSI Scenario)

	Base Case	Optimistic Case	Pessimistic Case	
Utilisation Rate	82	87	72	%
Average Ticket Price	$150	$200	$100	per performance
Attendance Rate	72	82	62	%
Basic Rate (per session per seat)	$28	$30	$26	per session per seat
Merchandise Sales				
Average Spending	$125	$125	$105	per person
Rentals				
Cafes / Restaurants (smaller than 500 sq.m.)	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
Cafes / Restaurants (500 sq.m. or above)	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
Retail Shops	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
VVIP Facilities	$6,000	$6,500	$5,000	per sq.m. NOFA per annum
Resident Company Space	$2,000	$2,500	$1,500	per sq.m. NOFA per annum
Sponsorship as % of Earned / Venue Income	12	14	7	%
Cleaning and Security Costs	$260	$286	$234	per sq.m. GFA per annum
Electricity	$312	$343	$281	per sq.m. GFA per annum
Water	$36	$40	$32	per seat

9.4 For the Exhibition Centre the relevant assumptions refer to the hire charge discounts for cultural users, the utilisation rates of the different galleries, rental rates for retail space, attendance, clearing and security costs, and public and educational programming costs (see Table 6). Like the large performing arts venues, the Exhibition Centre is quite sensitive to demand and the operating risk premium is therefore fairly high.

Table 6 Assumptions under Base / Optimistic / Pessimistic Cases – Exhibition Centre (PSI Scenario)

	Base Case	Optimistic Case	Pessimistic Case	
Hire Charges				
Gallery 1	37	42	32	per sq.m. per day
Gallery 2	45	50	40	per sq.m. per day
Gallery 3	47	52	42	per sq.m. per day
Gallery 4	57	62	52	per sq.m. per day
Discount for Cultural Uses	30%	30%	40%	
Utilisation				
Utilisation Rate	72%	82%	62%	
Gallery 1 (commercial)	177	212	142	days per annum
Gallery 2 (commercial)	177	212	142	days per annum
Gallery 3 (commercial)	177	212	142	days per annum
Gallery 4 (commercial)	177	212	142	days per annum
Rental of Retail Space	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
Attendance	1,500,000	1,800,000	1,050,000	per annum
Cleaning and security	$300	$330	$270	per sq.m. GFA per annum
Public Programming Costs	$600,000	$350,000	$750,000	per annum

9.5 For M+ the relevant assumptions refer to the attendance, hire charges, sponsorship, public and educational programme revenue, rental and other income, and cleaning and security costs (Table 7). The operating risk of M+ is low given its self generated income only covers a small proportion of operating costs.

Table 7 Assumptions under Base / Optimistic / Pessimistic Cases – M+ (Phase 1, PSI Scenario)

	Base Case	Optimistic Case	Pessimistic Case	
Total Attendance	1,500,000	1,800,000	1,050,000	per annum
Hire Charge per engagement	$7,000	$8,400	$4,900	per hire
Food Service Concession Rental	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
Retail Shop Rental	$4,000	$4,500	$3,000	per sq.m. NOFA per annum
Public Programme Revenues	$5,000,000	$6,000,000	$3,500,000	per annum
Fundraising - Special Events	$20,000,000	$24,000,000	$14,000,000	per annum
Other Income	$4,000,000	$4,800,000	$2,800,000	per annum
Cleaning and security	$300	$330	$270	per sq.m. GFA per annum

Exhibit 1: Risk Analysis: Calculation of Expected Values of Risk (Design and Build Procurement Option)

Stage	Activities	Possible Risk	Category of Risk	Risks/Changes	Possible Consequences	Probability of Occurrence			Possible Consequence(% of estimated cost)			Expected % Value of consequence	Cost Assumption	Expected Value of Consequence ($m) = (Expected % Value) x (Cost Assumption)	Expected Value of Consequence (as % of total construction costs of $17,699 m)	Possible Mitigation Measures
						Low	Medium	High	Min.	Most Likely	Max.					
Design	Appointment of Consultants	1. Appointment by Design Competition 2. Direct Employment	Project Management Risk	1. Consultants not being able to handle (design and supervise) this type of project	1. Difficult to assess buildability based on preliminary designs produced at the tendering stage 2. Consultants who are able to produce good designs may not be good project administrators		***		-2.00%	3.50%	8.00%	2.700%	construction cost for art & cultural works	338.61	1.9131%	
	Inception and Scope Development	1. Change of scope 2. Project feasibility	FunctionalRisk	1. Change of GFA 2. Change of functional use of space (symphony to orchestra, etc)	1. Government has fixed this.	***			-5.00%	10.00%	15.00%	4.000%	construction cost for all works	707.96	4.0000%	1. Feasibility Study 2. Study the user demand.
					2. Suit the market and the technology			***	-0.50%	10.00%	15.00%	8.950%	construction cost for fitting out cost (= 30%) of art & cultural works	336.73	1.9025%	
	Master Layout Plan	1. Change of OZP 2. Impact assessment study 3. Gazette	Approval Risk	1. Disapproval	1. Delayed by 6 months			***	-0.30%	1.00%	2.00%	0.920%	construction cost for all works	162.83	0.9200%	
	General Building Plan	1. Building Department Approval	Approval Risk	1. Disapproval	1. Delayed by 2 months		***		-0.15%	0.15%	0.30%	0.105%	construction cost for all works	18.58	0.1050%	
	Site Investigation	1. Deviation of founding strata	Underground Condition risk	1. Deeper bedrock	1. Deeper foundation 2. Friction Pile			***	-1.00%	10.00%	15.00%	8.900%	construction cost for founation cost (= 20%) of all works	315.04	1.7800%	
	Foundation Plan	1. BD and GEO approval of Plan 2. Pre-drilling 3. Loading test 4. Post-drilling 5. Report completion	Approval Risk	1. Disapproval	1. Delayed by 2 months	***			-0.15%	0.15%	10.00%	1.030%	construction cost for all works	182.30	1.0300%	
	Super-structural Plan	1. BD approval	Approval Risk	1. Disapproval	1. Delayed by 2 months	***			-0.15%	0.15%	0.30%	0.060%	construction cost for all works	10.62	0.0600%	
	Drainage Plan	1. BD approval	Approval Risk	1. Disapproval	1. Delayed by 2 months	***			0.00%	0.00%	0.00%	0.000%	usually will not affect the overal programme	0.00	0.0000%	
	Curtain Wall	1. BD Approval 2. Design wind load (wind tunnel test) 3. Safety test for consent	Approval Risk	1. Disapproval	1. Delayed by 2 months	***			0.00%	0.00%	0.00%	0.000%	usually will not affect the overal programme	0.00	0.0000%	
Review	Specialist Works	1. Approval by relevant Authorities	Functional Risk	1. Disapproval	1. Delayed by 2 months	***			-0.15%	0.15%	0.30%	0.060%	construction cost for all works	10.62	0.0600%	
Tender	Tender Preparation	1. Change of scope 2. Construction period3. Form of contract (D&B and Conventional)	Project Management Risk,Completeness Risk	1. Changes of scope 2. Wrong construction period 3. Wrong form of contract	1. Re-tender 2. Non-compliance in tender return	***			-1.00%	10.00%	15.00%	4.400%	increase in construction cost for all works	778.76	4.4000%	
	Invitation & Return	1. Construction climate (nos. of competent contractors)	Project Management Risk	1. Wrong Contractor	1. Re-tender 2. Non-compliance in tender return	***			-1.00%	2.00%	4.00%	0.900%	increase in construction cost for all works	159.29	0.9000%	
	Assessment and Award	1. Correct assessment 2. Timely award of contract	Project Management Risk	1. Wrong award	1. Delay, poor quality and claim		***		-1.00%	7.50%	10.00%	5.400%	increase in construction cost for all works	955.75	5.4000%	
Construction	Site Investigation	1. Possible founding stratum variation	Completion Risk,Quality Risk,Safety RiskBudget	1. Deviation from the design	1. Amendment of the design 2. Increase the foundation cost and construction time		******		0.00%	0.00%	0.00%	0.000%	included in item "Site Investigation" above		0.0000%	
	Foundation	1. Delay of construction 2. Change of design	Completion Risk,Quality Risk,Safety RiskBudget	1. Delay of construction 2. Failure of the pile test	1. Acceleration by contractor 2. Additional Piles	***			0.00%	0.00%	0.00%	0.000%	included in item "Site Investigation" above		0.0000%	
	Superstructure	1. Delay of construction 2. Change of design	Completion Risk,Quality Risk,Safety RiskBudget	1. Delay of construction	1. Acceleration by contractor 2. delayed one month	***			-0.15%	0.15%	0.30%	0.060%	construction cost for all works	10.62	0.0600%	
	Curtain wall	1. Delay of construction 2. Change of design	Completion Risk,Quality Risk,Safety RiskBudget	1. Delay of construction	1. Acceleration by contractor	***			0.00%	0.00%	0.00%	0.000%	will not affect the overal programme	0.00	0.0000%	
	Services	1. Delay of construction 2. Change of design	Completion Risk,Quality Risk,Safety RiskBudget	1. Delay of construction	1. Acceleration by contractor	***			0.00%	0.00%	0.00%	0.000%	will not affect the overal programme	0.00	0.0000%	
	Fitting-out	1. Delay of construction 2. Change of design	Completion Risk,Quality Risk,Safety RiskBudget	1. Delay of construction	1. Acceleration by contractor	***			0.00%	0.00%	0.00%	0.000%	will not affect the overal programme	0.00	0.0000%	
	Report Completion	1. Non-compliance of the statutory requirement	Approval Risk	1. Failure of OP inspection	1. Delay by one month		***		-0.15%	0.15%	0.30%	0.105%	construction cost for all works	18.58	0.1050%	
	Testing and Commissioning	1. Non-compliance of the statutory requirement	Approval Risk	1. Failure of OP inspection	1. Delay by one month		***		-0.15%	0.15%	0.30%	0.105%	construction cost for all works	18.58	0.1050%	
	Occupation Permit	1. Non-compliance of the statutory requirement	Approval Risk	1. Failure of OP inspection	1. Affect the operation of facilities - delayed one month		***		-0.15%	0.15%	0.30%	0.105%	construction cost for all works	18.58	0.1050%	
	DLP	1. Breakdown of major equipments	Approval Risk	1. Defects identified	1. Affect the Operation - delayed one month	***			-0.15%	0.15%	0.30%	0.060%	construction cost for all works	10.62	0.0600%	
Interior	Exhibits	1. Set up of the exhibits	Construction risk	1. Exhibits delay	1. Affect the operation - delayed one month		***		-0.15%	0.15%	0.30%	0.105%	construction cost for all works	18.58	0.1050%	
Operation	Operation (50 years)	Structural repair (20 years and every 7 years)	Operation Risk	1. Concrete Spalling	1. Repair of concrete and assume no effect on operation	***						0.000%			0.0000%	
		MEP repair (15 Years)	Operation Risk	1. Major equipment broken down	1. Repair of equipment .and assume no effect on operation	***						0.000%			0.0000%	
		Fitting out repair (10 to 15 years)	Operation Risk	1. Damage of ceiling, cladding etc.	1. Repair and assume no effect on operation	***						0.000%			0.0000%	
		Curtain wall Repair (15 years)	Operation Risk	1. Broken of glass	1. Repair and assume no effect on operation	***						0.000%			0.0000%	