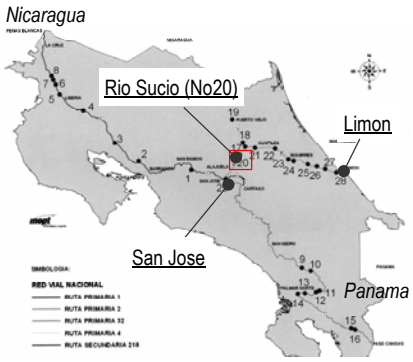
13.4 Results of Social Cost & Benefits in each Bridge

Followings show the details for example of the results of Social Costs & Benefits such as Rio Sucio in Rout 32 (Bridge No20) and Rio Aranjues in Route 1 (Bridge No2), then the summary results of 10 selected bridge.

1) Rio Sucio in Route 32 (Bridge No20)

Rio Sucio is located on Route 32 which connects from San Jose to Limon and is the important road network for the international distribution using the Limon port, and in the national forest (See in the right). Therefore, this bridge has most important role even for domestic but for international network. In the results of traffic volume survey in 2002, average number of vehicles passed in a day is 8,360 vehicles included the 20.2% of 5-axis vehicles. The Annual increase rate is about 4 or 5%.



Bridge type is Concrete box girder and has passed about 30 years since its construction.

The detour route is already discussed in 13.2.1 3), if this bridge falls down, light vehicle should detour another route (R.126 to R.4) where the heavy vehicle can not through must stop until it will open again.

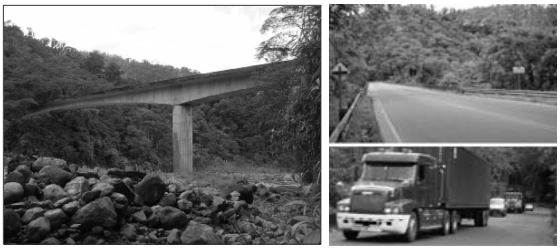


Figure 13.4.1. Rio Sucio (R.32)

According to the results of inventory & detailed inspection, the without case which the rehabilitation & reinforcement works will not conduct to this bridge is assumed as follows;

Table 13.4.1. The Scenario in without case for Rio Sucio

Scenario No.	Details of Scenario			Influence for Social aspects
	Parts	Results	year	
No 1	Main Girder Floor System	Increase of Damaged Area ⇒ Impassable	Within 30 years	1. Traffic Closure: 30 days for construction of provisional bridge 2. No suspension during the reinforcement of main girder & replacement of floor system using the provisional bridge
No 2	Pier	Increase of Deficiency of Cross-sectional Area ⇒ Reduction of Resistance for earthquake ⇒ Collapse of Piers due to earthquake	Within 50 years	1. Traffic Closure: 30 days for preparation of bailey bridge 2. No suspension during the re-construction of new bridge

Source: JICA Study Team

After applying above scenario, each social cost has been calculated. Note that scenario No2 is caused by earthquake so that the social cost is estimated as 1/50 of each year's cost affected by the 30 days traffic closure.

On the other hand, during the rehabilitation & reinforcement of this bridge is identified by the study team. During these works, traffic restriction is estimated as 1- direction traffic restriction for 100 days in the length of every 100 m in order to keep the traffic flow.

The results of the social costs & benefit for Rio Sucio is described as below. Net social benefit will be 564 million colones in 2007 price. The appearance of these costs and benefits are figured in below.

Table 13.4.2. Results of Social Costs/benefits for Rio Sucio

Unit: Million Colones

Item	Amount in 30 years	2007 Price *Discount Rate = 12 %*	Note
Social Costs Traffic Restriction during Rehabilitation & Reinforcement	16	16	- 1-dir. Traffic Restriction: 100 days - In 2007
Social Benefits			
Scenario 1 *Deficiency of Super Structure*	4,130	153	- Traffic Closure: 30 days - In 2036
Scenario 2 *Earthquake*	1,818	427	- Traffic Closure: 30 days - In 2008 to 2036 with 1/50 probability
Total	5,921	580	
Net Social Benefit	5,905	**564**	- Benefits – Costs

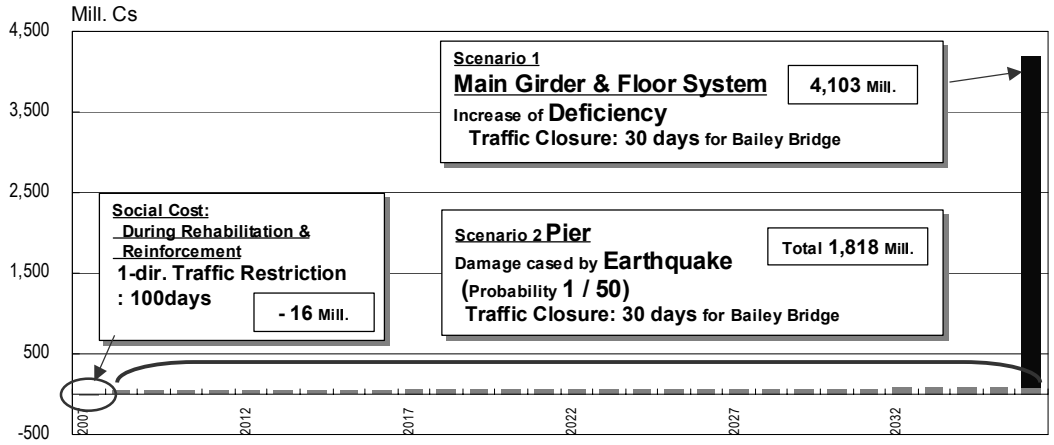
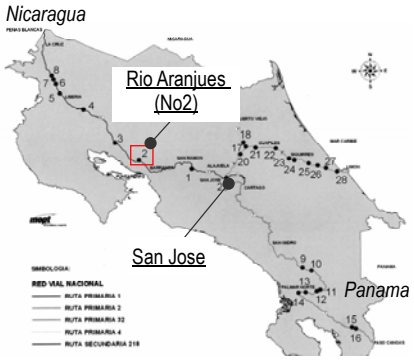


Figure 13.4.2. Appearance of Social Cost & Benefits for Rio Sucio (R.32)

2) Rio Aranjuez (R.2)



Rio Aranjues is located on Route 1 at 112 km far from San Jose (See in the right). Therefore, this bridge has most important role even for domestic but for international network. In the results of traffic volume survey in 2002, average number of vehicles passed in a day is 8,360 vehicles included the 20.2% of 5-axis vehicles. The Annual increase rate is about 4 or 5%.

Bridge type is steel truss and has passed about 50 years since its construction.

There is only the way for detour from "CUATRO CRUCES ~ PITAHAYA" through Route 604 and the Regional Road for only the light vehicle after the results of MOPT interview survey.

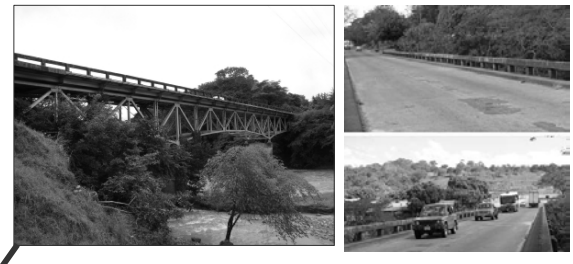


Figure 13.4.3. Rio Aranjuez (R.2)

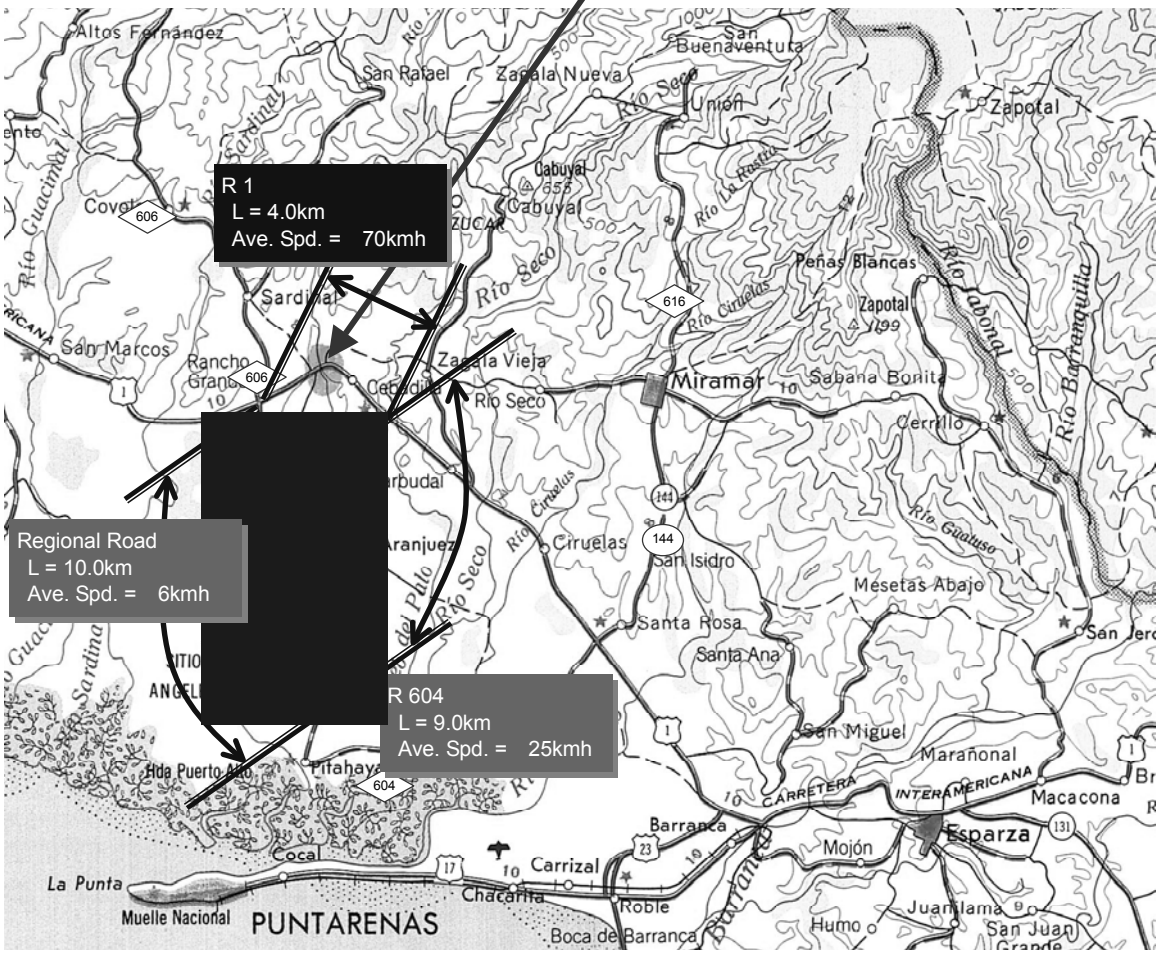


Figure 13.4.4. Detour Route for Rio Aranjuez (R.2)

According to the results of inventory & detailed inspection, the without case which the rehabilitation & reinforcement works will not conduct to this bridge is assumed as follows;

Table 13.4.3. The Scenario in without case for Rio Aranjuez

Scenario No.	Details of Scenario			Influence for Social aspects
	Parts	Results	year	
No 1	Floor Deck Floor System	Increase of Damaged Area ⇒ Impassable	Within 10 years	1. Traffic Closure: 20 days for emergent rehabilitation for floor deck 2. Traffic Restriction 1-dir.: 100 days during the reinforcement & replacement of floor system
No 2	Main Girder	Increase of Deterioration & Collusion of Paint ⇒ Reduction of Cross-Section Area	Within 20 years	1. Traffic Closure: 1 day for reinforcement or replacement of Main Girder
No 3	Main Girder	Increase of Cumulated Live Load ⇒ Fatigue around Connections	Within 30 years	1. Traffic Closure: 1 day for reinforcement or replacement of Main Girder
No 4	Pier	Earthquake ⇒ Damage of Piers due to earthquake	Within 30 years	1. Traffic Restriction 1-dir.: 3hrs. 7days for emergency rehabilitation of piers
No 5	Pier	Earthquake ⇒ Collapse of Piers and Bridge Falls	Within 50 years	1. Traffic Closure: 30 days for preparation of bailey bridge 2. No suspension during the re-construction of new bridge

Source: JICA Study Team

After applying above scenario, each social cost has been calculated. Note that scenario No4 and 5 are caused by earthquake so that the social cost is estimated as 1/30 or 1/50 of each year's cost affected by the influence to traffic.

On the other hand, during the rehabilitation & reinforcement of this bridge is identified by the study team. During these works, traffic restriction is estimated as 1- direction traffic restriction for 100 days.

The results of the social costs & benefit for Rio Aranjuez is described as below. Net social benefit will be 604 million colones in 2007 price. The appearance of these costs and benefits are figured in below.

Table 13.4.4. Results of Social Costs/benefits for Rio Aranjuez

Unit: Million Colones

Item	Amount in 30 years	2007 Price *Discount Rate = 12 %*	Note
Social Costs Traffic Restriction during Rehabilitation & Reinforcement	10	10	- 1-dir. Traffic Restriction: 100 days - In 2007
Social Benefits			
Scenario 1 *Deficiency of Super Structure*	1,020	368	- Traffic Closure: 20 days - 1-dir. Traffic Restriction: 100 days - In 2016
Scenario 2 *Deficiency of Super Structure*	54	6	- Traffic Closure: 1 day - In 2026
Scenario 3 *Deficiency of Super Structure*	76	3	- Traffic Closure: 1 day - In 2036
Scenario 4 *Deficiency of Super Structure*	0.021	0.005	- 1-dir. Traffic Restriction: 3hrs. 7days - In 2008 to 2036 with 1/30 probability
Scenario 5 *Earthquake*	1,007	237	- Traffic Closure: 30 days - In 2008 to 2036 with 1/50 probability
Total	2,157	614	
Net Social Benefit	2,147	**604**	- Benefits – Costs

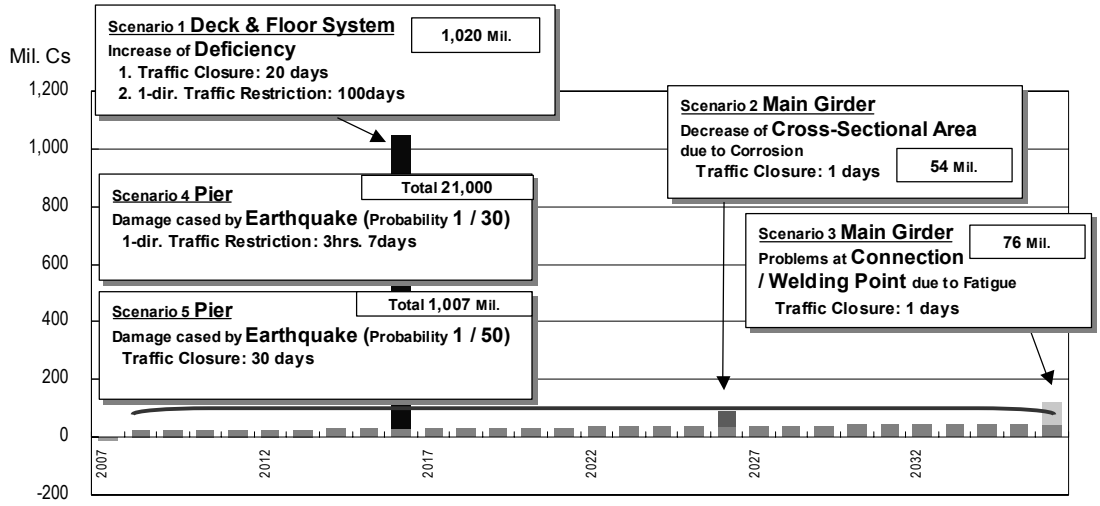


Figure 13.4.5. Appearance of Social Cost & Benefits for Rio Sucio (R.32)

3) 10 selected Brdige

As it is used in same context in above, the each results of the net social benefit for 10 selected bridge is summarized in figure below. Comparison of Net Social Benefit for 10 Bridges is shown below. It is found that Rio Abangares (Bridge No3) and Rio Chirripo (Bridge No26) have the much value of social benefit for rehabilitation and reinforcement among these bridge. These are in the Route 1 and 32 which are the important network for international transportation and have not enough redundancy for the road network. From the next section, the economic evaluation for rehabilitation & reinforcement will be treated using the work cost & benefit added to social costs & benefit, in order to find the EIRR and B/C.

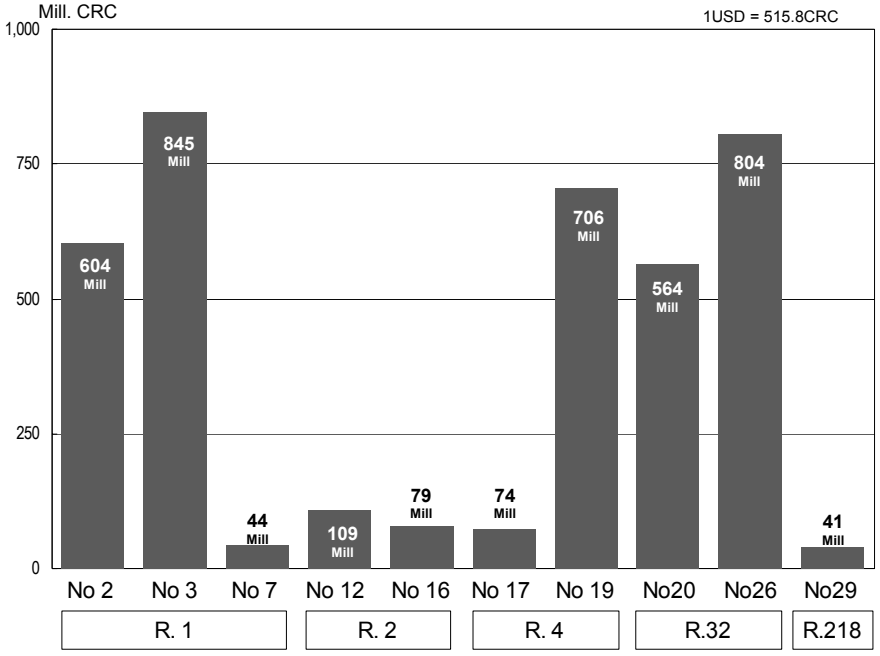


Figure 13.4.6. Results of Net Social Benefits for 10 selected Bridge (Discount Rate = 12%)

13.5 Work Cost for each Bridge

13.5.1 Assumptions for Economic Evaluation

The project costs for rehabilitation & reinforcement have been estimated in the chapter12. In the economic evaluation, price should be converted as the economic cost from the financial cost. For project components purchased in Costa Rica, no conversion factor is needed, since it is assumed that the market is competitive for these resources also because they do not impact on exports/imports. For the tradable resources, it is used the standard conversion factor is used as 0.83[3] from the prices in Costa Rican colones (CRC). Note that all taxes/duties are excluded from economic costs. Because the project cost includes 13% of sales tax in this study, it is multiplied by 0.87 for tax reduction. After tax reduction, followings assumptions summarized in table blow is used for economic cost evaluation.

Table 13.5.1. Project Economic Cost Evaluation Assumptions

Type of Cost		Assumptions	Shadow Price
Construction Cost	Exclusive of Labor[4]	- 50%: Tradable Equipment & Material[5] - 50%: Non-Tradable	- multiplied by 0.83 of SCF - No,
Labor Cost	For Construction For O&M	- Skilled labor - Semi-skilled/ unskilled labor	- No, because of Competitive market - No[6]
Engineering Service & Others	Indirect Cost	- 50%: Tradable - 50%: unreadable	- multiplied by 0.83 of SCF - No,

Operation & maintenance costs are taken into consideration in with case, and work costs such as emergent recovery, rehabilitation, reinforcement, preparation of Bialy bridge and re-construction costs for each scenario in without case is also estimated as the benefits of this project.

Currency exchange rate is used as the "1USD=515.8CRC[7], 1USD = 116.91JPY and 1JPY = 4.41CRC" estimated in 12.2.2 (1). The CRC is taken for the economic evaluation.

13.5.2 Results of Work Cost for 10 Selected Bridge

The table below shows that the rough cost of Maintenance item and emergency recovery or re-construction work in "without case". Note that each items for rehabilitation & reinforcement cost in "with case" should be different due to the condition and situation of bridge.

[3] The Standard Conversion Factor to remove the shadow price is taken as 0.83 from the results of interview to domestic consultants and economists in University of Costa Rica. Note that older research in the "de Evaluación Económica, elaborado por la Dirección de Planificación del MOPT en 1980" takes as 0.90.

[4] Labor Cost is assumed as 10% of total project cost.

[5] These ratio is assumed by the reference of similar projects.

[6] The wage for semi-skilled/ unskilled labor in MOPT & CONAVI regulations is same fee under the national low of works.

[7] CRC = Costa Rican Colone, JPY = Japanese Yen, USD = U.S. Dollar

Table 13.5.2. Rough Costs of each Items

Items			Unit Cost	Note
Maintenance	Inspection	Periodic	31,000.00	CRC/Bridge
		Detail	168,000.00	CRC/Bridge
	Sup. - St.	Re-Painting	101.80	USD/m^2
		Repair for Floor System (Injection)	10.28	USD/m (crack length)
		FRP Bounding	308.75	USD/ m^2 ; 2-Layer
		Overlay of Pavement	9.57	USD/ m^2
		Expansion Joint Replacement	1,139.25	USD/ m
		Asphalt Paving	11.50	USD/ m^2
		Water Proofing	105.30	USD/ m^2
	Sub - St.	Rolling Stone Protection	20,000.00	USD/ pier ; Bridge No17
			48,000.00	USD/ pier ; Bridge No20
		Protection for Scouring (Gabion)	230.18	USD/ m ; 2m*1m*1m
Emergency Recovery	Deck Slab Floor System	Emergency Repair	1,500.00	USD/ m^2 ; Bailey Bridge (1-span)
		Slab Replacement	**	USD ; Each Project Cost ; Bridge No 2, 3
			602.04	USD/ m^2 , BMS009 ; Bridge No12,19,20,26
	Main Girder	Member Addition Cover Plate Fixing, Steel Plate Bonding, Steel Plate Replacement	***	USD ; Each Project Cost ; Bridge No2, 3, 7, 16, 17, 26, 29
		Reinforcement	9,162.28	USD/ m^2 , BMS014 ; Bridge No12
	Pier	Urgent Repair Work	***	USD, 1.50 times of Concrete Jacketing
	Bailey Bridge	Preparation & Construction	1,500.00	USD/ m^2 / lane
	Re-construction		2,000,000.00	USD/ 50m-span Bridge

The results of these costs in each bridge has been summarized in the Appendix-13.5.

13.6 Economic Evaluation

13.6.1 Economic Internal Rate of Return (EIRR) and Net Present Value (NPV)

The result of Economic Internal Rate of Return (EIRR) for selected 10 bridges are shown in figure below. It is identified that there are 8 bridges whose EIRR has more than 20% and are feasible project for rehabilitation and reinforcement with national economic context. Although two bridges (Azufurado Bridge (No.7) and Chirripo Bridge (No.12) has less than 20% of EIRR, it is dangerous if we say that these bridge does not have worth for rehabilitation and reinforcement because these EIRR have been calculated under the sets of assumptions.

Net Present Value (NPV) has been calculated for 8 bridges using 12% of discount rate, except 2 bridges which have less than 20% of EIRR. The results are shown below. As the results of NPV, orders for higher value of NPV are as Chirripo Bridge (No.26), Puerto Nuevo Bridge (No.12) and Sucio Bridge (No.20). These results show the order of importance/beneficial rank for rehabilitation and reinforcement in the point of view for national economic.

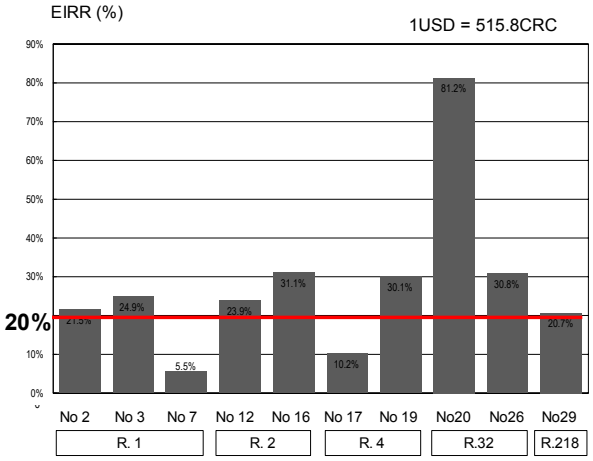
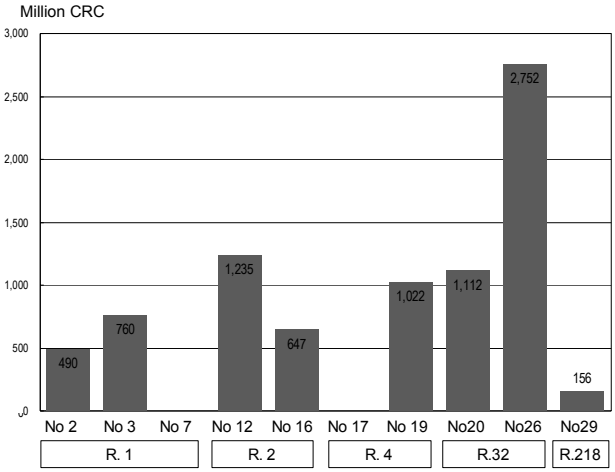


Figure 13.6.1. Results of EIRR



Beneficial Rank by NPV (EIRR>20%)

1. Chirripo Bridge	No.26	R.32
2. Puerto Nuevo Bridge	No.12	R.2
3. Sucio Bridge	No.20	R.32
4. Sarapiqui Bridge	No.19	R.4
5. Abangares Bridge	No.3	R.1
6. Nuevo Bridge	No.16	R.2
7. Aranjuez Brige	No.2	R.1
8. Torres Bridge	No.29	R.218

Figure 13.6.2. Results of NPV, Beneficial Rank for Rehabilitation & Reinforcement

The scenario for Chirripo Bridge (No.26) which has highest NPV is shown the table in next page, and its cost/benefit table is shown in Table 13.4.

Table 13.6.1. Scenario for Chirripo Bridge (No.26)

Cost	Rehabilitation & Reinforcement	Slab Deck (FRP Bonding), Prevention System for Unseating (Bridge Sear Widening, Connection System), Expansion Joint (New Installation), Asphalt Paving & Waterproofing, Pier (Height of Transversal Beam Increase), Foundation (Footing Widening) (Social: 1-dir. Traffic Closure 100days)
	Maintenance	Routine Inspection (every 5 years), Detailed Inspection (every 10 years) Repair for Floor System (Injection), Overlay of Pavement, Replacement of Expansion Joint, Asphalt Paving & Waterproofing, Pier Protection
Benefit	Scenario 1	After 15years, Not Passable due to Increase of Deficiency (Deck Slab) Social Cost: Traffic Suspension 30 days Work Cost: Bailey Bridge Construction, Slab Replacement
	Scenario 2	After 20 years, Lack of Cross-sectional Area due to Deterioration of Paint & Corrosion (Main Girder) Social Cost: 1-dir. Traffic Closure 3hrs. 7days Work Cost: Steel Plate Replacement
	Scenario 3	After 30 years, Damaged Cracks around Connections due to Fatigue (Main Girder) Social Cost: Traffic Suspension 24hrs. & : 1-dir. Traffic Closure 3hrs. 7days Work Cost: Cover Plate Fixing
	Scenario 4	Within 30 years, Falling Down at Main Girder of Side Span due to Earthquake Social Cost: Traffic Suspension 30 days Work Cost: Bailey Bridge Construction & Re-Construction

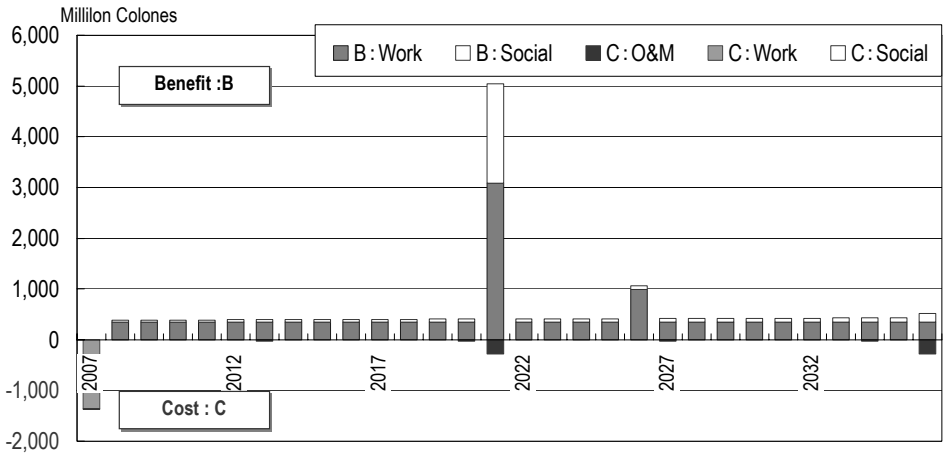
Table 13.6.2. Cost/Benefit Table for Chirripo Bridge (No.26)

Unit: CRC, 1USD = 515.8CRC

	year	Costs				Benefits			Results
		Work		Social	**Total Cost**	Work	Social	**Total Benefit**	**Net Benefit**
		Rehabli. & Renf.	Maintenance	Traffic Rest.	(A)	Scenario 1 to 5	Scenario 1 to 5	(B)	(B-A)
1	2007	1,355,277,221		11,437,992	**1,366,715,214**				**-1,366,715,214**
2	2008				**0**	343,814,571	41,049,885	**384,864,456**	**384,864,456**
3	2009				**0**	343,814,571	42,732,137	**386,546,708**	**386,546,708**
4	2010				**0**	343,814,571	44,414,388	**388,228,959**	**388,228,959**
5	2011		31,000		**31,000**	343,814,571	46,096,640	**389,911,211**	**389,880,211**
6	2012				**0**	343,814,571	47,778,891	**391,593,462**	**391,593,462**
7	2013		25,619,012		**25,619,012**	343,814,571	49,461,142	**393,275,713**	**367,656,701**
8	2014				**0**	343,814,571	51,143,394	**394,957,965**	**394,957,965**
9	2015				**0**	343,814,571	52,825,645	**396,640,216**	**396,640,216**
10	2016		168,000		**168,000**	343,814,571	54,507,897	**398,322,468**	**398,154,468**
11	2017				**0**	343,814,571	56,190,148	**400,004,719**	**400,004,719**
12	2018				**0**	343,814,571	57,872,399	**401,686,970**	**401,686,970**
13	2019				**0**	343,814,571	59,554,651	**403,369,222**	**403,369,222**
14	2020		25,619,012		**25,619,012**	343,814,571	61,236,902	**405,051,473**	**379,432,461**
15	2021		283,132,225		**283,132,225**	3,088,479,607	1,950,493,762	**5,038,973,369**	**4,755,841,145**
16	2022				**0**	343,814,571	64,601,405	**408,415,976**	**408,415,976**
17	2023				**0**	343,814,571	66,283,656	**410,098,227**	**410,098,227**
18	2024				**0**	343,814,571	67,965,908	**411,780,479**	**411,780,479**
19	2025				**0**	343,814,571	69,648,159	**413,462,730**	**413,462,730**
20	2026		168,000		**168,000**	989,167,656	71,331,369	**1,060,499,024**	**1,060,331,024**
21	2027		25,619,012		**25,619,012**	343,814,571	73,012,662	**416,827,233**	**391,208,221**
22	2028				**0**	343,814,571	74,694,913	**418,509,484**	**418,509,484**
23	2029				**0**	343,814,571	76,377,165	**420,191,736**	**420,191,736**
24	2030				**0**	343,814,571	78,059,416	**421,873,987**	**421,873,987**
25	2031		31,000		**31,000**	343,814,571	79,741,668	**423,556,238**	**423,525,238**
26	2032				**0**	343,814,571	81,423,919	**425,238,490**	**425,238,490**
27	2033				**0**	343,814,571	83,106,170	**426,920,741**	**426,920,741**
28	2034		25,619,012		**25,619,012**	343,814,571	84,788,422	**428,602,993**	**402,983,980**
29	2035				**0**	343,814,571	86,470,673	**430,285,244**	**430,285,244**
30	2036		283,269,225		**283,269,225**	348,540,475	167,148,694	**515,689,169**	**232,419,945**

EIRR = 30.8%

NPV at 12% = 2,752,424,784 Colones



13.6.2 Sensitivity Analysis

The Results of Sensitivity Analysis are shown below. It shows that its sensitivity against the increase of cost or decrease of benefit is not so high, therefore, the switching value of cost is 2.8 times as the based one, and the switching value of benefit is 0.3 times as based one. Note that EIRR will be reduced from 30.8% to 27.0% if social costs/benefits are not taken into the consideration in this evaluation. In this context, NPV will be also reduced from 2,752 million CRC to 1,948 million CRC. In Addition, the results of Aranjuez Bridge (No.2) is shown in the table below.

Table 13.6.3. Scenario for Chirripo Bridge (No.26)

Scenario		EIRR	NPV （million CRC）	Switching Value
Cost	+10%	28.4%	2,607	Base * 2.8877
	+20%	26.4%	2,461	
Benefit	-10%	28.2%	2,331	Base * 0.3463
	-20%	25.2%	1,910	

EIRR: 30.8%, NPV: 2,752 million CRC

Table 13.6.4. Scenario for Aranjuez Bridge (No.2)

Scenario		EIRR	NPV （million CRC）	Switching Value
Cost	+10%	19.8%	431	Base * 1.8297
	+20%	18.4%	372	
Benefit	-10%	19.7%	382	Base * 0.5465
	-20%	17.7%	274	

EIRR: 21.5%, NPV: 489 million CRC

As reference, it is conducted the sensitivity analysis for the Azufrado Bridge (No.7) which has the loest EIRR (5.5%). It is obtained that if EIRR is equal to 12.0%, cost must be reduced to 0.27 times as the base one or benefit must be increased t 2.89 times as the base one.

Table 13.6.5. Scenario for Azufrado Bridge (No.7)

Scenario		EIRR	NPV （million CRC）	Switching Value
Cost	+10%	5.0%	-143	Base * 0.2758
	+20%	4.4%	-162	
Benefit	-10%	4.9%	-131	Base * 2.8997
	-20%	4.2%	-137	

EIRR: 5.5%, NPV: -124 million CRC

CHAPTER 14 MANAGEMENT AND DEVELOPMENT OF INFORMATION SYSTEM

14.1 Existing Information System for Roads and Bridges

14.1.1 Existing Organization for Information Management

1) Planning Division of MOPT

The information of national highway, the regional roads, the bridges and the marine ports are administrated and utilized in the Planning Department of MOPT. Reserves of these inventory data, the inspection data are utilized for an annual plan for the maintenance of infrastructure.

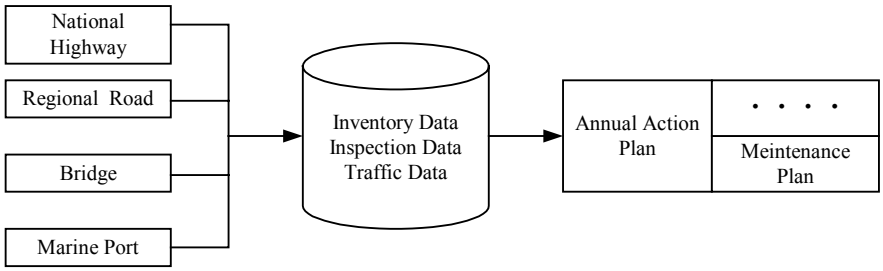


Figure 14.1.1. Management of Road Information

2) Bridge Department of MOPT

The technical supports for the bridges including the total planning, design and the inspection of bridges are carried out by the Bridge Department in MOPT. Although, the department maintain drawings of bridges they merely utilize the inventory data from the Planning Department.

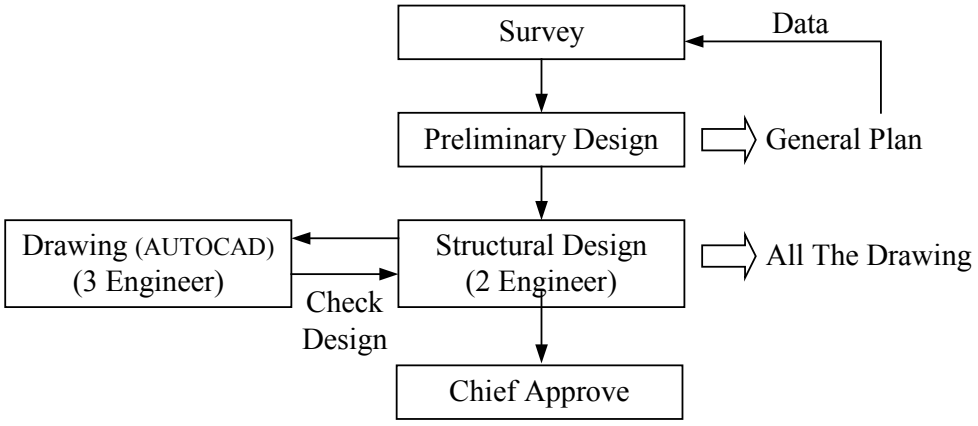


Figure 14.1.2. Flow of Information in the Bridge Department

Five hundred bridges are inspected annually based on an inspection manual by inspectors in the Planning Department. However, the inspectors are not bridge engineers and the Bridge Department does not utilize the information. The CONAVI and the Local Governments carried out the bridge inspections and their results including comments and photos of the

bridges are sent to the Bridge Department. The Bridge Department carried out technical support for the CONAVI and the Local Governments based on the information.

3) CONAVI and Local Government

There are road engineers but no bridge engineer in the CONAVI and the Local Governments. Therefore, the Bridge Department in MOPT carried out technical supports for the CONAVI and the Local Government regarding the bridge issues. The CONAVI selects locations of roads necessary to be repaired and carried out contracts for constructions based on an annual action plan which prepared by the Planning Department of MOPT.

14.1.2 System Administration and Development

1) MOPT

There are two departments in the MOPT for the system developments and the administrations. The Information Department administrates whole network system in the MOPT and the Planning Department administrates the systems in the Public Works Division. The systems are developed by the engineers in the MOPT without the outsourcings. The organizations and its burden sharing for the administration of the network systems are as follows:

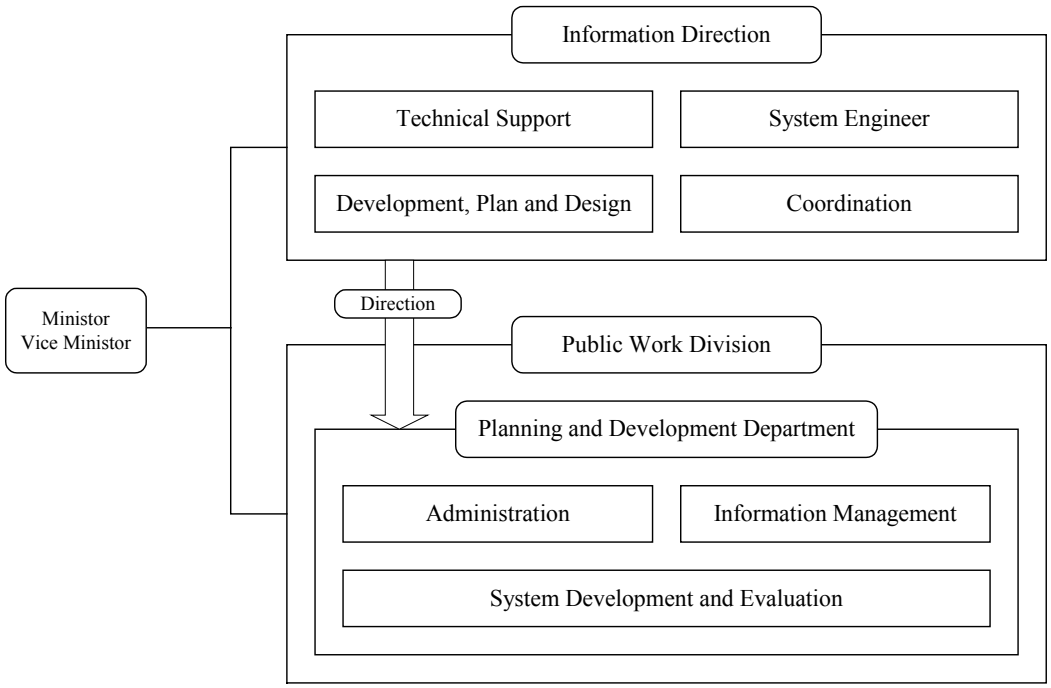


Figure 14.1.3. Organization for System Development and Administration

There are two major works for the system developments and the administrations and they are:

Technical Support:	Maintain hardware and software and administrate the network including the purchases for the personal computers for the staff of the MOPT.
System Engineering:	Analyze, develop and maintain the Information Systems.

2) CONAVI

The Information Department in the CONAVI is carried out the system development and the administration. The department carried out the development of the systems by an outsourcing or by the own engineers and the administration and the maintenance of several information systems including the purchase for a information soft from markets. Although majority of the systems in the CONAVI are utilized by the General Affaires Department, the administration systems for the roads and the bridges are studied and developed by the Information Department. The organization of the CONAVI is shown in Figure 14.1.4

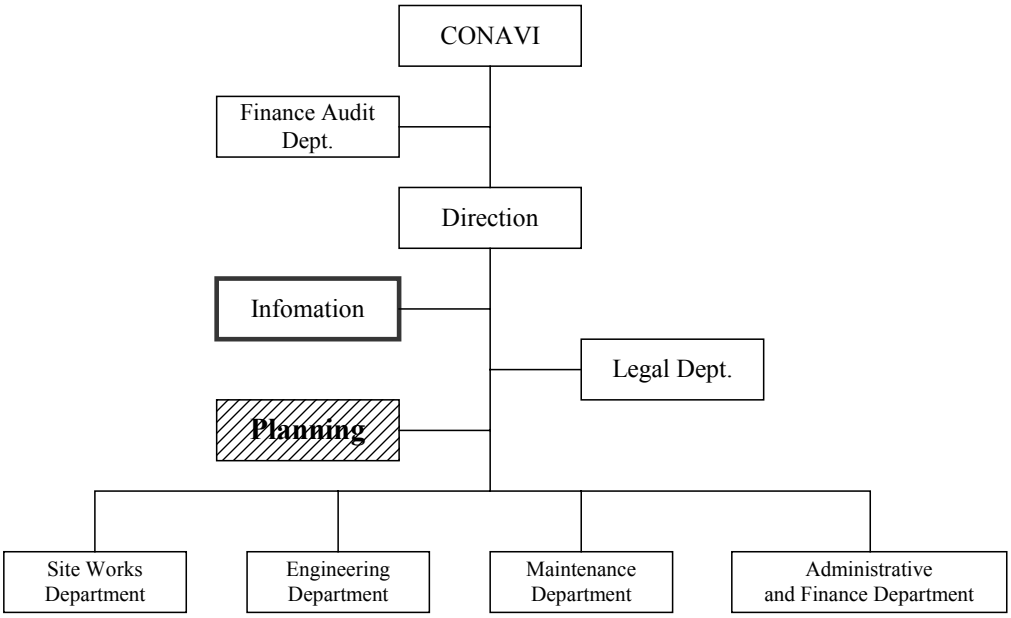


Figure 14.1.4. Organization of the CONAVI

14.1.3 Summery of the Existing System

1) MOPT (Public Works Division)

The summery of the systems for the roads and the bridges which are utilized in the MOPT are shown in Table 14.1.1. The administration for the inventory data for the roads and the bridges is carried out by the Planning Department. The data are utilized for the planning of an annual budget purchase and for the selection of locations of the roads for the maintenance.

2) CONAVI

The information systems maintained in the CONAVI are shown in Table 14.1.2. There is an inventory display system by using the GIS (ArcInfo) for the administration of the roads and the bridges. The inventories are established based on the information from the Planning Department of the MOPT.

Table 14.1.1. System Inventory of the Public Works Division in MOPT

Target	System	Description	Development	Time to Develop	Note
Local Road	SPEM	A maintenance system for pavements. An engineer from Germany maintains and supports the system continuously.	Germany	1992-1993	Replacement as SAM which developed in eighties.
National High Way	HDM4	Maintenance system for pavements developed by world bank. Functions of the system are as follows: a. Economic analysis b. Prioritization of location of road for maintenance c. Prospect for future deterioration	World Bank	—	
	DESYROUTE	Information of pavements is registered into database (DESYTROUTE) automatically by using inspection vehicles. However, the inspection vehicles are in failure now and information is registered manually.	France	1996	
	DESYSEMI	A system utilized in exchange of DESYROUTE. The system is utilized for one inspection vehicle and another vehicle is utilized for measurements of vibrations.			
	DESYVISAGI	Database system to manage data registered by DESYROUTE, DESYSEMI			
Bridge	DBF (Data of Bridge File)	Reform version of a system developed ten years ago by the France. Information of bridge dimensions, inspection results are registered in the system. Deteriorations of each part of bridges are evaluated by eight degrees based on an inspection manual. Five hundred bridges are inspected annually and all bridges are inspected within two years. Photos obtained through site inspections are unemployed.	MOPT	1996	Average weights for each bridge part are applied for evaluation of bridge deterioration

Table 14.1.2. System Inventory in CONAVI

No.	System	User	Form of Acquisition	Programming language	Operation System	Data Base	Engineers of the System
1	Fixed Assets	Address Administrative	Purchase	Visual Basic 6.0	Windows 2000 Server	Oracle	Outsourcing
2	System of Financial Information (**SIIF**)	Address Administrative	Internal Development	Natural		Adabas	1
3	Payment Management	Address Administrative	Internal Development	Natural	OS-390	Adabas	1
4	Accountancy	Address Administrative	Purchase	Visual Basic 6.0	Windows 2000 Server	Oracle	Outsourcing
5	Budget	Address Administrative	Internal Development	Natural	OS-390	Adabas	1
6	Licitation	Add. Administrative/Supplier	Internal Development	Lotus Notes	Windows 2000 Server	Lotus Notes	1
7	Control of Orders (Warehouses)	Add. Administrative/Supplier	Internal Development	Lotus Notes	Windows 2000 Server	Lotus Notes	1
8	Images	Add. Administrative/Supplier	Purchase	Visual Basic 6.0	Windows 2000 Server	SQL Server	Outsourcing
9	Web page	Add. Administrative/Supplier	Hiring	ASP	Windows 2000 Server		Outsourcing
10	Guarantees	Add. Administrative/Supplier	Internal Development	Lotus Notes	Windows 2000 Server	Lotus Notes	1
11	Human Resources (ERP)	Add. Administrative/Hum. Resources	Donation	Power Builder	Windows 2000 Server	SQL Server	Outsourcing
12	Lists	Add. Administrative/Hum. Resources	Internal Development	Natural	OS-390	Adabas	1
13	Administration of Movable Equipment	Add. Administrative/Gen. Services	Internal Development	JAVA	Unix	DB2	3
14	Control of Correspondence	Add. Administrative/Gen. Services	Internal Development	Lotus Notes	Windows 2000 Server	Lotus Notes	1
15	Request of Vehicle Services	Add. Administrative/Gen. Services	Internal Development	Lotus Notes	Windows 2000 Server	Lotus Notes	1
16	Administration of Projects (ERP)	Address of Works	Internal Development/Buys				
17	Readjustments	Planning and Control	Internal Development	Natural	OS-390	Adabas	1
18	Costs of Works	Planning and Control	Internal Development				
19	System of Geographic Information - GIS	Planning and Control	Purchase	Visual Basic 6.0	Windows 2000 Server	dBASE/ Access	Outsourcing
20	Control of Rent of Machinery	Conservation Avenue	External Development	Visual Basic 6.0	Windows 2000 Server	SQL Server	Outsourcing
21	Control in Agreements of Board of directors	Secretariat of Acts	Hiring				
22	Control of Restricted Accesses	Commission of accesses	Internal Development				
23	Inventories - TRACK-IT (Help Desk)	Computer science	Purchase	Visual Basic 6.0	Windows 2000 Server	SQL Server	Outsourcing

Note: System of geographic information –GIS is the system for Road and Bridge

14.2 Information System Development

14.2.1 Environments of the Information System Development

The environments of the information system development are different in each department by the state of the utilization of a software. The contents of the system utilized in the MOPT are shown in Table 14.2.1. Approximately two hundred fifty (250) personal computers are allotted to the staff of the MOPT and about 80% of the computers are not fulfilled the specifications specified by the Information Department of the MOPT.

Therefore, the budget for the renewal of the personal computer are prepared and 170 sets of personal computers will be allotted to the regional offices. The objectives of the improvement of the environments for the information system in the regional offices are to upgrade skills of the staff in the offices to adapt the Road Management System. Full dress operation of the Road Management System is planned and is explained in the Section 14.2.4 System Development Plan in this report. The Visual Basic as a language for the system development, the ArcInfo as the GIS software and the TCP/IP for protocol are commonly adopted for the information system in the MOPT.

Table 14.2.1. Environment of the System Development

Item	Software	Description	Note
Language	Visual Basic6.0	A programming language developed by the Microsoft. The language offered with special development tool to ease the development of application software.	Common in Each Department
DBMS	Access2000,2003	A data base software of the Microsoft. The soft is a part of the Microsoft Office. The software equipped “Jet Database Engine” and able to connect the Microsoft SQL Server or other database engines for ODBC	MOPT: Information Department (2000) CONAVI (2003)
	Visual Fox	A database soft for medium size database developed by the Microsoft for developers	MOPT: Planning
	ORACLE	A database software developed by the ORACLE.	CONAVI
	SQL Server7.0	A database software for large scale database developed by the Microsoft. The soft is scalable and reliable and make realize an easy management of database.	MOPT: Information CONAVI
GIS	Arc-Info	A GIS software offered by the ESRI and is used World wide GIS market.	Common
Server	Windows2000Server	A operation system for servers developed by the Microsoft	Common
Personal Computer for Staff	CPU	Pentium IV 2.8Ghz～3.4Ghz	Specification of personal computer in the MOPT
	Memory	512MB DDR SDRAM	
	Monitor	17 inch SVGA (1280×1050）	
	HDD	80GB SATA（7,200PRM）	
	OS	Windows XP Professional	
	Software	Office2003	

14.2.2 Network Environment

1) Local Area Network (LAN) in the Public Works Division

Personal computers in the Public Works Division are connected by the fiber cables through the switch principal from the server and are connected with the category 5 100 BASE-TX (100Mbps) through the Ethernet.

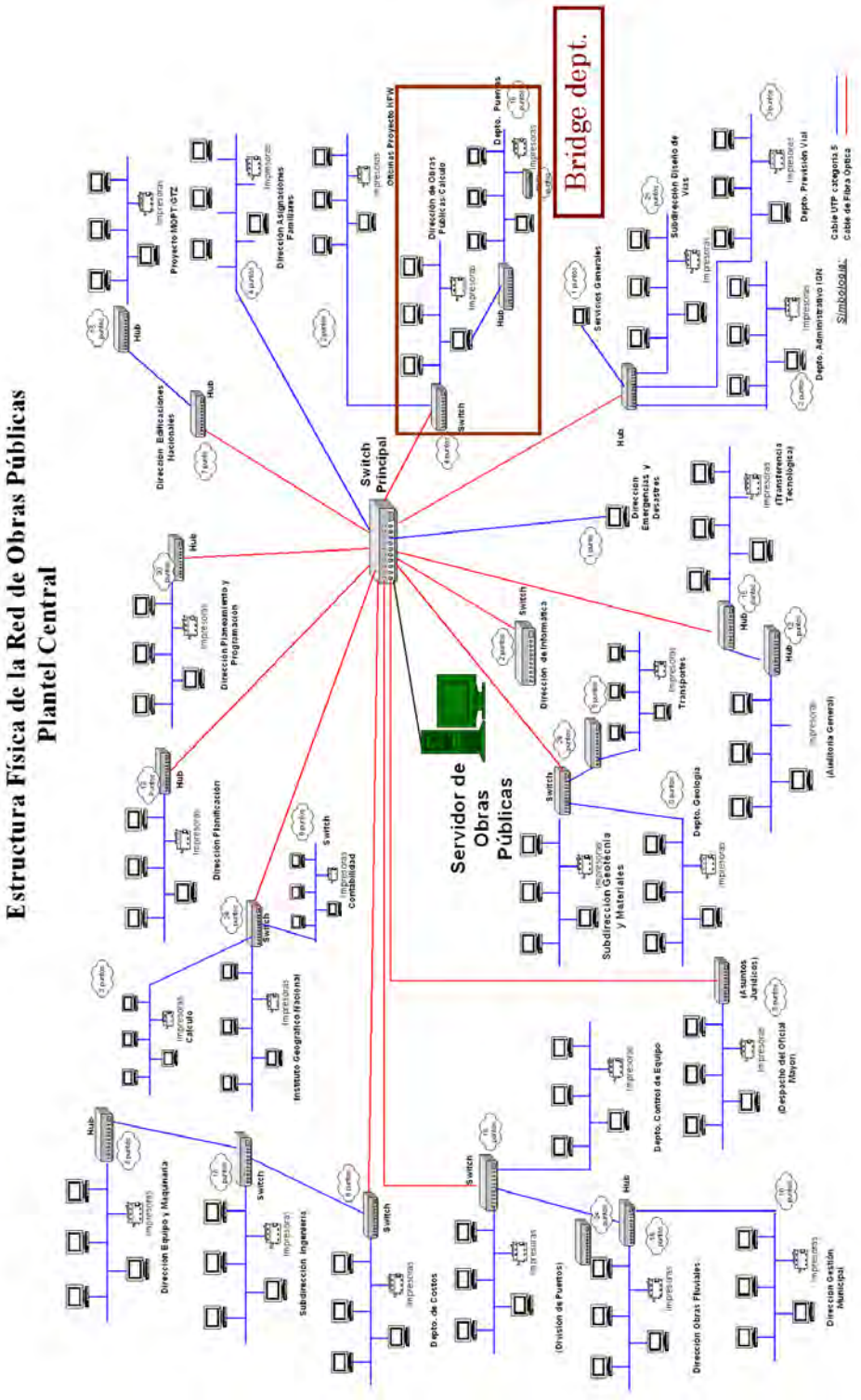


Figure 14.2.1. Network in the Public Works Division

2) Wide Area Network (WAN)

The network connections between the MOPT, the CONAVI and the Local Government are shown in Figure 14.2.2. The CONAVI and several Local Governments are connected by the exclusive lines and the other Local Governments are connected by the Modems through the general lines.

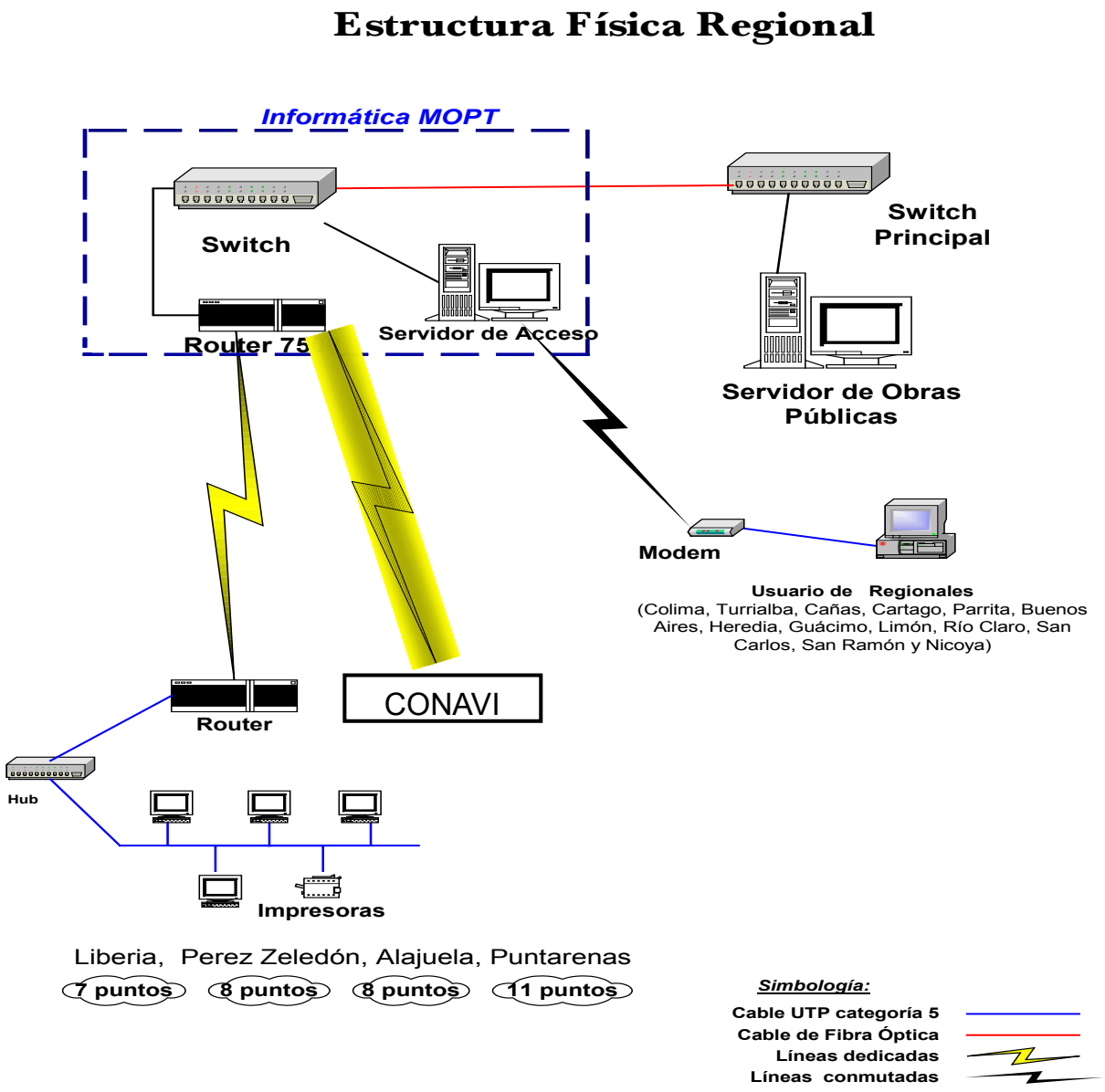


Figure 14.2.2. Network Connection between the MOPT, the CONAVI and the Local Governments

14.2.3 Road and Bridge Management System

1) Condition of the Existing System

The Road Management System which utilized in the MOPT are shown in Table 14.2.2.

Table 14.2.2. Existing Systems for Road Management

System	Description
SPEM (Pavement)	The SPEM is developed by German engineers in 1993 for the management of local roads. A German engineer still supports the system and the system is managed in good condition. Utilizations of the system are limited within the MOPT
HDM4 (Pavement) （DESYROUTE, DESTSEMI, DESYVISAGI）	Annual action plan for road maintenance is studied through economic analysis, prioritization for maintenance of road, prediction of deterioration by using the HDM4. The locations for maintenance of roads are finally selected by the CONAVI considering the annual action plan and political decisions.
Bridge Management System (BMS)	Bridges are inspected by the inspectors of the Planning Department based on the inspection manual. However, The information is not used by the Bridge Department since the inspectors are not bridge engineers. The Bridge Department maintains drawings of bridges and manages to support requests from other departments.

2) Existing Issues

The issues for the existing information systems for the roads and the bridges in the MOPT are as follows:

- Number of computers and the skills of the staff for the system in the Local Governments are not sufficient.
- The information is not unified within the MOPT, the CONAVI and the Local governments.
- The systems are developed by each department separately and they are not common systems within each department.
- Exchanges of information are not sufficient when the systems are developed by each department and some indispensable information and functions for the bridge management do not exist in the systems.
- Drawings and photos of bridges are not registered in the database and do not utilized commonly.
- The bridge inspectors are not trained and the bridge inspections do not carried out properly. The criteria for prioritization of bridge repair are not clear.
- The systems offered from an abroad can not be maintained continuously and the systems are utilized in ad hoc.

3) Recommendation for System Improvement for Bridge Maintenance

The recommendations for the improvement of the existing systems to adopt the bridge maintenance are as follows:

- Training computer skills for the staff of the Local Governments
- Share information between the MOPT, the CONAVI, and the Local Governments
- Exchange information and technical cooperation between the relevant departments for the system development.
- Effective use of the image information including drawings and photos.
- Establish a bridge inspection manual and training the bridge inspectors.
- Develop an evaluation systems for the prioritization of repair.
- Training of the system engineers and establishes organizations for the system maintenance.

14.2.4 System Development

The total road management system (SIGVI) is now under development as future system by the Public Works Division in the MOPT. The system is improved from the existing road management system (SPEM). The system is developed by the Planning Department in the Public Works Division and the Bridge Division is not involved for the system development. Participation of the Bridge Department for the system development is inevitable especially for the bridge parts in the system. It is necessary to improve the skills of the local office staff for the personal computer to manage the SIGVI effectively. Consequently, the MOPT start a plan with following steps for a full dress exploit of the SIGVI.

a. Install new computers in the local offices.
b. Training the local office staff to improve the skills of massage for the existing SPEM system.
c. Start exploit of the SIGVI.

Table 14.2.3. Total Road Management System (SIGVI) (1/2)

Item	Description
Progress of System Development	The system is developed as improved version of the SPEM. The system manages information including pavements, national highways, bridges and marine ports.
Objective	The system is for the total road management including management of inventory and support to establish an annual action plan for maintenance of roads.
User	Staff of the MOPT, the CONAVI and the Local Governments
System Composition	Decentralized data base system (C/S system)
Application software	- Visual Basic6.0 - SQL Server7.0 - Access2000
Data managed	- Basic Data including inventory and inspection. - Data for cost estimations including construction methods, labor costs, equipment, and unit costs of the construction methods. - Information of users including their name, department and post.
Function	- Management of inventory data - Rough cost estimation for the maintenance of pavements. - Support to establish an annual action plan. - Output data into Excel files

Table 14.2.3. Total Road Management System (SIGVI) (2/2)

Item	Description
Security Management	・ User Identification Identify a user who tries to enter the system by the name of the user and the password corresponds to the commission of the users. ・ Decentralization of data base. A SQL server is utilized as a database and the data is synchronized with the Access2000 in the offices within the network. The data could be protected and available even if the SQL server is out of order.
Additional Function in Future	・ Management of image data. The image data such as the drawings and the photos are not maintained in the existing system. It is possible to introduce the data into the system. ・ Control the location by Map While no Map system is utilized in the existing system, a Map system shall be added in the system. The GIS data created by the Arc-Info are already exists in the system.
Issues	・ While the bridge data are exist in the system, it is developed by the Planning Department referring to the bridge data system developed in Guatemala. Opinions of the Bridge Department are not reflected in the system. It is necessary to investigate indispensable data for the bridge management between the Planning, the Bridge and the Information Department ・ The functions for prioritization of bridge repair shall be added.
Note	The bridge data maintained in the SIGVI are as follows: The vertical clearances under girder, The heights of curbs, The gradients, The cross grades, The sight distances, The road signs, The medians, The lights, The radius of curves etc.

The total image regarding the management of the existing system, the flow of the information and the system development are illustrated in figure 14.2.3.

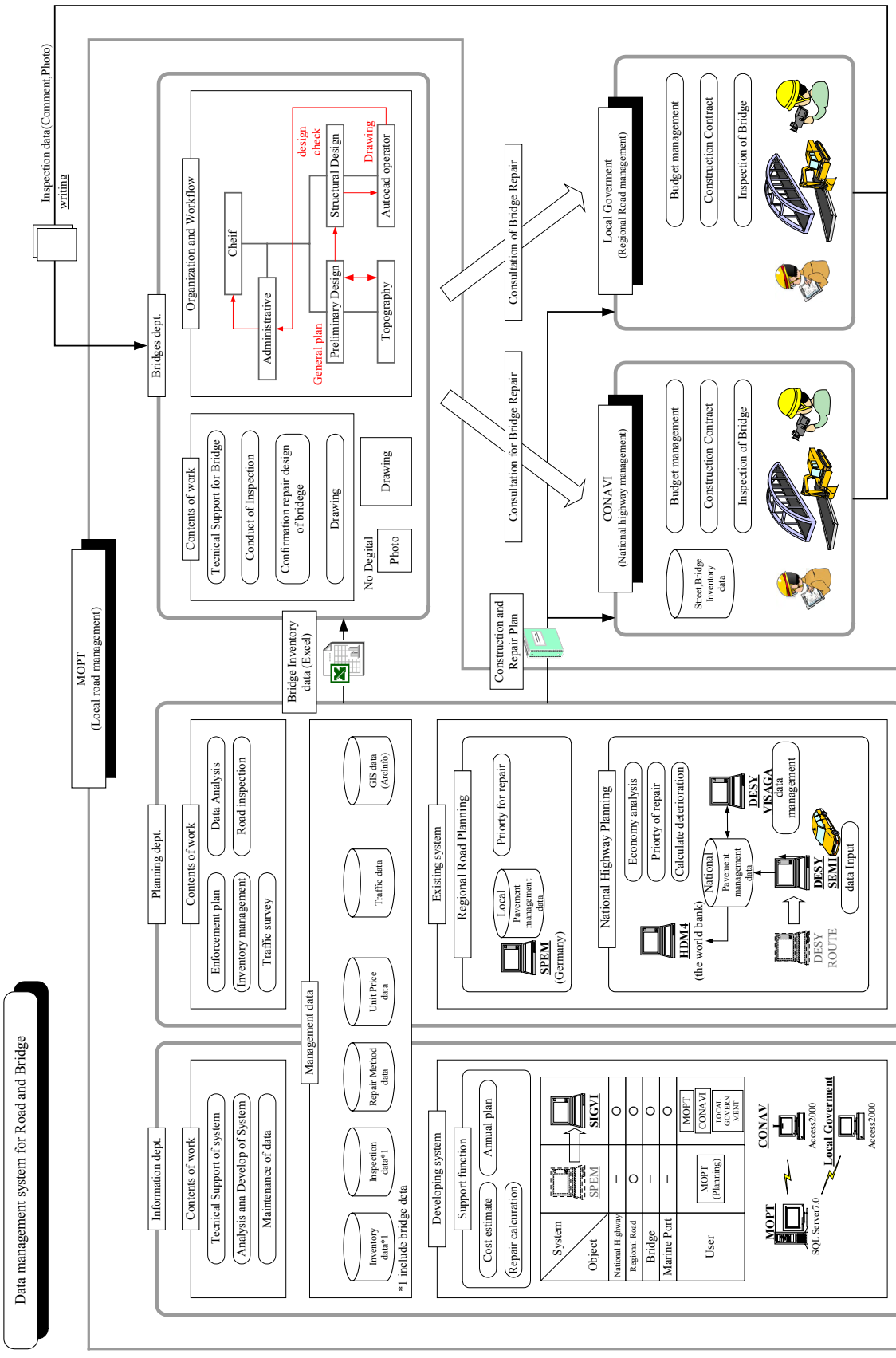


Figure 14.2.3. Existing System of the MOPT, the CONAVI and the Local Governments and System Development Plan

14.3 Bridge Management System (BMS)

The basic concept of the bridge management system (BMS) and the method of operation for the system are discussed in this section.

14.3.1 Objective of the System

The Bridge Management System (BMS) is the decision support tool responsible for managing the inspection, the analysis and the maintenance for the numerous components that makes up a bridge. The bridge inventory, the bridge deficiency and the analysis for the evaluation of the data are organized in the BMS.

14.3.2 Concept of the System

The system supports the record of the data for the bridge maintenance and the bridge maintenance activities utilizing the data base. The concept of the BMS is shown in Figure 14.3.1.

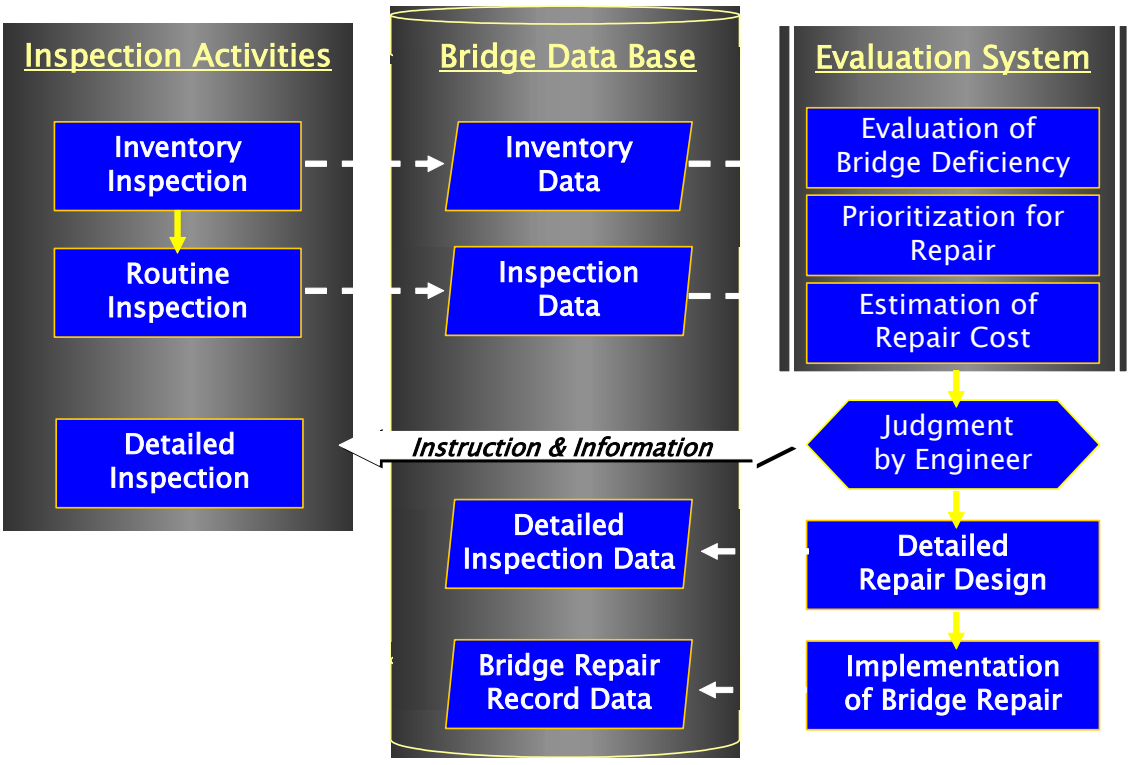


Figure 14.3.1. Concept of the BMS

1) Concept of Functions in the System

The concepts of the functions in the system are as follows;

(1) Function for the registration and the renewal of the data

The bridge inventory data include the dimensions of the bridges, the photos, the drawings and the comments for the bridge condition are registered and renewed into the bridge inventory data and the bridge inspection data. The bridge inspection data include the results of the evaluation of the deterioration of the bridges, the comments and the photos. The access to these data shall be allowed only for the authorized administrator of the BMS.

(2) Function for the administration of data

The registered data in the data base are able to access and retrieve from the data base by the user who has concern to the bridge management. The data base store numerical and literal data and the image data such as the photos and the drawings of the bridges. The other relevant data are recorded in a folder of the concerned bridge.

(3) Function for support a bridge repair

The system has a function to manage a plan for the bridge repair based on the inventory data and the inspection data. The function includes evaluation of the bridge deficiencies, the prioritization and the cost estimation for the bridge repair.

(4) Function for the data retrieve

The data stored in the system is able to be retrieved into the formats. The data that are available from the system are:

1. The Bridge Inventory Data including the general dimensions of a bridge, the dimension of a superstructure.
2. The Bridge Inspection Data including the inspection results, the photos of damages of a bridge.

(5) Function to show a location of a bridge

The location of the concerned bridge is plotted on the map utilizing the coordinate of the bridge. It is possible to highlight to make clear the bridge location by selecting the bridge from the table.

14.3.3 System Component

The system consists of a saver and clients (C/S type system) and every data are administrated by the saver. The system component and the environment of the operation and the data stored in the system are shown in Figure 14.3.2. When the file server is not available, all data shall be stored in the data base server.

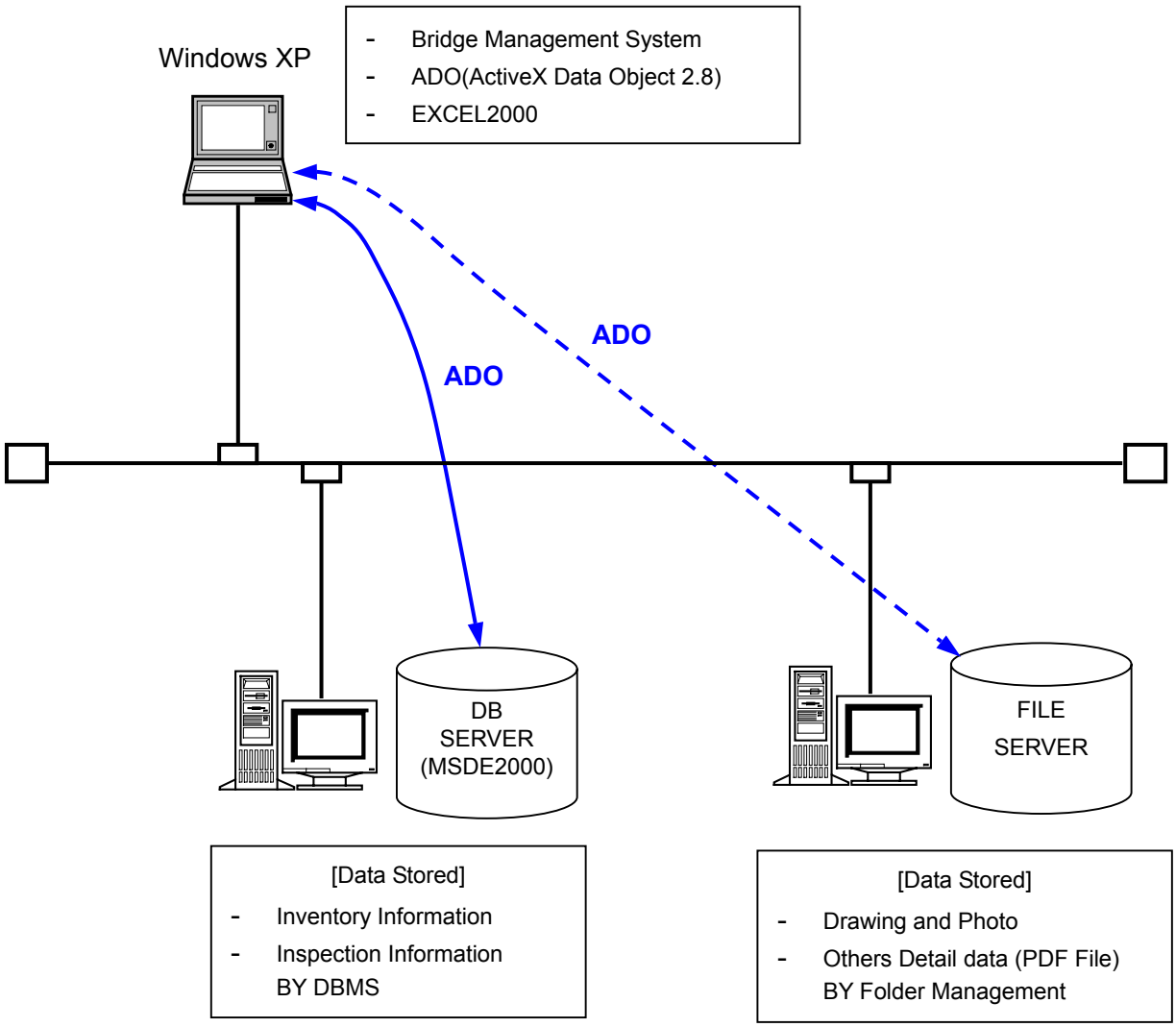


Figure 14.3.2. Hardware Components of the System

14.3.4 Tools for the System Development

The tools for the system development are as follows:

1. The Language: Visual Basic Version 6.0
2. The Data base management system: Access 2000 and MSDE 2000
3. The Connection of data: ADO (Active X Data Object 2.8)

14.3.5 Environment for the System Operation

The tools for the system development are as follows:

1) Client Computer

1. The Central Processing Unit (CPU): The Pentium4 2.0giga-hertzs (GHz) or more progressed CPU.
2. The Operation System (OS): The Windows XP Home Edition or Professional
3. The Screen: The Screen with 1024 x 768 dots or more.
4. The Hard Disk (HD): The HD with 50 mega-bytes(GB) or more storage capacity.
5. The Soft wear: The Excel 2000

2) Data base (DB) Server

1. The CPU: The Pentium4 3.0 GHz or more progressed CPU
2. The OS: The Windows XP Server or Professional
3. The Hard Disk (HD): The HD with 5 GB or more storage capacity.
4. The Soft wear: The Micro Soft Data Editor (MSDE) 2000 (SQL Server)

3) Image File Server

1. The CPU: The Pentium4 2.0 GHz or more progressed CPU
2. The OS: The Windows XP Server or Professional
3. The HD: The HD with 200 GB or more storage capacity.

The required file size for the image data including the photos and the drawings is shown in Table 14.3.1.

Table 14.3.1. Required Image File Size

Item	InventorySheet (MB)			Inspection Sheet (MB)			Detail Inventory Sheet (MB)		
	Count	Unit Size	Sum	Count	Unit Size	Sum	Count	Unit Size	Sum
Photo	30	0.2	6	40	0.2	8	40	0.2	8
Drawing	1	1.5	1.5	—	—	—	5	1.5	7.5
Frequency	1			5			5		
Subtotal	7.5			40			77.5		
Total (1Bridge)	125								
*1300 Bridges	162,500								

14.3.6 System Operation

The concept of the Bridge Management System is shown in Figure 14.3.3.

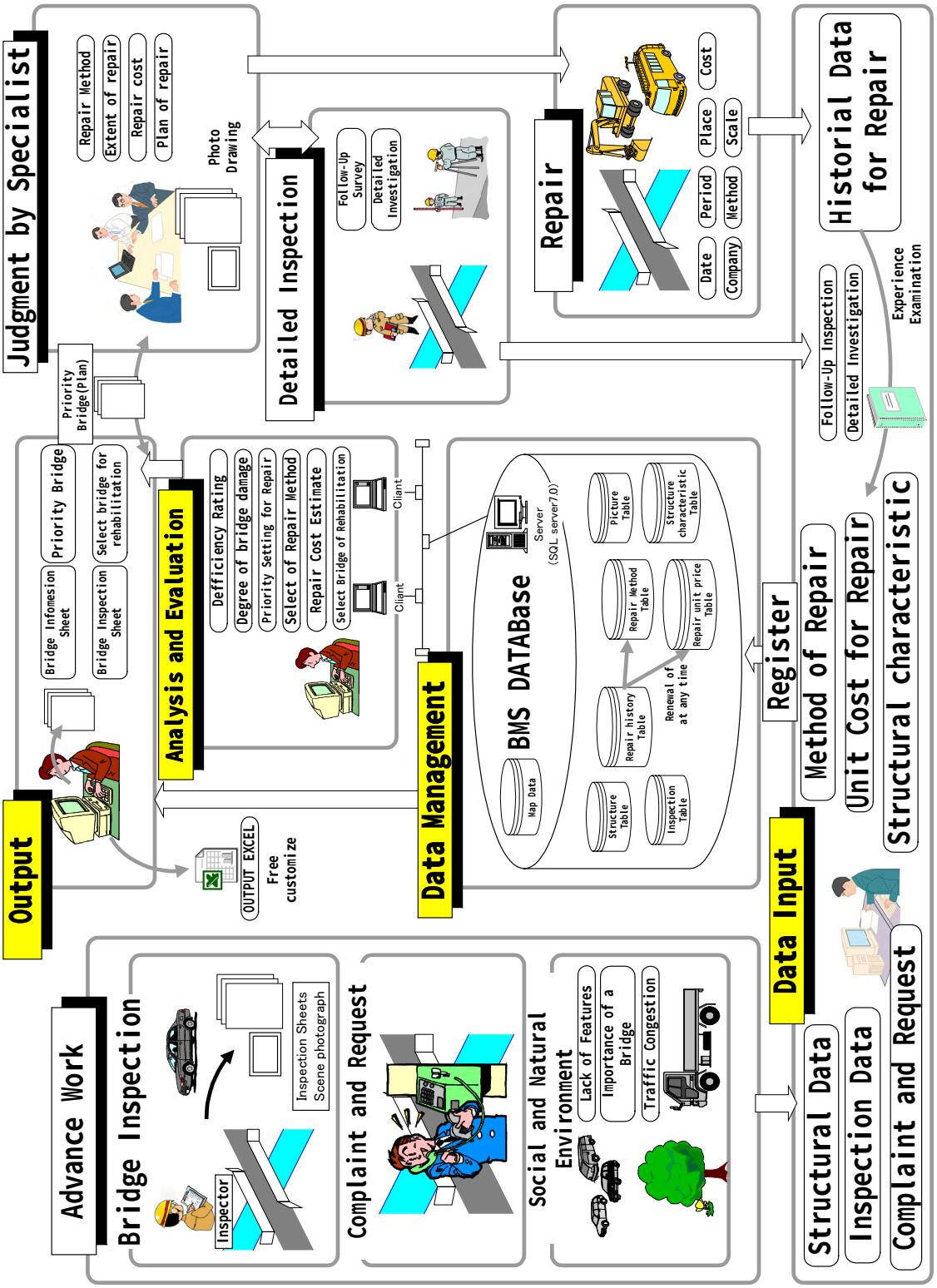


Figure 14.3.3. Concept of the Bridge Management System

1) Authority for the access to the System

The expected users for the system are the bridge engineers, the inspectors, the bridge planners and the system administrators. Every user has an authority to access and retrieve the data in the system however only the system administrator has authority to modify the data in the system. When the inspector carried out the bridge inspection, the inspection data shall be updated through the system administrator. The engineer has responsibility to transfer the information such as the bridge inventory, the photos, the drawings, the repair cost and the other relevant detail of the bridge to the system administrator when a bridge is repaired or improved.

2) The Organization for the Maintenance of the Data Base

The data base for the BMS will be maintained by the organization as shown in Figure 14.3.4. The final data shall be registered by the system administrator to keep the consistency of the data base.

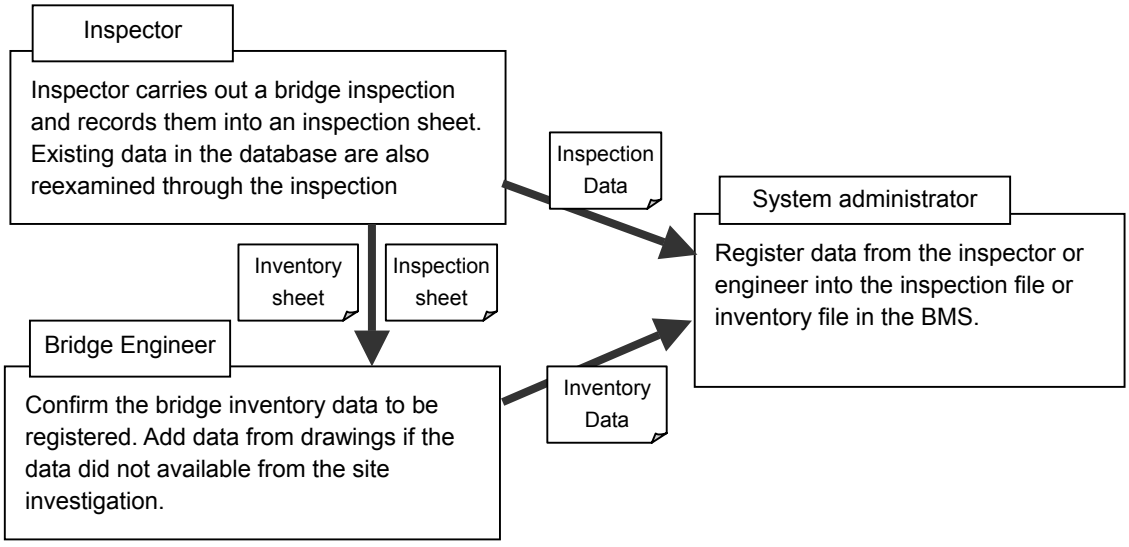


Figure 14.3.4. Organization for the construction of the Data Base

14.3.7 Process of a Data Registration

1) Registration of the System data

The inventory data and the inspection data are registered in the data base. The data base are processed to evaluate the degree of bridge deficiency, the priority of bridge repair and the repair cost in the system. The data base is established by the following procedure.

(1) Bridge Inventory data

A complementary bridge inventory survey shall be carried out as much as possible together with the bridge inspection. The bridge inventory data are processed by the following procedure:

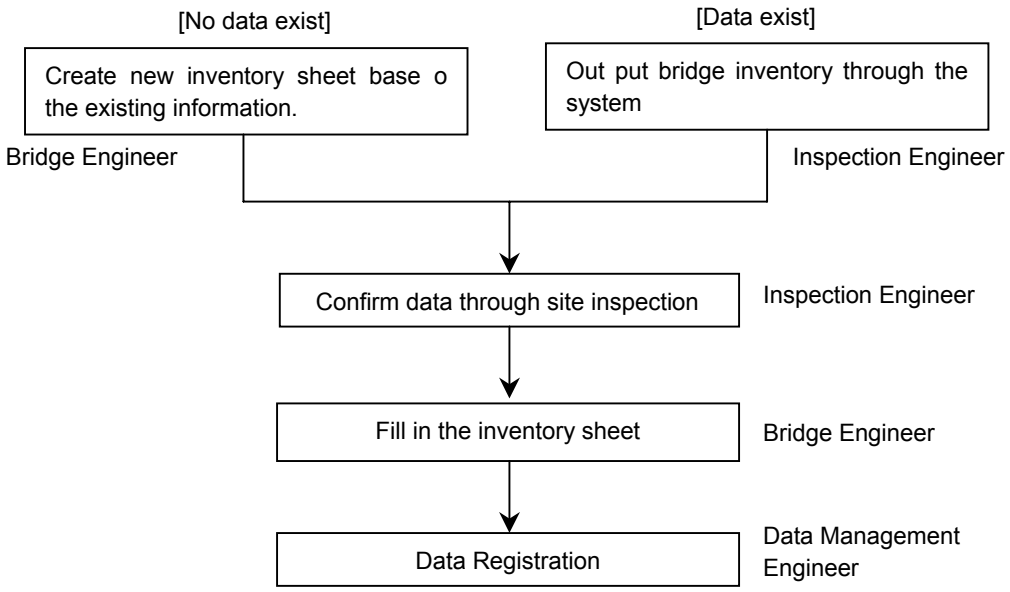


Figure 14.3.5. Process of the Inventory Data Registration

(2) Bridge Inspection Data

The bridge inspection data are processed by the following procedure.

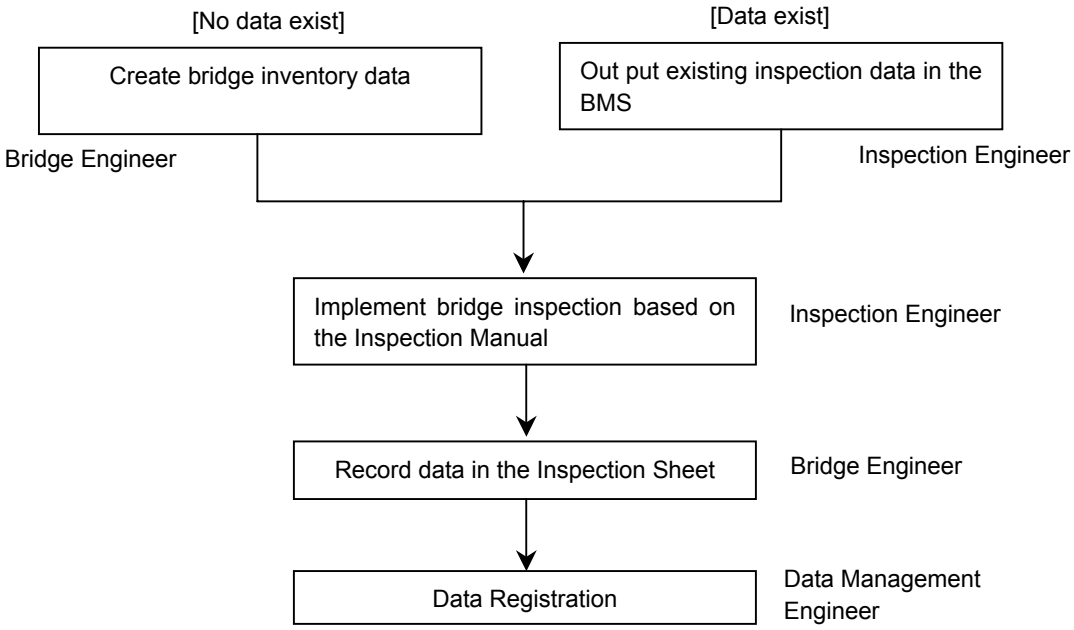


Figure14.3.6. Process of the Inspection Data Registration

(3) Other relevant bridge information

Other relevant bridge information includes the information of repair or the reinforcement of the bridge shall be registered into the system. The process of the registration of the relevant data is shown in Figure 14.3.7.

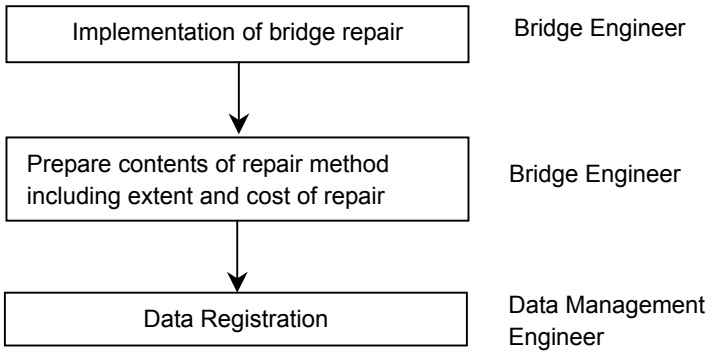


Figure14.3.7. Process of the relevant data registration

2) Image Data Registration

(1) Photo Data

The photo data shall be recorded by the digital camera and the size of the photo shall be 800 x 600 pixels (SVGA). The photo data in the JPEG file shall be registered in the system.

(2) Drawing Data

When the original drawings of the concerned bridge exist, the drawings shall be scanned to register the BMS. If the stain on the drawing is not negligible, the stain shall be clean up before scanning. When drawings are not available, new bridge plans shall be created by the computer aided design system (CAD) based on the inventory data. The JPEG type file shall be used for the drawing data and the size of the file is within 1.5 mega bites.

3) Coordinate of the Bridge

A bridge coordinate is one of the most important information to confirm a bridge location. The Global Positioning Satellite (GPS) system is used to record the coordinate. The bridge location which recorded by the GPS shall be the center of a bridge.

14.4 Operation for the System

14.4.1 Movement of the Display

The movement of the display of the BMS is shown in Figure 14.4.1.

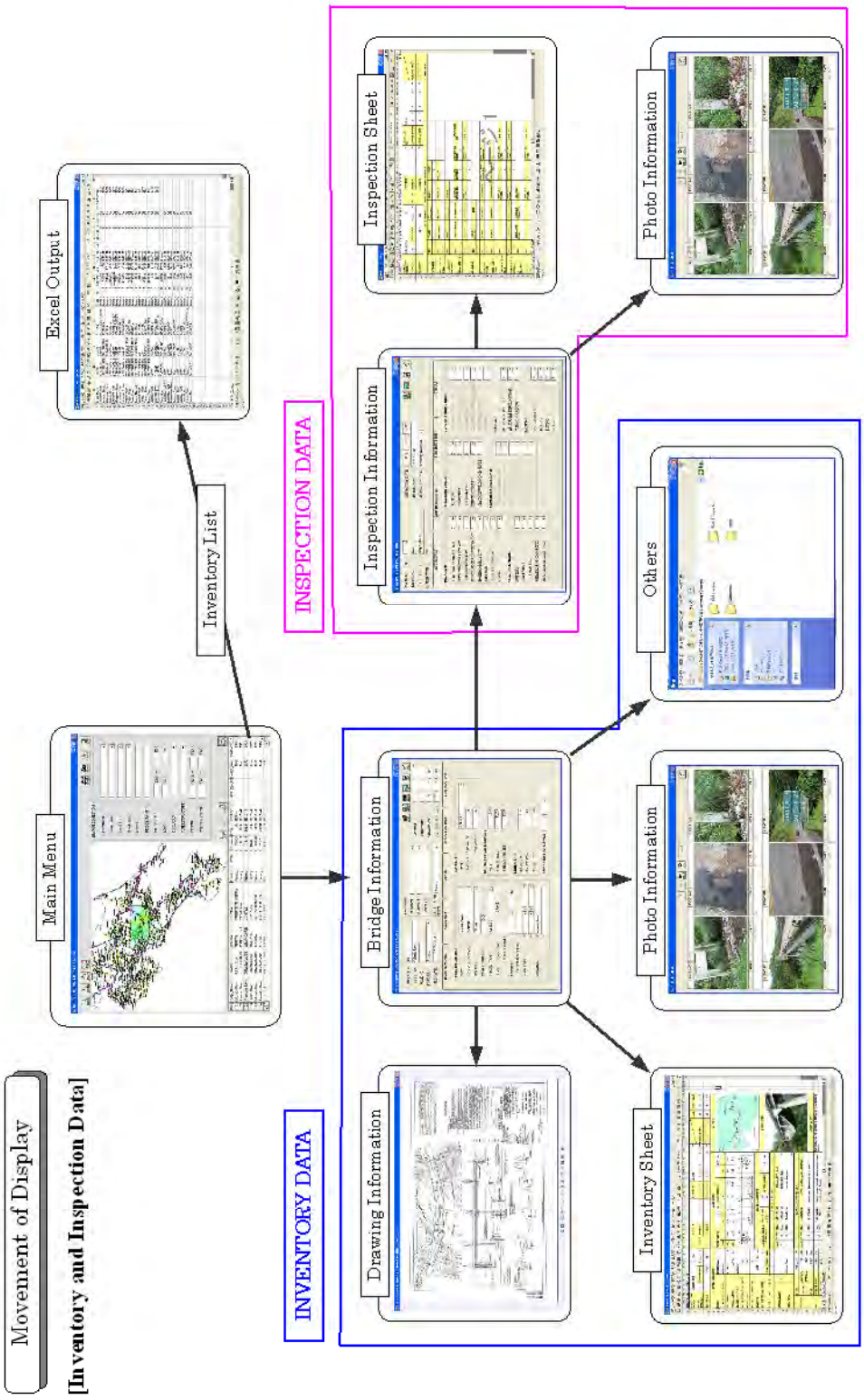


Figure 14.4.1. Movement of the Display (1/2)

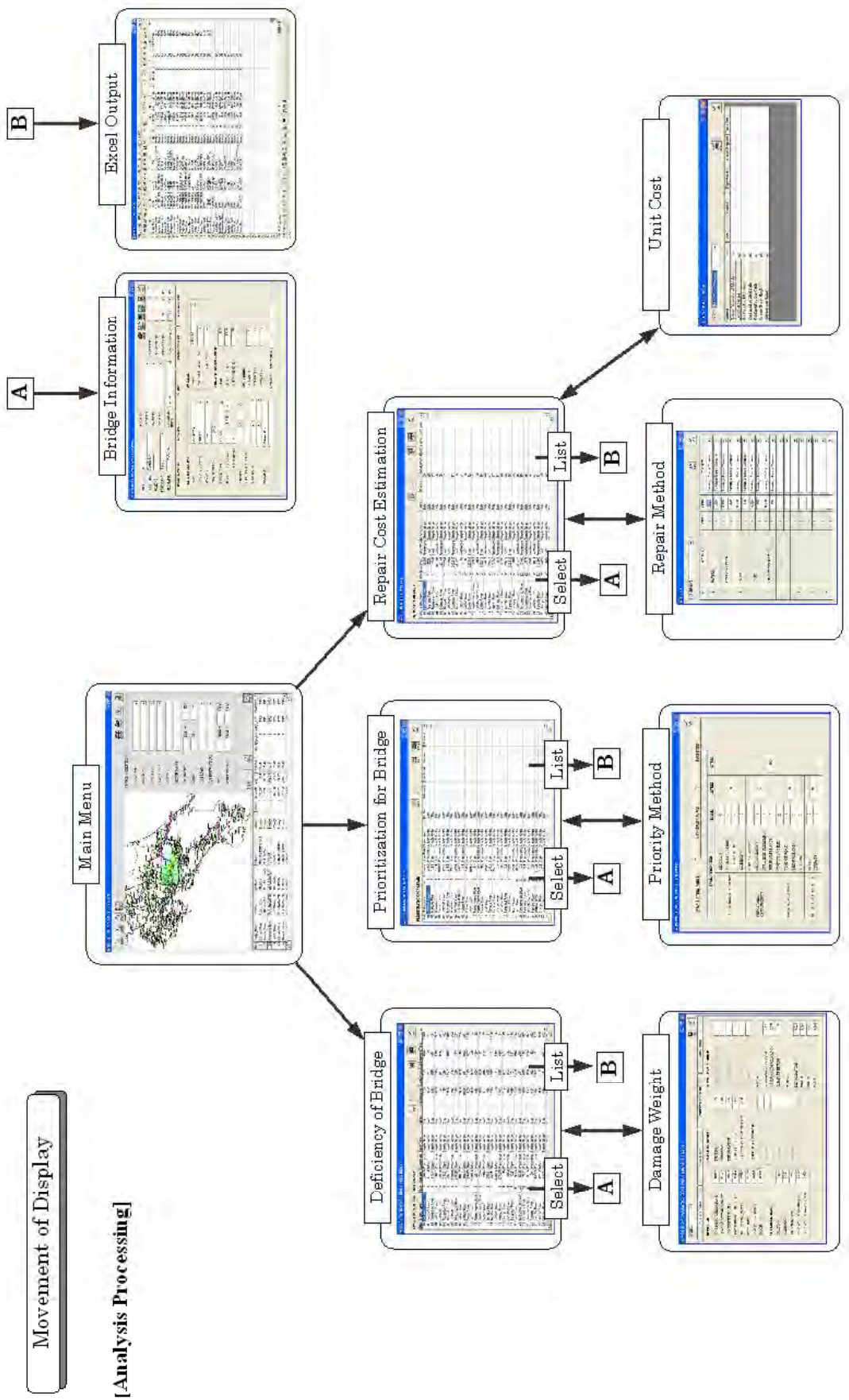


Figure 14.4.1. Movement of the Display (2/2)

14.4.2 Flow of the System Operation

1) Retrieval of the Bridge Inventory

The flow of the retrieval of the basic bridge inventory data including the bridge dimension, the drawings and the photos after the access to the concerned bridge is shown in Figure 14.4.2.

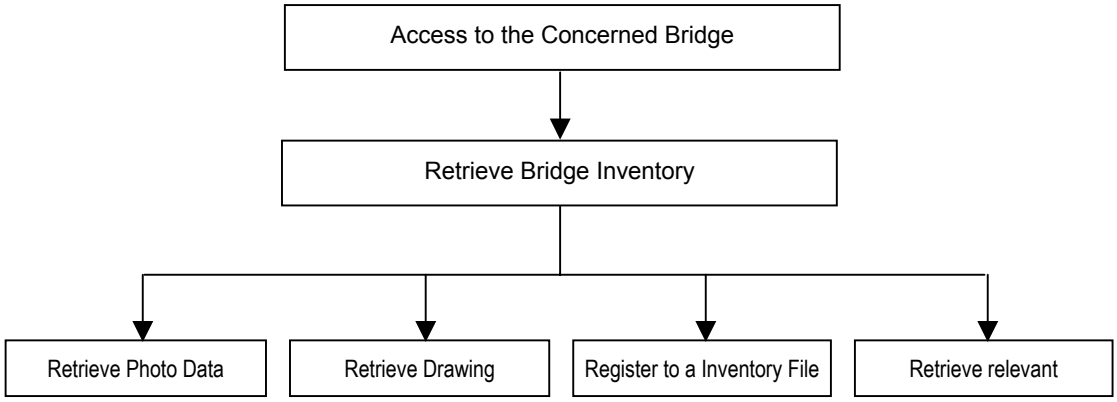


Figure 14.4.2. Retrieval of the Bridge Inventory Data

2) Retrieval of the Bridge Inspection Data

The flow of the retrieval of the inspection data from a list of bridge elements after access to the concerned bridge is shown in Figure 14.4.3.

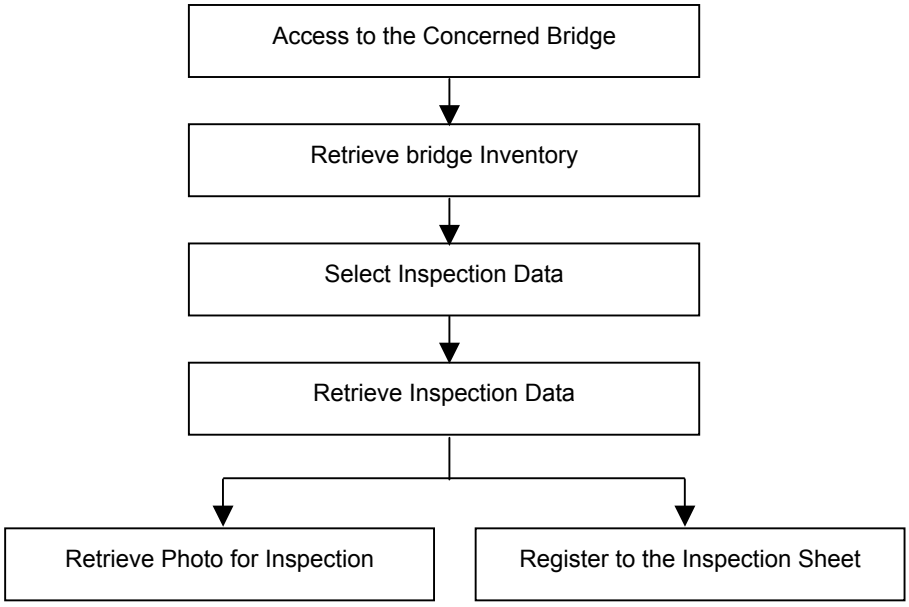


Figure 14.4.3. Retrieval of the Bridge Inspection Data

3) Evaluation of the Bridge Deficiency

The total bridge deficiencies are evaluated after the determination the weights of each damage for the bridge elements. The flow of the evaluation of the bridge deficiency is shown in Figure 14.4.4.

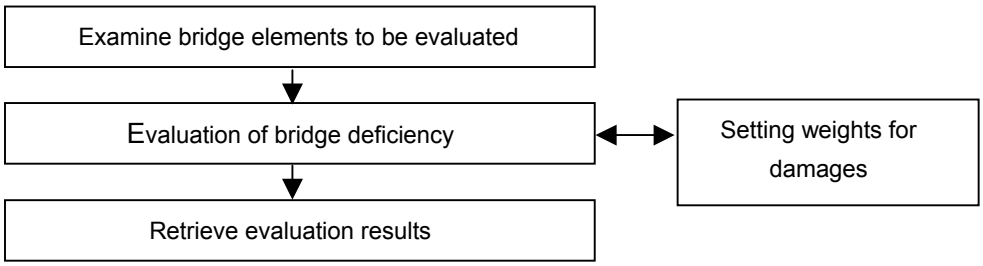


Figure 14.4.4. Evaluation of the Bridge Deficiency

4) Prioritization for the Bridge Repair

The priority for the bridge repair will be carried out after a selection of items for the prioritization for bridge repair and determine the weights for each item. The flow of the prioritization for the bridge repair is shown in Figure 14.4.5.

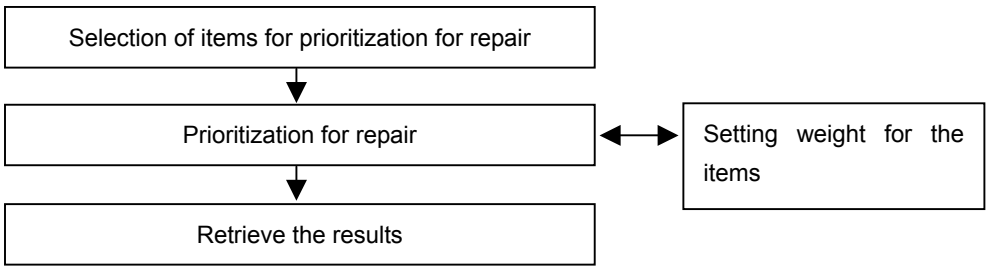


Figure 14.4.5. Prioritization for Bridge Repair

5) Cost Estimation for the Bridge Repair

The bridge repair costs are estimated after the selection of the standard repair methods and their unit cost. The flow of the cost estimation is shown in Figure 14.4.6.

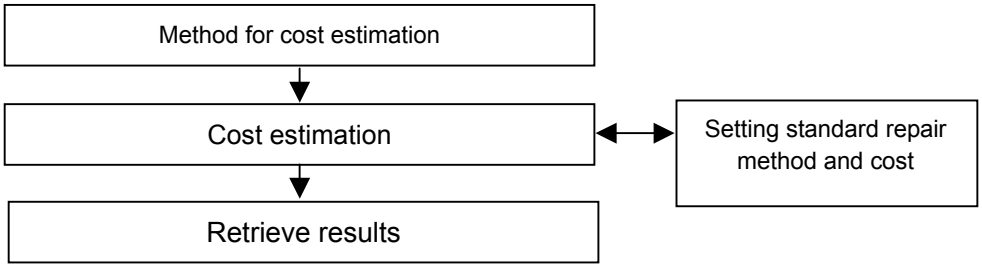


Figure 14.4.6. Cost Estimation for the Bridge Repair