MINISTRY OF PUBLIC WORKS AND TRANSPORTS

Action Plan for Bridge Maintenance Cycle

October 2017

Version 1

GENERAL DIRECTORATE OF TECHNIQUES

ROAD INFRASTRUCTURE DEPARTMENT, MPWT

ISSUE AND VERSION RECORD

VERSION	DATE	RECORD	APPROVED by
Version 1	October 2017	1st Edition	Mr.Chhim Phalla Director, Department of Road Infrastructure

DIRECTOR ORDER

ON

Action Plan for Adoption of Bridge Maintenance Cycle

Bridges crossing rivers are the most fundamental infrastructure that supports the people's lives and socioeconomic activities, spread to develop all over the road in Cambodia.

If the bridge is damaged severely on the structural members, it will be high cost and take much time to manage it. Furthermore, while implementing the repair/replace work, the impact such as traffic congestion and environmental issue are immeasurable.

The Department of Road Infrastructure (RID) of the Ministry of Public Works and Transport (MPWT) has a responsibility avoiding serious incidents such as falling bridges through proper bridge inspection and maintenance work and provide citizens good conditioned bridges.

The RID has drafted the Action Plan for Adoption of Bridge Maintenance Cycle that describes the bridge inspection and maintenance works systematically.

This document also mentions the purpose of the bridge inspection and maintenance work, the roles of each department, and the flow of basic tasks.

Based on the draft Action Plan, RID shall implement the bridge maintenance cooperated with the related departments.

Phnom Penh, 5 October 2017

Chhim Phalla

Director, Department of Road Infrastructure

The Ministry of Public Works and Transport

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Action plan for Bridge Maintenance Cycle Implementation
(Draft August 2017)

1 Objectives of the Action Plan

This action plan is to define actions to be taken to implement bridge maintenance cycle.

2 Bridge Maintenance Cycle

The concept of Bridge Maintenance Cycle to implement is shown in Figure 1.

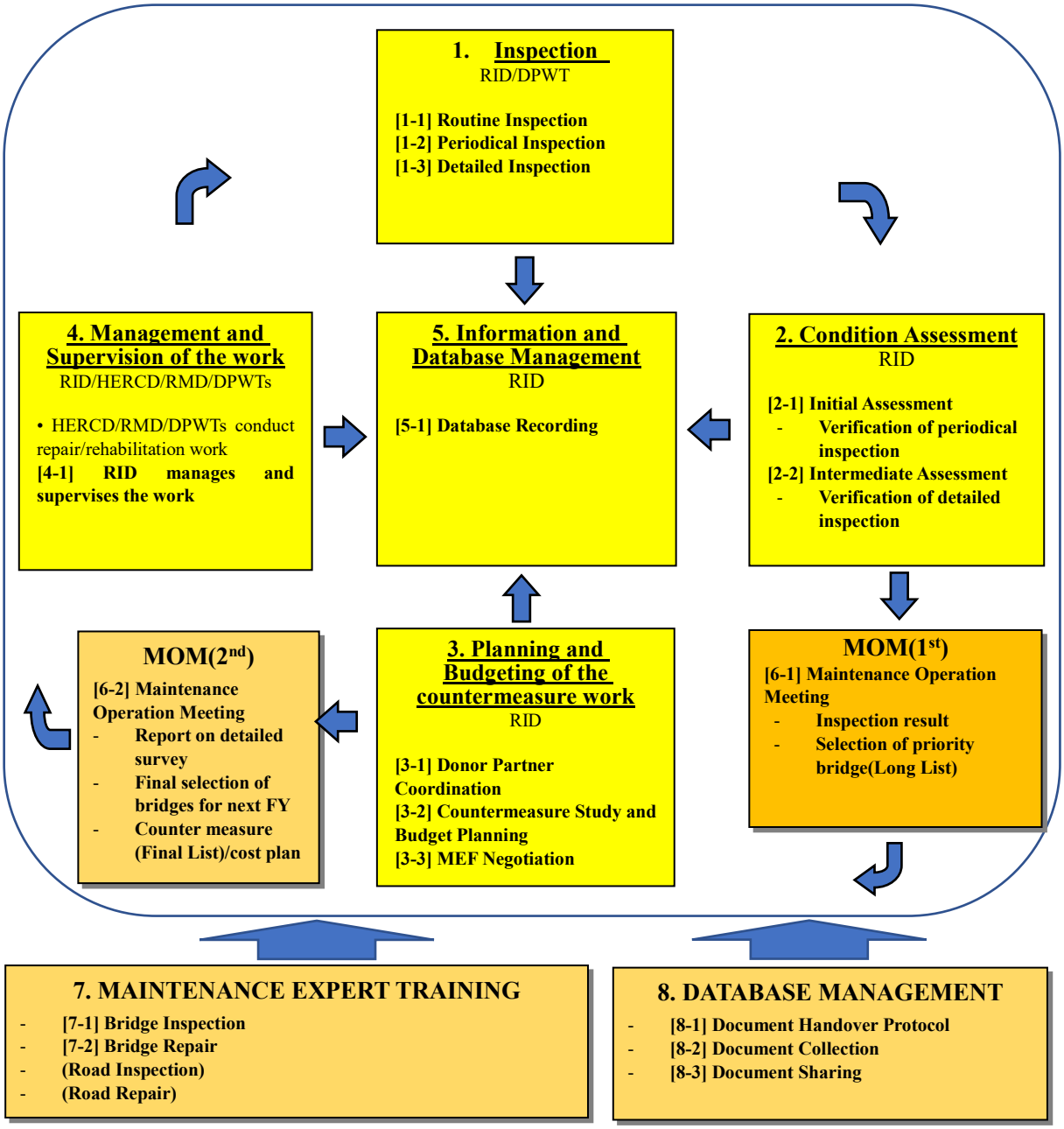


Figure 1 Concept of Bridge Maintenance Cycle

3 Action Plan

Action plan to implement the bridge maintenance cycle continuously is hereinafter explained. The organizational structure, function and principles for bridge maintenance are described in Appendix 1 Institutional Framework for Bridge Maintenance.

3.1 Bridge Inspection

(1) Action to take

[1-1] Routine Inspection: Conducting Routine Inspection of bridges along with road inspection.

[1-2] Periodic Inspection: Conducting Periodic Inspection of selected bridges of the year (inspect all bridges through 5 years (= approximately 450 bridges per year)

[1-3] Detailed Inspection: The detailed bridge inspection is to be conducted for the selected bridges (approximately 5 to 10 bridges per year) from Periodic Inspection result in the 1st Maintenance Operation Meeting (MOM).

(2) Implementer

RID Bridge Inspection Team

Support from DPWT

3.2 Condition Assessment

(1) Action to take

[2-1] Initial Assessment: Review and evaluation of the periodic inspection result. The evaluation result will be verified in 1st MOM. Prepare long list.

[2-2] Intermediate Assessment: Assessment of detailed survey result. Select priority bridge to prepare short list.

(2) Implementer

RID

ME (Maintenance Expert)

3.3 Planning and budgeting

(1) Action to take

[3-1] Donor Partner Coordination: Coordination with donor fund project and reflect to short list.

[3-2] Counter measure study and budget plan: Study counter measure based on the detailed survey and prepare budget plan. Prepare the Final List.

[3-3] MEF Negotiation: with MEF for the select target bridges for next fiscal year (FY 2018) using inspection result.

(2) Implementer

RID

ME

DPWT

3.4 Management and Supervision

(1) Action to take

[4-1] Supervision of Works: Supervision of the work by DPWT

(2) Implementer

RID

ME

DPWT

3.5 Information and Database Management

(1) Action to take

[5-1] Record the inspection result into the database

- Update of database
- Provision of data to DPWTs

(2) Implementer

RID

ME

3.6 Maintenance Operation Meeting (MOM)

Function of MOM is attached in **Appendix 2**

(1) Action to take

[6-1] 1st MOM

- Inspection result
- Selection of priority bridge (Long List)

[6-2] 2nd MOM

- Report on detailed survey
- Final selection of bridges for next FY (Final List)
- Counter measure/cost plan

[6-3] Monitoring Meeting

- Verification of intermediate assessment
- Donor partner coordination
- Preparation of Short List

(2) Implementer

RID

ME

(DPWT)

3.7 Maintenance Expert Training

Concept paper of maintenance expert is in **Appendix 3**.

(1) Action to take

[7-1] Maintenance Expert Training for Bridge:

To conduct training of Maintenance Expert to RID and DPWT officials on the bridge maintenance

[7-2] Maintenance Expert Training for Road:

To conduct training of Maintenance Expert to RID and DPWT officials on the road maintenance

Training of Master Trainers

(2) Implementer

RID

ME

DPWT

3.8 Database Management

(1) Action to take

[8-1] Management of the Database

Management of the Bridge Database, Roads Database and Document Database

[8-2] Data Collection

Collection of the contract documents of past project, especially donor fund projects

Add and update the database

[8-3] Server management

Setting of server and its maintenance.

(2) Implementer

PMU, other department implemented the construction

RID

4 Implementation of Action Plan

Roles of Office in RID is shown in Figure 2.

Member of ME is shown in Appendix 4.

Check list of action plan is shown in Appendix 5.

Implementation schedule of action plan is shown in Figure 3.

Roles for implementation of Annual Roads and Bridges Maintenance Action Plan
(Referred to Prakas No 206: The Functions of RID)

Table 1 Actions –RID Offices

Actions	Primary responsible offices of RID	Related Departments
1. Inspection	RPT Office, RBM Office, RRM Office	DPWT
2. Condition Assessment	RPT Office, RBM Office, RRM Office	DPWT
3. Planning and Budgeting	RPT Office, RRM Office, RBM Office	DPWT
4. Management and Supervision of the work	RPT Office	DPWT
5. Information and Database Management	RPT Office, RRM Office, RCR Office	PWTTD
6. Maintenance Operation Meeting	RID Director,	DPWT
7. ME Training	RPT Office	ITVP
8. Document Management	RPT	

Table 2 RID Offices-Actions

Offices of RID	Actions	Responsible Person
RPT (Road Planning and Technical Office)	• Maintenance Operation Meeting • ME Training • Document Management	Director of RID
RRM (Road Routine Maintenance Office)	• Planning and Budgeting, • Management and Supervision of the Work, • Inspection, • Condition Assessment,	
RSE (Road Safety and Environment Office)	•	
RBM (Road Business Management Office)	•	
RCR (Road Construction and Repair Office)	• Information and Database Management	
PWTTD (Public Works and Transport Technical Department)	•	
(Related office) ITVP (Institute of Technical Vocation of Public Works and Transport)	• ME Training	

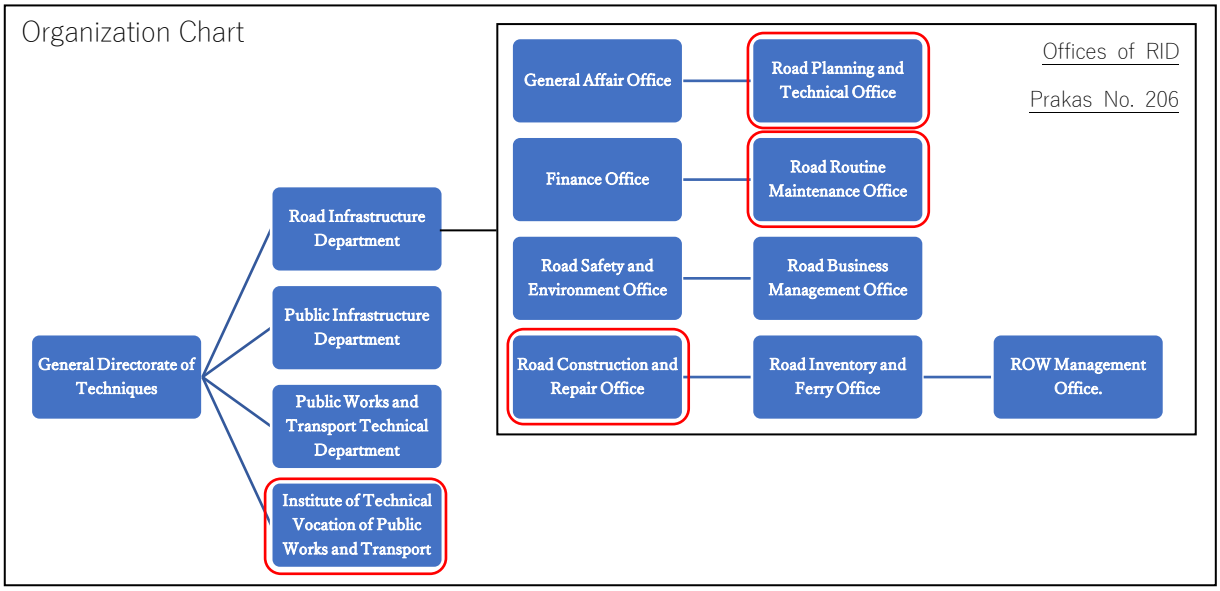


Figure 2 Roles of RID Offices (Draft)

【STANDARD PLAN】

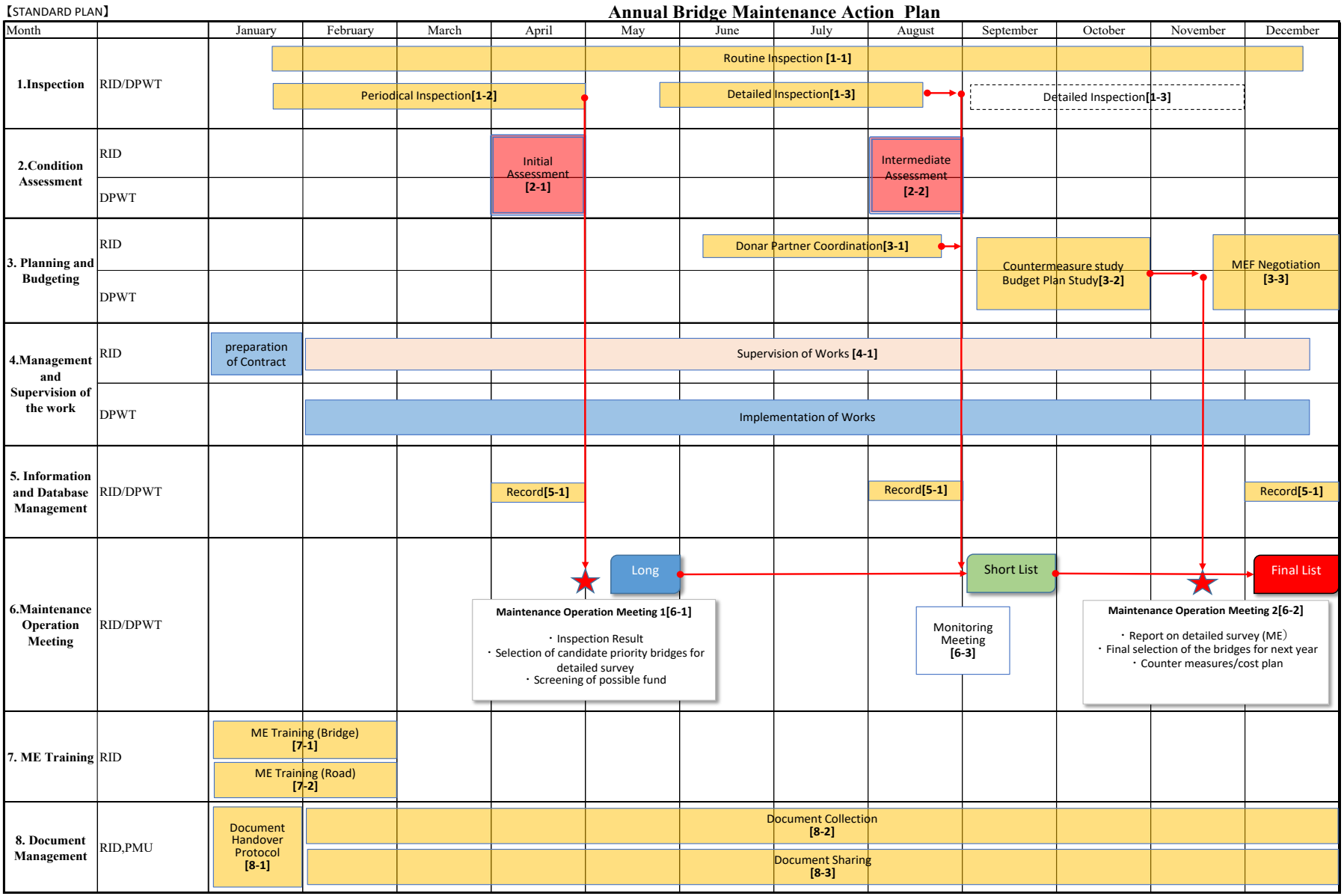


Figure 3 Annual Schedule of Action Plan (Bridge Maintenance Cycle)

5 List of Appendix

Appendix 1 Institutional Framework for Bridge Maintenance

Appendix 2 Function of Maintenance Operation Meeting (MOM)

Appendix 3 Concept paper of Maintenance Expert (ME) Program

Appendix 4 Check List of the Action Plan

Appendix 5 Database Management System

Appendix 6 List of Maintenance Experts

Appendix 7 Budget Plan

Appendix 1 Institutional Framework for the Bridge Maintenance

Chapter 1

Organizational Structure for Bridge Maintenance and Principal Responsibilities

1.1 Demarcation of Organizational Structure of Maintenance Management

The demarcation of responsibilities on maintenance management of bridges in MPWT is shown in Figure 1.

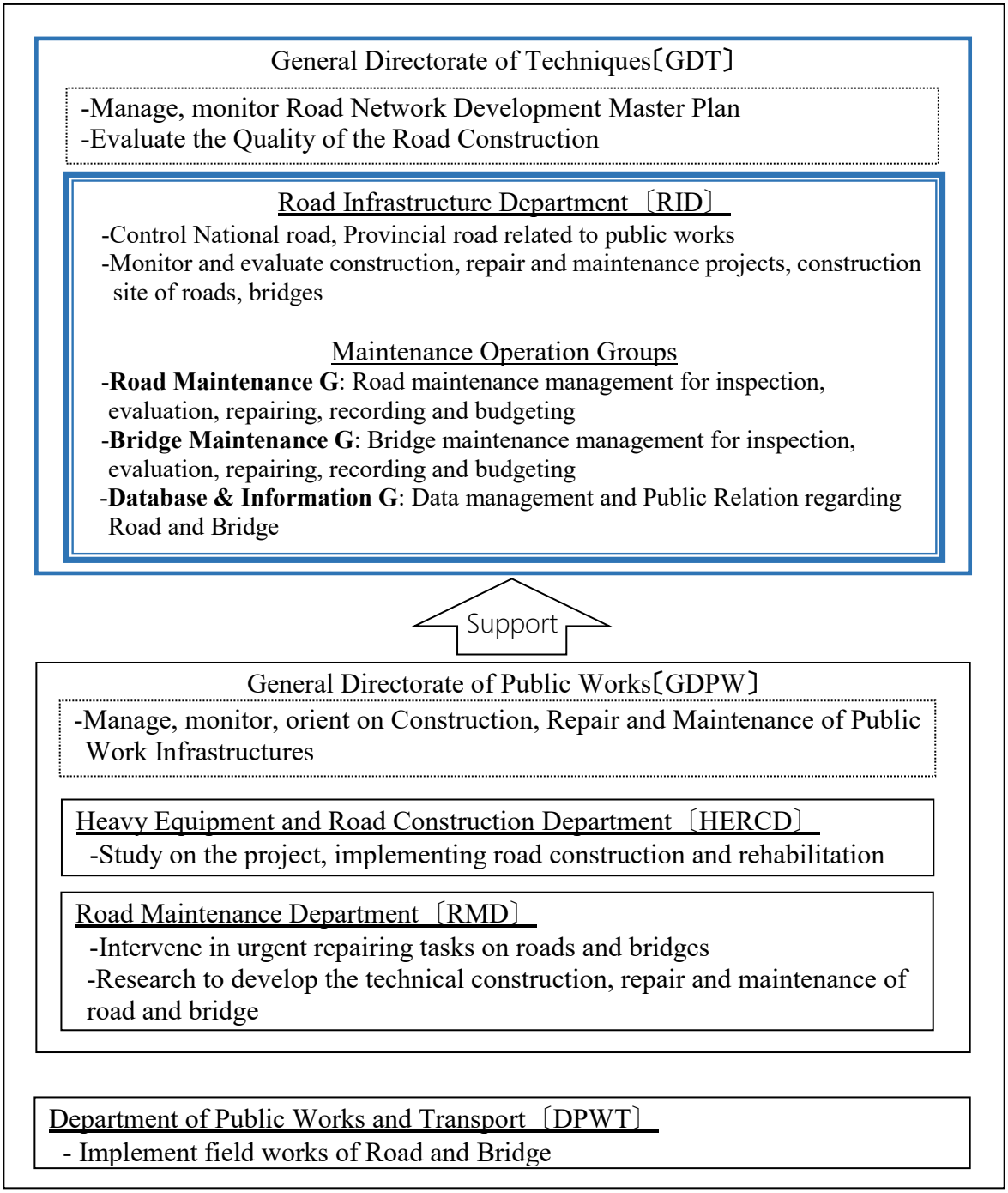


Figure 1 Proposed Demarcation of Responsibilities on Maintenance Management in MPWT

1.2 Departmental Function

(The demarcations written in Bold character are extracted only related to road and bridge maintenance management from original.)

The objective of the maintenance operations is to secure Road and bridge infrastructures which support socio-economic activities in Kingdom of Cambodia.

The relevant departments mentioned below in MPWT are responsible for the objective achievement.

(1) General Directorate of Techniques (GDT)

-Manage and Monitor Road Network Development Master Plan

GDT play a role of the maintenance management through the activities mentioned below.

-Set Targets and objectives of maintenance management.

-Approve the maintenance operations of roads and bridges.

-Approve the budget for maintenance management.

-Cooperate with relevant ministries and departments

(2) Road Infrastructure Department (RID)

-Monitor and evaluate construction, repair and maintenance work.

RID is key Department that is responsible for the maintenance management by implementing these activities mentioned below.\

-Draft Targets and objectives of maintenance management.

-Implement proper maintenance management of roads and bridges.

-Collect data related with maintenance operation and manage the Database.

-Hold maintenance operation meetings.

-Draft and secure the budget for maintenance management.

-Public relations activities

-Cooperate with relevant ministries and departments

(3) Relevant Departments in General Directorate of Public Works (GDPW)

-Manage, monitor, orient on construction, repair and maintenance of public work infrastructures.

Relevant Departments in GDPW collaborate with RID, GDT by implementing maintenance operations mentioned below.

1) Heavy Equipment and Road Construction Department (HERCD)

-Study on the project
-implement road construction and rehabilitation

2) Road and Maintenance Department (RMD)

-Intervene in urgent repairing tasks on roads and bridges
-Research to develop the technical construction, repair and maintenance of road and bridge

3) DPWTs

-Conduct road and bridge inspection supported by RID.

Chapter 2.
Proposed Organizational Function of RID for Bridge Maintenance

RID shall responsible for keeping the road and bridge infrastructures in the Kingdom of Cambodia in a satisfactory state through functions as below.

(1) Setting the Target of 3years and Annual Plan
(2) Holding Maintenance Operation Meetings(MOM) in every April and November.
(3) Controlling the progress of maintenance operation.
(4) Public relation activity
(5) Training on Bridge Maintenance (Maintenance Expert)

(1) Setting the Target of 3years/one year

The bridge maintenance plan is established to set the priority bridge for the coming 3 years. Annual Plan is established accordingly. RID is responsible to establish the bridge maintenance plan and its revision in collaboration with related departments.

(2) Holding Maintenance Operation Meetings(MOM) in every April and November.

RID has the principal responsible to manage the various maintenance operations which includes inspection, assessment, countermeasure work and recording.
Maintenance Operation Meetings(MOM) [1] is the meeting to supervise the bridge maintenance operations and to make decisions on bridge maintenance related plan. RID shall organize the meeting every April and November.

(3) Controlling the progress of maintenance operation.

RID is responsible to control the progress of the various maintenance operations which includes inspection, assessment, countermeasure work and recording by collecting from related Departments in regularly.
Maintenance operation is described in Chapter 3

(4) Public relation activity

RID is responsible for the public relations of the maintenance operation.

(5) Training on Road and Bridge Maintenance

RID is responsible to provide trainings for the bridge maintenance to MPWT technical officials.

[1] To refer draft concept for the Maintenance Operation Meeting (MOM)

Chapter 3.
Principles of Bridge Maintenance Operation

Road and Bridge Maintenance operation is based on five (5) elements as below.

(1) Inspection

(2) Condition assessment.

(3) Planning and Budgeting of the countermeasure.

(4) Management and Supervision of the work

(5) Information and Database Management

The Road Maintenance G and **the Bridge Maintenance G** shall conduct or collect inspection data from the field. Based on collected data and condition assessment, maintenance priority shall be studied as well as estimation of required budget. The countermeasure for the defect (repair methods) is to be studied and to be approved in the Maintenance Operation Meeting(MOM).

The approved countermeasure is implemented by HERCD/RMD/DPWTs under supervising of RID.

The Database & Information G shall be responsible of the update of the database.

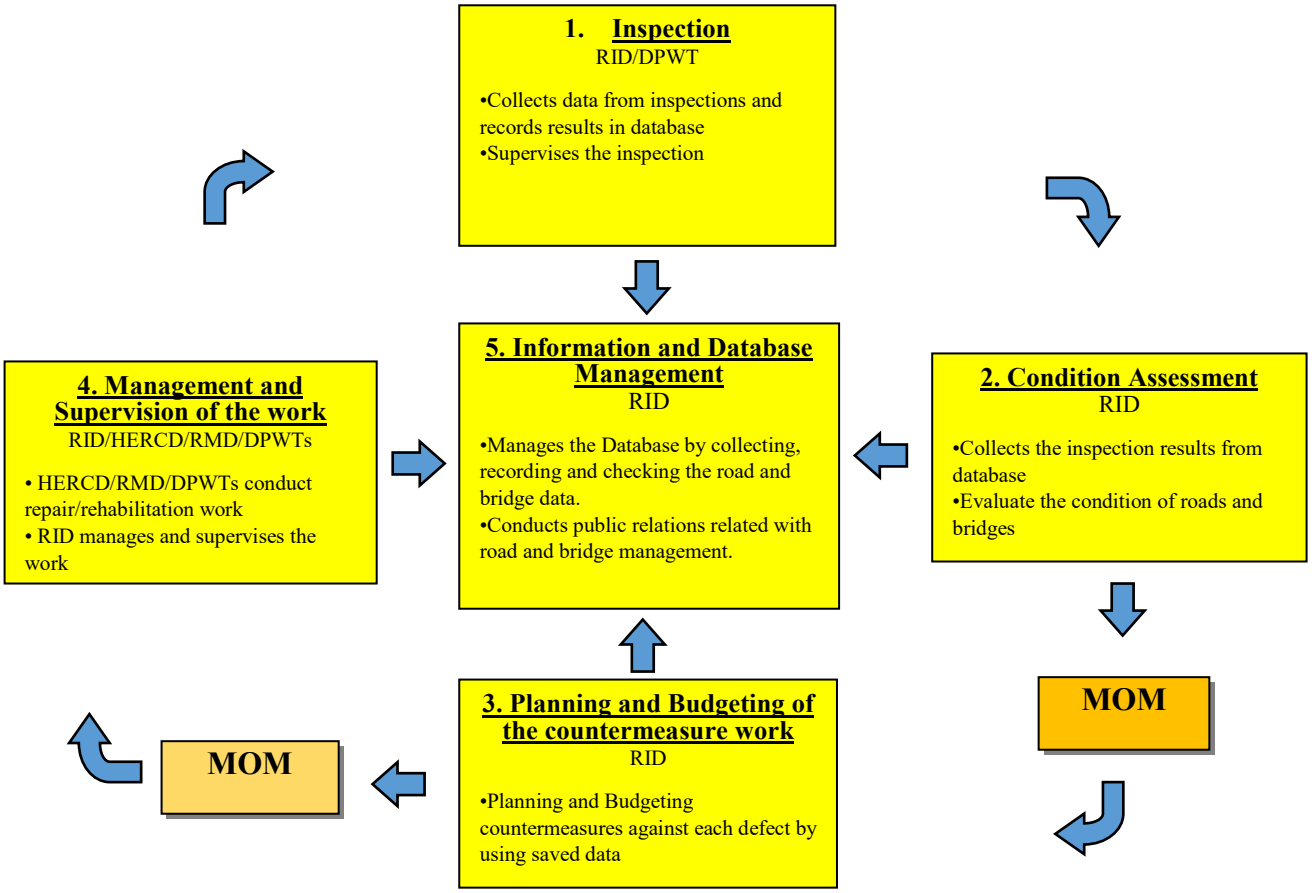


Figure 2 Five (5) Principles of Maintenance Work

(1) Inspection

The purpose of the inspection is to find the defects of the bridge and collect data explaining condition of the defects. The collected data is stored in the Database and used for assessment of the structure soundness. There are three types of inspection below;

[Initial Inspection]

This is the inspection to be applied to the newly constructed bridge or newly handed over bridge to MPWT to collect inventory data as well as to evaluate the initial condition.

RID and DPWTs conduct the initial inspection for/after newly constructed bridge.

[Planned Inspection]

This is the periodical inspection to the predetermined bridges.

RID and DPWTs conduct planned inspection in every five years.

Note: DPWTs executes Inspection with RID's supports.

[Emergency Inspection]

This is the inspection of bridge to be applied to the damages bridges by natural disaster or manmade catastrophe (accidents etc.,). RID and DPWTs conduct the Inspection.

(2) Condition Assessment

The purpose of condition assessment is to verify the state of the damage and draft the countermeasure(s) against the problem.

The condition assessment is implemented in two stages;

1) Primary assessment: implemented by DPWTs officials with RID support. (by visual inspection to report to RID)

2) Detailed assessment: implemented by the Maintenance Expert (ME) in RID in collaboration with HERCD/RMD.

RID has a responsibility for the assessment result. HERCD and RMD assist the condition assessment by advising to RID.

(3) Planning and Budgeting of the Countermeasure(s)

RID/HERCD/RMD shall study the effective countermeasure(s) for recover the function of the structure and submit the condition assessment result and proposed countermeasure(s) to MOM. The MOM studies the plan in order to request to the management class decision in MPWT.

RID collects the approved countermeasures for each structure and draft a three-year maintenance plan in consideration with soundness, cost, location and total cost of the maintenance operations.

(4) Management and Supervision of the Work

RID shall provide supervision service to the work done by HERCD/RMD/DPWTs. works. RID shall confirm the completion of the work as planned for the handover and collect data related with the work to record in the Database.

(5) Information and Database Management

Database & Information G is responsible for the management of the database system. All relevant departments are mandated to provide timely accurate data to the **Database & Information G**. The collected data are used for further maintenance operations and budgeting.

Chapter 4.
Function Matrix

Table 1 Departmental Function in Five Element

Required Task	DPWT	HERCD/RMD	RID	Remarks
1. Inspection				
(1) Planning inspection	Discuss the plan with RID		Planning inspection (Type, Area, methodology, Cost, etc.)	(January)
(2) Conduct inspection -Initial inspection -Routine inspection -Periodic inspection -Emergency inspection	Conducts inspection		Conducts inspection and support DPWT	RID/DPWT conduct inspection. From Mar. to Dec.
(3)Record inspection data			-Collect the inspection data (bridge data, location, defects, other info.) -Save data to Database	

Required Task	DPWT	HERCD/RMD	RID	Remarks
2. Condition Assessment				
(1) Preparation			-Collect inspection data from Database	
(2) Primary Assessment	Implement primary assessment supported by RID	Assist RID's support	Implement primary assess with DPWT	DPWT/RID implement primary assessment by using inspection data.
(3) Final Assessment	Discussion with RID for determine counter measure(s)	Discussion with RID for determine counter measure(s)	Maintenance Expert (ME) implement final assessment and draft counter measure(s)	4 times/ year Once/every quarter

Required Task	DPWT	HERCD/RMD	RID	Remarks
3. Planning and Budgeting of the Countermeasure(s)				
(1) Preparation			- Collect inspection data from Database -Select SD, D ranked bridge	
(2) Planning countermeasure(s)		Support RID's study	Study the state of the structure and draft countermeasure(s) to recover the function of the SD, D bridges	
(3) Cost estimation			Estimate the rough cost of the countermeasure(s)	Through MOM Twice a year
(4) Get approval from high class officials in MPWT		Support RID's submission	Submit the draft counter-measure(s) and rough cost to get approval of high class officials through the meeting in MPWT	
(5) Budgeting			Prepare budgeting document to submit MEF and arrange budget meeting with MEF Negotiate with MEF for budgeting	

Required Task	DPWT	HERCD/RMD	RID	Remarks
4. Management and Supervision of the Work				
(1) Preparation			-Prepare tendering documents	
(2) Repair work etc.	Implement field works	HERCD: Implement rehabilitation works RMD: Implement repair and maintenance works	Supervise the works	In case of difficult and high tech. work, HERCD/RMD supports DPWT
(3) Collect the data of the works	Submit the data to Bridge G, RID	Submit the data to Bridge G, RID	Bridge G, RID collects the data and check them. (After checking them, the data are submit to Database G, RID	

Required Task	DPWT	HERCD/RMD	RID	Remarks
5. Information and Database Management				
(1) Database management			Database G, RID is in charge of Database management such as collect, check, save(update) of the data	
(2) Public relation			Database G, RID plans the RID's public relation through selecting targets, making the publication material	

Appendix 2 Function of Maintenance Operation Meeting (MOM)

1. Position of this ministerial ordinance	This ordinance is applied to bridge maintenance in the Kingdom of Cambodia.
2. Objective	This ordinance is set to contribute to socio-economic activity with appropriate inspection, maintenance and budgeting of bridges in the Kingdom of Cambodia.
3. Definition of terms	
Maintenance operation	This term means a series of activities including maintenance plan, inspection, evaluation, repairing, supervision and recording, budgeting.
Maintenance Operation Meeting (MOM)	This term means periodical meeting about maintenance operations in the Kingdom of Cambodia.
4. Development of maintenance plan	RID is responsible to develop the maintenance plan of next year including setting targets, inspection plan, maintenance plan and budgeting in December .
Maintenance plan	This plan states targets and activities of maintenance operation of the next year. The items shown below are included. A) Targets; Ministerial strategy and 3 year plan B) Annual action plan for inspection and maintenance plan; Activities/ Methodology C) Budget plan; the amount of approximate budget (3 years and annual)
5. Maintenance Operation Meeting (MOM)	MOM shall be held twice a year with following objectives.
5.1 1st MOM	
Objective	This meeting is to be held after preparation of result on periodical bridge inspection. Objectives are; 1) To check inspection progress 2) To check inspection result 3) To select candidate priority bridges for detailed survey 4) Screening of possible fund (national/ donor partner, others)
MOM chairperson	Director of RID
Secretariat	RID
Participation organizations	Maintenance Experts (MEs) DPWT and other organizations and individuals appointed by the chairperson.
Frequency and time	April or May

5.2 2nd MOM

Objective	This meeting is to be held after preparation of result of detailed survey/ intermediate condition assessment and counter measure plan. 1) To report detailed survey result 2) To agree final list of bridges for next FY. 3) To conquer countermeasures to be taken for the selected bridges 4) Screening of possible fund (national/ donor partner, others)
MOM chairperson	Director of RID
Secretariat	RID
Participation organizations	Maintenance Experts (MEs) DPWT and other organizations and individuals appointed by the chairperson.
Frequency and time	November

6. Inspection/Recording

Objective	To confirm the damage situation identified and soundness of bridges, Periodical inspection is implemented.
Inspection equipment	Inspection equipment are given
Inspector	Inspectors are selected from follows in principal. ・RID officials ・Other MPWT officials ・Related DPWT officials
Inspection method	Inspection methods are described in the Bridge Inspection Manual.

7. Evaluation

Objective	To evaluate the defects on the bridges and to determine future measures taken by analyzing the causes of damages identified by inspection
Evaluator	Evaluator is a person to evaluate damages of bridges from a technical point of view. RID officials appointed by MOM chairman takes this position.
Damage evaluation criteria	Damages are classified into SD (serious damage), D(damage) and O(observation) depending on degree of the damage.
Evaluation method	Evaluation method of damage is basically by two phases of following evaluation.
Primary Evaluation (PE)	Evaluators classify all identified damage in SD and D and O depending on its degree and consider policies including implementation schedule.
Study and determine the counter measures(CM) for each defect.	Items should be considered. A) Type of CM

B) When will be conducted
C) Who will conduct
D) How will it be conducted
E) How much to conduct

Secondary Evaluation (SE) — High class officials approve the evaluation results and the counter measures reported by PE members.

8. Repair work/Recording

Objective — To improve the function of structures lost by damage with reinforcement and substitution .

Repair method — Repair methods are described in the Bridge Repair Manual.

9. Budgeting

Objective — to set up budget allocation of inspection, maintenance and related work

Target (Project and Budget Target) — To coordinate with other sector and related infrastructure, This includes the assessment of economic trend, existing infrastructure and Ministerial strategy,
then setting up overall project and budget strategy.

3 year strategic plan — In order to effective budget plan and smooth negotiation with MEF, this includes structural damage evaluation, maintenance priority, repair volume and cost
for 3 years long list of bridge.

Budget Plan — This includes annual budget plan for inspection, maintenance and repair/ replace plan.

10. Overall maintenance management

Objective — To manage the progress of maintenance operations by holding MOM with related departments under MPWT.

Appendix 3 Concept Paper of Maintenance Expert (ME) Program

（Objective）

Article 1 This is created for better and sustainable maintenance for road and bridges under MPWT. This is to set a training program for education of Maintenance Experts in charge of road and bridges which contribute to raise the status of the engineers, providing clear requirement for maintenance work and improve quality of maintenance of road and bridges.

（Requirement of ME applicants）

Article 2 ME applicants need to meet requirement mentioned below;

Employee of MPWT or DPWT

Anyone who has approval from MWPT

（Category of ME）

Article 3 Category of ME is defined as table below;

ME Master Trainer	Decision making. Identification of bridges damage, judgement of severity, ranking evaluation and recommendation for repair method
ME	Capable to inspect bridges in accordance with MPWT's standard

（Certification and examination）

Article 4 MPWT (or RID) conduct training program and examination to certify ME.

2. Execution of ME system is under the responsibility of MPWT－Road Infrastructure Department.

（Recognition of ME certificate）

Article 5 MPWT set "Committee for certification of Road and Bridge Maintenance Expert" within MPWT.

2. Secretary of the committee is set in MPWT－Road Infrastructure Department.

（Issue of certificate）

Article 6 MPWT (or RID) issue certificate to ME.

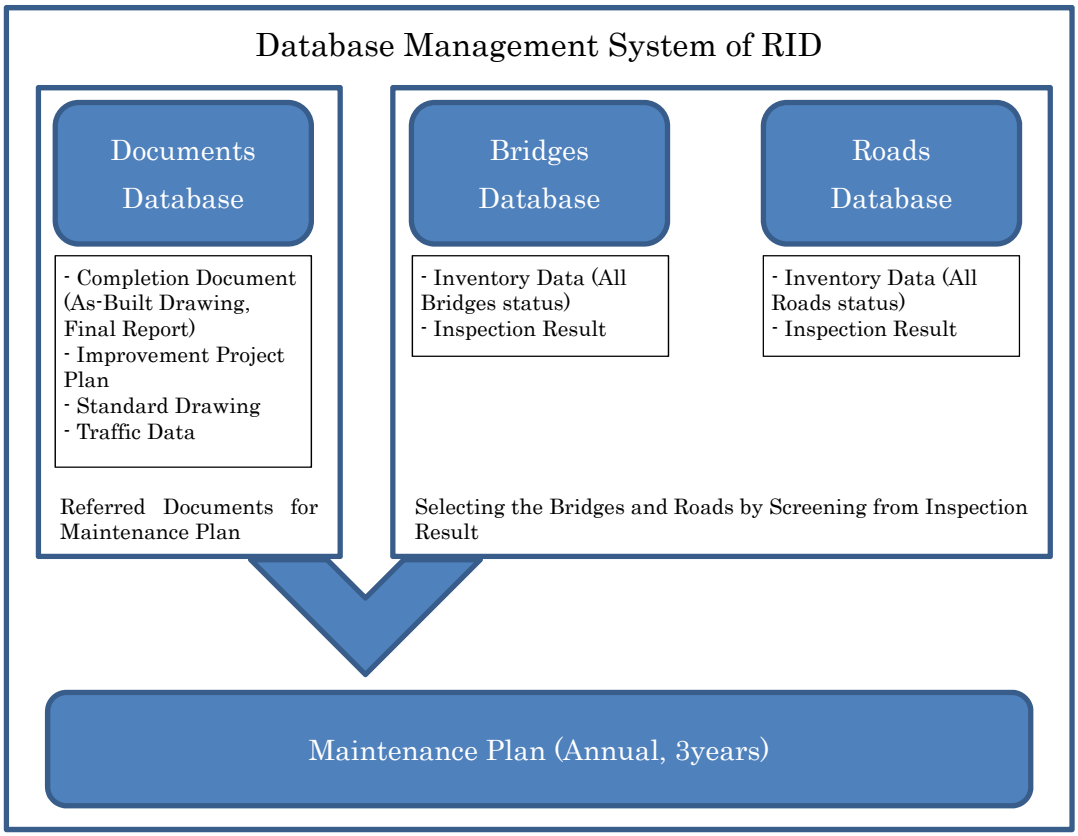
（Others）

Article 7 Any items requires to be specified may be issued separately in other form.

Appendix 4 Database Management System of RID

1. Database Management System of RID

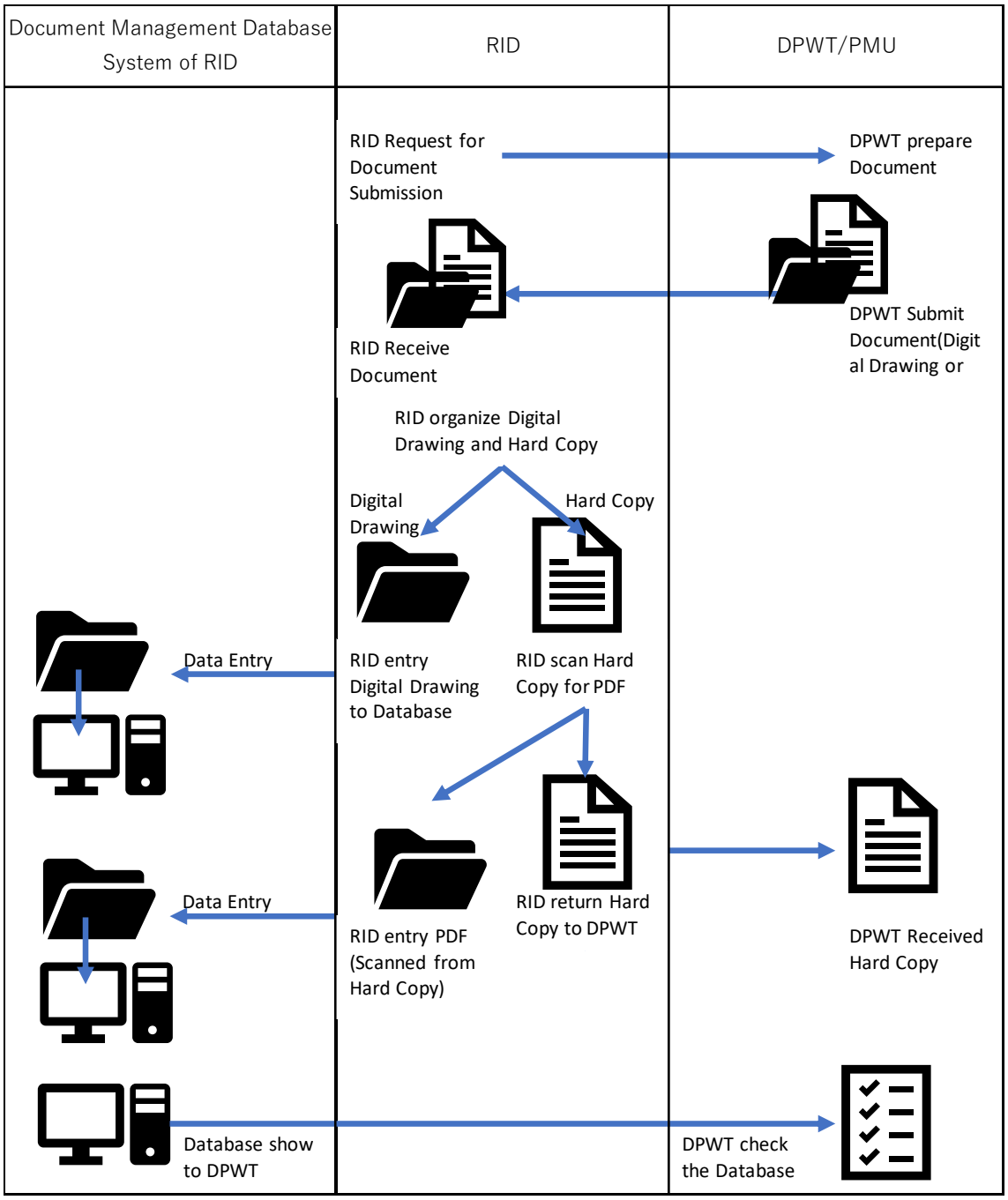
   To conduct Maintenance Cycle for Roads and Bridges as sustainable, RID manages three (3) databases for Roads, Bridges and Documents to store all inventory of Roads and Bridges. Especially, all related documents for Road and Bridge Projects will be digitalized to PDF and stored to Document Management Database System of RID. Also, the maintenance plan as annual and three (3) years will be prepared by RID based on screening from inspection result of Roads and Bridges. After the selection of the Roads and Bridges for the maintenance, related documents in past such as "As-Built Drawing" must be referred for budget planning and maintenance plan. Framework of Document Management System of RID is shown as the following,



2. Document /Data Collection

   All related documents for the maintenance should be collected by RID in cooperation with other Departments and PMUs. Also, RID should have responsible to collect the documents to store the Database. The Workflow of Document collection is the following,

●Workflow of Document collection



3. Database Server Specification and Maintenance

As minimum specification for the Database Server, the size of storage is enough for 1,000GB(=1TB) for document collection. According to the following conditions, the estimation of total data volume for 10 years is almost 280GB. In case the data size will become for double amount,1TB could be covered. However, life cycle of the equipment and OS would be lass than 10 years. Therefore, the replacement of equipment should be considered periodically such short or middle term in order to secure maintenance cost.

●Estimation for Document Data Size

Document Type	Data Format	Estimation Units/year	Data size	
As-Build Drawing	PDF, JPEG	Size A1, 400dpi/page	53.50	MB/page
		20 pages/project,	1,070.00	MB/project
		20 projects/year	21,400.00	MB/year
Project Report	PDF, JPEG	Size A4, 200dpi/page	1.10	MB/page
		200 pages/project,	220.00	MB/project
		20 projects/year	4,400.00	MB/year
Official Letter	PDF, JPEG	Size A4, 200dpi/page	1.10	MB/page
		10 pages/project,	11.00	MB/project
		20 projects/year	220.00	MB/year
Other Documents	Excel, Word	Size A4,	1.00	MB/page
		10 pages/set,	10.00	MB/set
		200 setss/year	2,000.00	MB/year
		Total	28,020.00	MB/year

※100,000MB=100GB=0.1TB

28.0 GB/year

●Server Specification and Cost

	Item	Amount
Initial Cost	Server Equipment (2TB(1TBx2), LAN)	$1,520
	Network setup	$500
	OS Installation Cost (Linux, Open Souce Software)	$100
Annual Cost	Maintenance Cost for Server ($50 x 4times)	$200
	Maintenance Cost for Network(Network Cable and Router Replacament)	$500

Appendix 5 List of Maintenance Experts

Bridge Maintenance Expert

- Mr. Nin Menakak
- Mr. Chea Dara
- Mr. Eam Sovisoth
- Mr. Long Davuth
- Mr. Hou Sovannarith
- Mr. Chheng Gyvorn
- Mr. Mak Sopheap
- Mr. Thou Saovry
- Mr. Chhay Chakriya
- Mr. Mam Sovarn
- Mr. Ros Sreng
- Mr. Chhouk Sochea
- Mr. Va Panha
- Mr. Nop Kilarith
- Mr. Veth Piseth
- Mr. Nut Sovanneth
- Mr. Penh Otdom

Road Maintenance Experts

MT DRIMS
- Mr. Hay Chandara
- Mr. Sitthy Panhavuth

ME (through self training)
- Mr. You Dara
- Mr. Sa Sivutha
- Mr. Veth Piseth

MT Road Repair
- Mr. You Dara
- Mr. Hay Chandara
- Mr. Sitthy Panhavuth

Appendix 6 Check List of the Action Plan

Action to take	Plan		Actual		Remark
	By who	By when	By who	By when	How to check
1. Bridge Inspection					
[1-1] Routine Inspection	RID/DPWT	Every month			Routine inspection form
[1-2] Periodic Inspection	RID/DPWT	end April			iPAD database/ Long List
[1-3] Detailed Inspection	RID/DPWT	end August			iPAD database/ Short List
2. Condition Assessment					
[2-1] Initial Assessment	RID	end April			MOM minutes
[2-2] Intermediate Assessment	RID	end August			Short list
3. Planning and budgeting					
[3-1] Donor Partner Coordination	RID	end August			Monitoring meeting minutes
[3-2] Counter measure study and budget plan	RID/DPWT	end Sep			Short list
[3-3] MEF Negotiation	RID/DPWT	end Dec			Final list
4. Management and Supervision					
[4-1] Supervision of Works	RID	Every month			Inspection report
5. Information and Database Management					
[5-1] Record the inspection result into the database	RID	End April			Database
	RID	End August			Database
	RID	End Dec			Database
6. Maintenance Operation Meeting (MOM)					
[6-1] 1st MOM	RID/DPWT	End April			Minutes/ Long list
[6-2] 2nd MOM	RID/DPWT	End Nov			Minutes/ final list
[6-3] Monitoring Meeting	RID/DPWT	End August			Minutes/ short list
7. Maintenance Expert Training					
[7-1] Maintenance Expert Training for Bridge	RID	January			Training record
[7-2] Maintenance Expert Training for Road:	RID	February			Training record
8. Document Management					
[8-1] Document Handover Protocol	RID.PMU				
[8-2] Document Collection	RID				
[8-3] Document Sharing	RID				

Appendix 7 Budget Plan for Bridge Maintenance under Chapter 61

Required cost to implement bridge maintenance cycle is estimated as below;

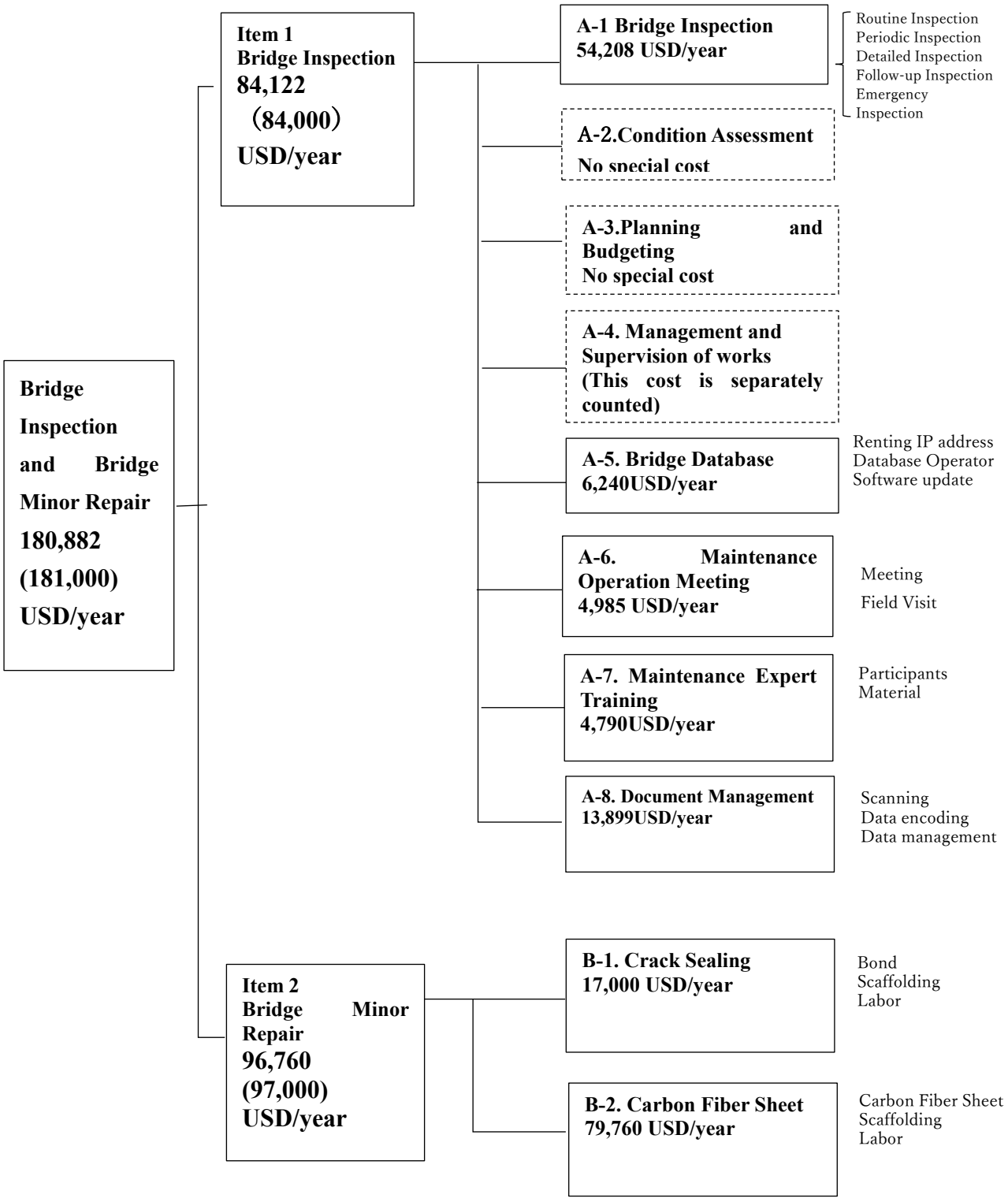


Figure　Cost Components and estimated cost for bridge maintenance cycle

Required cost for Bridge Inspection Works

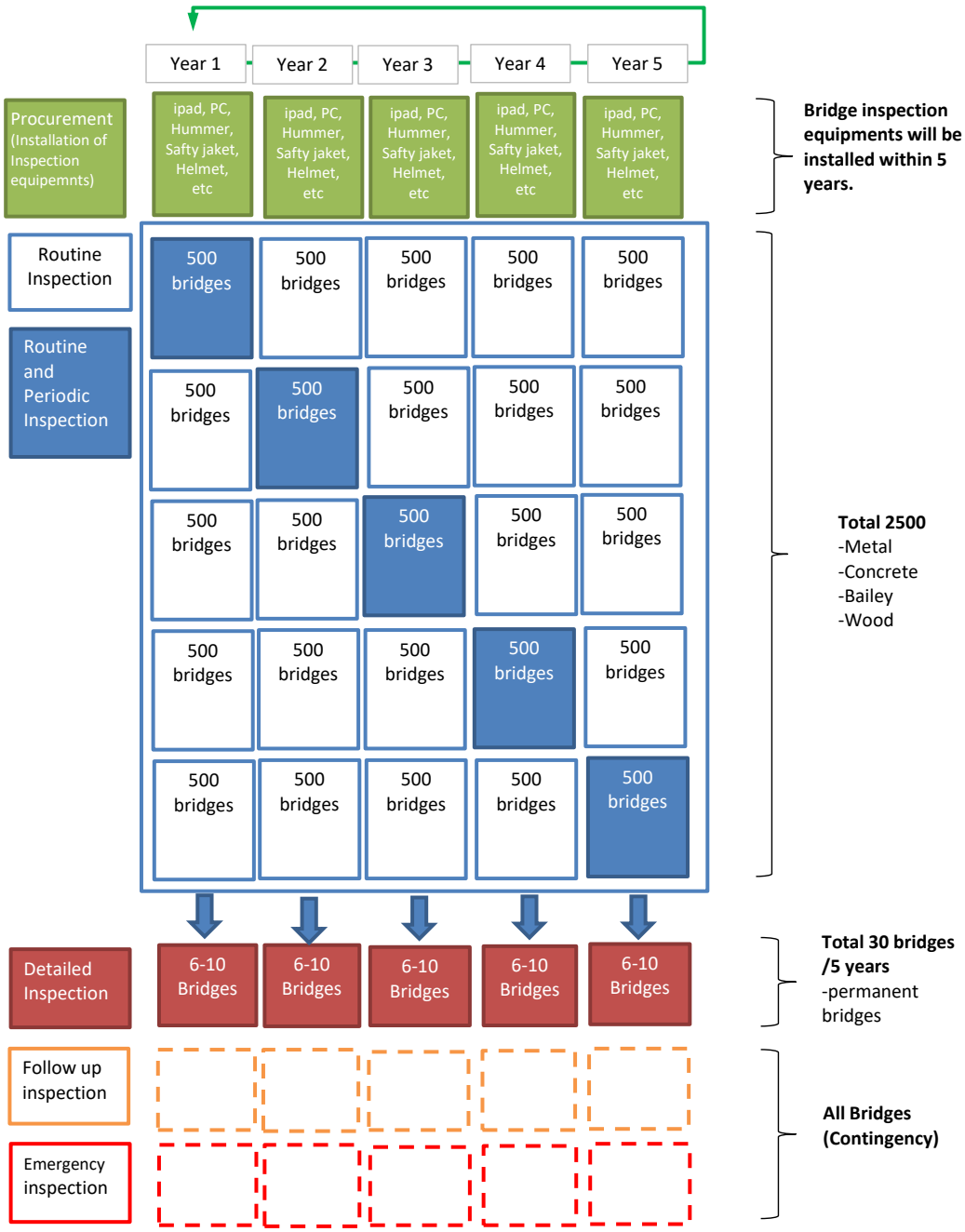
	Action No	Item	Cost Item	Work Description	unit	Cost	Details	Remarks
Bridge Inspection	1	Bridge inspection	Routine Inspection	2300 bridges	USD	24,310		
			Periodic Inspection	460 bridges(5 year routine inspection)	USD	10,816		
			Detailed Inspection	10 bridges (damaged bridges)	USD	8,552		
			Follow-up Inspection	contingency	USD	3,873	A-1	
			Emergency Inspection	contingency	USD	1,937		
			Equipment Procurement	Installation of inspection equipment	USD	4,720		
		Total of 1			USD	54,208		
	2	Condition Assessment						Separete estiamtion
	3	Planning and Budgeting						Separete estiamtion
	4	Management and Supervision of work						Separete estiamtion
	5	Bridge database	Renting server lental	IP address	USD	240		20USD/month
		Database Operator	operator	1 person x 500x12 months=6000 USD	USD	6,000		IT
		Upgrade of Filemaker	soft update		USD		A-2	unitil 21 Oct 2018, all software is under su-pport serveice
								from 22 Oct 200 USD for File Maker Pro and 1600USD for File Maker Server
		Total of 5				6,240		
	6	Maintenance Operation Meeting	Meeting	2 times ME and DPWT	USD	3,475	A-4	April and November
			Field Visit	1 time ME and DPWT	USD	1,510		1 time /year
			Manual Printing	100nos x 15 USD =1500USD	USD	1,500	A-5	25 DPWT x 4 books =100books
		Total of 6		Total	USD	4,985		
	7	Maintenance Experts Training	Training	Bridge Maintenance Expert	USD	4,790	A-3	3 days x 2 times
		Total of 7		Total	USD	4,790		
	8	Document Management		Data collection	USD	7,776	A-6	Initial Cost for 2017
				Operation	USD	6,123		
		Total of 8				13,899		
	7	**Total**				**84,122**		

Required cost for Bridge Minor Repairs

	Action No	Item	Cost Items	Work Description	unit	Cost	Details	Remarks
Bridge Minor Repairs	1	Crack Sealing	Crack bond injection	Crack L=331m (approx 7 bridges)	USD	17,000	B-1	Unit rate 51.4USD/m
								7 bridgesto repair/year
		Total of 1				17,000		
	2	Concrete Surface Reinforcement (CFS)	Carbon Fiber Sheet	One (1) bridge (100m2 asumption)		79,760	B-2	Unit Rate 797.6 USD/m2, 1 bridge repair/year
		Total of 2				79,760		
	3							
		Total of 3				0		
	4							
		Total of 4				0		
	5							
		Total of 5				0		
	6	Total				96,760		

Bridge Inspection	**USD**	**84,122**	
Bridge Repair	**USD**	**96,760**	
Total	**USD**	**180,882**	

A-1 Bridge Inspection Implementation Program and Required Cost



Inspection Type	Nos of bridges	Required cost	Target Br	person day/year	Remark
Procurement of eqipment		4,720 USD			Installation of inspection equipment
1.Routine Inspection	2,500	24,310 USD	All	168	
2.Periodic Inspection	500	10,816 USD	Permanent	120	5 blocks
3.Detailed Inspection	10	8,552 USD	Permanent	34	hummer inspectio, robot camera 10% scaforlding
4.Follow up Inspection	contingency	3,873 USD	All		20% of(2+3)
5.Emergency Inspection	contingency	1,937 USD	All		10% of (2+3)
Total		54,208 USD			

Figure Schematic Image of Bridge Inspection Plan

Cost Estimation of Inspection

	No	Classification of Inspection	Inspection Method	Frequency	Target Bridges	Price	Unit	Initial price		Remark
Initial Cost	Procurement		Inspection Equipments			4,720	US$/Province	118,000		ipad, PC, software, hummer, binoculars, safty equipments
	* All province is going to conduct Periodic Inspection once / 5years. Bridge inspection equipments will be installed within 5 years.									
	Total							**23,600**		

Annual Cost

	No	Classification of Inspection	Inspection Method	Frequency	Target Bridges	Price	Unit	Cost/year	Unit	Remark
Running Cost	1	Routine Inspection	Distance Visual Inspection	Once / Month	**All bridges(approx.2500bridges)**	2,026	USD/month/ time	24,310	USD/12 months	Gasoline fee required for patrol all bridges on national roads(15,506km), 0.15USD/km (inspection is conducted by RID and DPWTs along with road routine inspection)
	2	Periodic Inspection	Visual Inspection	Once/5Year	**approx. 500 bridges/ year** (all bridges is divided into 5 blocks and conduct every year, 1 cycle/5 years)	54,079	USD/2500 bridges	10,816	USD/500 bridges	AP-1 for breakdown Approximately 500 bridges/year Total aprox. 2,500 Bridges averate 21.6USD/bridge
	3	Detailed Inspection	Close touching inspection	Once/ Year	**approx. 6-10 bridges/year** Selected bridges of D andSD bridges (1.2% of all bridges=30 bridges/5years)	42,758	USD/30 bridges	8,552	USD/6 bridges	AP-2 for breakdown Permanent bridges (ex.concrete bridges) Using robot camera, hummer, binocurous scope, Ipad, Consider scaffolding 10% of bridge surface area to approach average 1,400US$/Bridge
	4	Follow-up Inspection (SD/D bridges)	Visual Inspection	Once/ Year	SD/D bridges			3,873		Contingency 20% of total (Periodic +Detailed)
	5	Initial Inspection	Visual Inspection	At handover	New bridges			1,937		Contingency 10% of total (Periodic +Detailed)
	6	Emergency Inspection	Close touching inspection	As requested	Damaged bridges caused by natural disaster, traffic accidents etc.,					
	Total							**49,488**		

AP-1 Estimating Inspection Cost (Periodic Inspection)

No	Province/City	Number of Bridges (Bridges)	Inspection days (days)	Cost (US$)	Necessary to stay in prvince for MPWT official and driver (Quantity of accomotation) (Night)	Accmodation fee ($20/night) (US$)	Total Inspection cost (US$)
1	Banteay Meanchey	76	8	1,680	16	320	2,000
2	Battambong	141	9	1,890	18	360	2,250
3	Kandal	287	33	6,930	66	1,320	8,250
4	Kep	2	1	210	2	40	250
5	Koh Kong	58	3	630	6	120	750
6	Kompong Cham	93	8	1,680	16	320	2,000
7	Kompong Chhnang	71	7	1,470	14	280	1,750
8	Kompong Speu	91	7	1,470	14	280	1,750
9	Kompong Thom	59	5	1,050	10	200	1,250
10	Kompot	119	8	1,680	16	320	2,000
11	Kratie	105	11	2,310	22	440	2,750
12	Mondul Kiri	39	3	630	6	120	750
13	Otdor Meanchey	176	12	2,520	24	480	3,000
14	Pailin	33	3	630	6	120	750
15	Phnom Penh	33	4	840	8	160	1,000
16	Preah Sihanouk	57	5	1,050	10	200	1,250
17	Preah Vihear	202	15	3,150	30	600	3,750
18	Prey Veng	84	6	1,260	12	240	1,500
19	Pursat	214	19	3,990	38	760	4,750
20	Ratanak Kiri	24	2	420	4	80	500
21	Siem Reap	123	8	1,680	16	320	2,000
22	Steung Treng	89	8	1,680	16	320	2,000
23	Svay Rieng	33	5	1,050	10	200	1,250
24	Takeo	66	6	1,260	12	240	1,500
25	Tbaung Khmum	48	5	1,050	10	200	1,250
Total		**2,323**	**201**	**42,210**	**402**	**8,040**	**50,250**
Total Cost (US$)		**50,250**					

Unit price

Inspection (1day)

ME Master	Team leader	20	US$/day	MPWT Official allowance
ME Inspection	Co-leader	20	US$/day	DPWT Official allowance
ME Assistant	Assisitant	20	US$/day	DPWT Official allowance
Car fee		150	US$/day	Rent a Car
Total		**210**	**US$/day**	

Accomodation (1day/person)

Accmodation fee		**20**	**US$/day**	**MPWT Official's+driver's**

Quantity of Inspection person (1 Time)

MPWT	201	Person
DPWT	402	Person
Total	**603**	**Person**

Plan of Activity (Per year)

	Quantity of Inspection person (Person)			Inspection Cost (US$)	Remark
	MPWT	DPWT	Total		
1 Time / year	201	402	603	50,250	

Average Cost

50,250 / 2,323 = 21.6 USD/Bridge

Cost for 2500 Bridges

21.6 x 2500 = 54,079 USD

AP-2 Estimating Inspection Cost (Detailed Inspection)

No	Province/City	Quantity of Closed Inspection		Total Inspection cost
		Number of Bridges	Area of Bridge	
		(Bridges)	(m^2)	(US$)
1	Banteay Meanchey	76	21,084	1,285
2	Battambong	141	34,849	2,123
3	Kandal	287	55,502	3,382
4	Kep	2	11,918	726
5	Koh Kong	58	23,135	1,410
6	Kompong Cham	93	19,116	1,165
7	Kompong Chhnang	71	22,080	1,345
8	Kompong Speu	91	91,805	5,594
9	Kompong Thom	59	43,952	2,678
10	Kompot	119	29,391	1,791
11	Kratie	105	23,496	1,432
12	Mondul Kiri	39	16,447	1,002
13	Otdor Meanchey	176	18,123	1,104
14	Pailin	33	15,596	950
15	Phnom Penh	33	27,557	1,679
16	Preah Sihanouk	57	34,700	2,114
17	Preah Vihear	202	49,877	3,039
18	Prey Veng	84	28,066	1,710
19	Pursat	214	15,015	915
20	Ratanak Kiri	24	24,426	1,488
21	Siem Reap	123	38,506	2,346
22	Steung Treng	89	26,490	1,614
23	Svay Rieng	33	11,971	729
24	Takeo	66	12,625	769
25	Tbaung Khmum	48	6,004	366
Total		**2,323**	**701,732**	**42,758**
Structual damaged bridges		**173**		
Target of Detailed Inspection Bridges		**28**		
Rate of Detaild Inspection		**1.2%**		
Area of Scaffolding Bridge(m^2)**		**846**		

* **Bridges which have defects on structural parts(slab,girder) are judged as SD/D/DorO.**

** **10% of Datailed Inspection Bridges**

Unit price

Inspection Cost(1day)

ME Master	Team leader	20	US$/day	MPWT Official allowance
ME Inspection	Co-leader	20	US$/day	DPWT Official allowance
ME Assistant	Assisitant	20	US$/day	DPWT Official allowance
Car fee		150	US$/day	Rent a Car
Total Cost		**210**	**US$/day**	

Accomodation (1day/person)

Accmodation fee		**20**	**US$/day**	**MPWT Official's+driver's**

Scaffolding (m^2)

Material		5	US$/$m^2$	Buying Price \$50/m^2 They can be used 10 times.
Transpotation	150km	9	US$/$m^2$	
Installation&Remove	Labor	20	US$/$m^2$	
Total		**34**	**US$/$m^2$**	

Cost of Closed inspection

	Quantity	Unit price	Unit	Price(US$)	Remark
Inspection	56	210	US$/day	11,760	2 Day / Bridge
Accomodation fee	112	20	US$/day	2,240	
Scaffolding	846	34	US$/$m^2$	28,758	
Total Cost(US$)				**42,758**	

Quantity of Inspection person (1 Time)

MPWT	56	Person
DPWT	112	Person
Total	**168**	**Person**

Plan of Activity (Per year)

	Quantity of Inspection person (Person)			Inspection Cost (US$)	Remark
	MPWT	DPWT	Total		
1 Time / year	56	112	168	42,758	
1 Time / 4 years	14	52.5	66.5	10,690	
1 Time / 5 years	**11**	**22**	**34**	**8,552**	

AP-3 Estimating Routine Inspection cost (Fuel fee)

		Length	Unit Price (US$)	Price (US$)
Natinal road	1-Digit	2,254	0.15	338
	2-Digit	5,007	0.15	751
Provincal road		6,244	0.15	937
Total (Each Province)		**13,506**		**2,026**

Estimating Routine Maintenance cost (1 Time / Year)

		Length (m)	Unit Price (US$)	Price (US$)
Cleaning	Bridge total length	78,833	0.10	7,883
Re-painting	Bridge total length	78,833	1.00	78,833
Total (Each Province)		**157,666**		**86,716**

Person day for Bridge inspection

	Nos of person		days /mont	MM/month	MM/year
DPWT		1	7	7	84
RID		1	7	7	84
				Total	168

Normally inspection takes min 3 days max 10days.

Estimating Procurement (Inspection equipments)

	Quantity	Unit Price (US$)	Price (US$)
ipad	1	800	800
PC	1	350	350
Soft ware(File Maker)	1	1,000	1,000
Hummmer	5	35	175
Digital Binoculars	1	2,000	2,000
Helmet	5	10	50
Safty Jacket	5	4	20
Safty Belt	5	50	250
Safty Cone	5	15	75
Total (Each Province)			**4,720**
Total (All Province)	**25**	**4,720**	**118,000**
Total (1 Year)			**23,600**

*Bridge inspection equipments will be installed within 5 years.

A-5 Bridge Database Operation Cost

A-5 Bridge Database System

Items	Quantity	Unit Rate (USD)	Total(USD)	Remarks
1)IP address rental	12.0	20	240	rental fee from provider
2)Database Operator	12.0	500	6,000	IT specialist
3)Update of filemaker	0.0	0	0	unitil 21 Oct 2018, all software is under su-pport serveice
				from 22 Oct 200 USD for File Maker Pro and 1600USD for File Maker Server
Total			**6,240**	

A-6 Maintenance Operation Meeting Cost

A-6 Cost for Maintenance Operation Meeting

Items	Quantity	Unit Rate (USD)	Total(USD)	Remarks
1. Meeting				
1)Master Trainers (RID)	9.0	20	180	・2 Master Trainers, 1 university lecturer 3 persons x 3 days =9
2)DPWT	50.0	20	1,000	・25 DPWT x 2 =50 (attending 1 day)
3)Travel Expense	50.0	20	1,000	・20 USD/person x nos of DPWTs attendants
4)Meeting Material	50.0	10	500	
5)Other expenses	159.0	5	795	・Tea and water 53x3=159
Total			**3,475**	
2. Site visit fro MOM				
1)Master Trainers	9.0	20	180	・2 Master Trainers, 1 university lecturer 3 persons x 3 days =9
2)DPWT (attend and support of MOM inspection)	50.0	20	1,000	・25 DPWT x 2 =50 (attending 1 day)
3)Travel Expense	9.0	20	180	・20 USD/person
4)Other expenses	50.0	3	150	・Water etc., 50persons
Total			**1,510**	
Ground Total			**4,985**	

A-7 Maintenance Expert Training Cost

A-7 Cost for ME Training

Bridge Inspection (BI) and Bridge Repair (BR) 3 days + 1 day =4 days

Items	Quantity	Unit Rate (USD)	Total(USD)	Remarks
1)Master Trainers	12.0	20	240	・2 Master Trainers, 1 university lecturer 3 persons x 4 days =12
2)Trainees	80.0	20	1,600	・20 trainees , 20x 4days =80
3)Travel Expense	23.0	20	460	・20 USD/person
4) Training Material	20.0	25	500	・Bridge Inspection Manual x1, Bridge Repair Manual x1, PPT
5) Training Material (Handbook-1)	500.0	1.15	575	・Reference book for 2000 Bridges (40pages) x 500
6) Training Material (Handbook-2)	500.0	1.15	575	・Bridge Inspection Handbook (40pages) x 500
7)Other expenses	78.0	5	390	・Tea and water 26x3= 78
8) Rental Car (for field training)	3.0	150	450	・Mini bus for 30 seats
Total			**4,790**	

A-8 Document Management Cost

A-8 Cost for Document Management

Items	Quantity	Unit Rate (USD)	Total(USD)	Remarks
1) Initial Cost for 2017				Data collection and setting
1)-1 Digital Strage Server	1.00	6,598	6,598	Storage Server (2.0TB), UPS, Windows Server License, Strage Rack, Switching Board, Monitor, Keyboard, Firewall
1)-2 Storage for Documents (Room)	1.00	0	0	Space in MPWT (XXm x XXm)
1)-3 Bookshelf	5.00	150	750	Store documents of 600 projects
1)-4 Assistant-2(Data Input Operator)	14.28	30	428	Input 1 project: 1min, 7h/day, 20projects x 5years(from 2013 to 2017)
		Sub total	**7,776**	
2)Annual Operation Cost from 2018				
2)-1 Assistant-1(Scan data processing Operator)	12.00	300	3,600	Permanent Staff A1 Processing: 30min, A3 Scan and Processing: 5min, A4 Scan and Processing: 1min, 7h/day, A1 drawing: 20pages x 20projects(for 1year) A4 Report: 100pages x 20projects (for 1year)
2)-2 Assistant-2(Data Input Operator)	31.42	30	943	Temporary Staff Input 1 project: 1min, 7h/day, 20 projects and 200 documents (for 1year)
2)-3 Maintenance Cost for Database System	4.0	50	200	Database Maintenance, quarterly back up and technical support by IT Consultant
2)-4 Maintenance Cost for Equipment	1.0	500	500	Equipment and Network Maintenance, Parts Replacement
2)-5 Annual License Cost for Windows Server	8.0	110	880	Windows Server License (8 licenses)
		Sub total	6,123	
Total			**13,899**	

B-1 Crack Sealing

Code	1-00001	Item	Concrete Crack Repair

Unit	m	Unitprice	51.4

	Decription	100m				1m		
			Loss rate / rate	Cost	Reference	Unit	Reference	Cost
(1)	Material cost			3806.35				38.0635
	Epoxy resin	485	1.25	606.25				6.0625
	Sealant	800	1.25	1000				10
	Syringes set	1750	1.25	2187.5				21.875
	Thinner	10	1.05	10.5				0.105
	Clay	2	1.05	2.1				0.021
(2)	Laber Cost	300	1	300	20person*3day *5$/person			3
(3)	Equipment Cost							0
(4)	(1)+(2)+(3)			4106.35				**41.064**
(5)	Inspection for repaire cost						(4) * 3%	1.231905
(6)	Transport worker and material						(4) * 4%	1.64254
(7)	Equipment hire						(4) * 15%	6.159525
(8)	Safety cost						(4) * 3%	1.231905
	Total							**51.329**

B-2　Carbon Fiber Sheet Method

Code	1-00003	Item	Concrete Surface Reinforcement

Unit	m^2	Unitprice	797.6

	Decription	$100m^2$ (10m×10m)				$1m^2$		
			Loss rate / rate	Coat	Reference	Unit	Reference	Cost
(1)	Material cost			63,608				636.08
	Carbon fiber sheet	32,000	1.05	33,600	(320\$/m^2) * (100m^2)			336
	Primer	2,000	1.25	2,500	(20\$/m2) * (100m2)			25
	Ground adjusting material	6,000	1.25	7,500	(60\$/m2) * (100m2)			75
	Synthetic resin adhesive	16,000	1.25	20,000	(160\$/m2) * (100m2)			200
	Gasoline	8	1	8	1\$ / 1 *8l			0.08
(2)	Laber Cost	200	1	200	20person*2day*5\$/person			2
(3)	Equipment Cost							0
(4)	(1)+(2)+(3)			63808				**638.08**
(5)	Inspection for repaire cost						(4) * 3%	19.1424
(6)	Transport worker and material						(4) * 4%	25.5232
(7)	Equipment hire						(4)* 15%	95.712
(8)	Safety cost						(4) * 3%	19.1424
	Total							**797.6**