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**A PROPOSED FAHP-BASED TECHNOLOGY SELECTION AND  
SPECIFICATION METHODOLOGY**

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by

*Kin Chung Liu*

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## APPENDIX A – USE CASE DIAGRAM (CASE STUDY III)

The following use-case diagram is extracted from the requirement specifications of the RFID-based tracking and planning system.

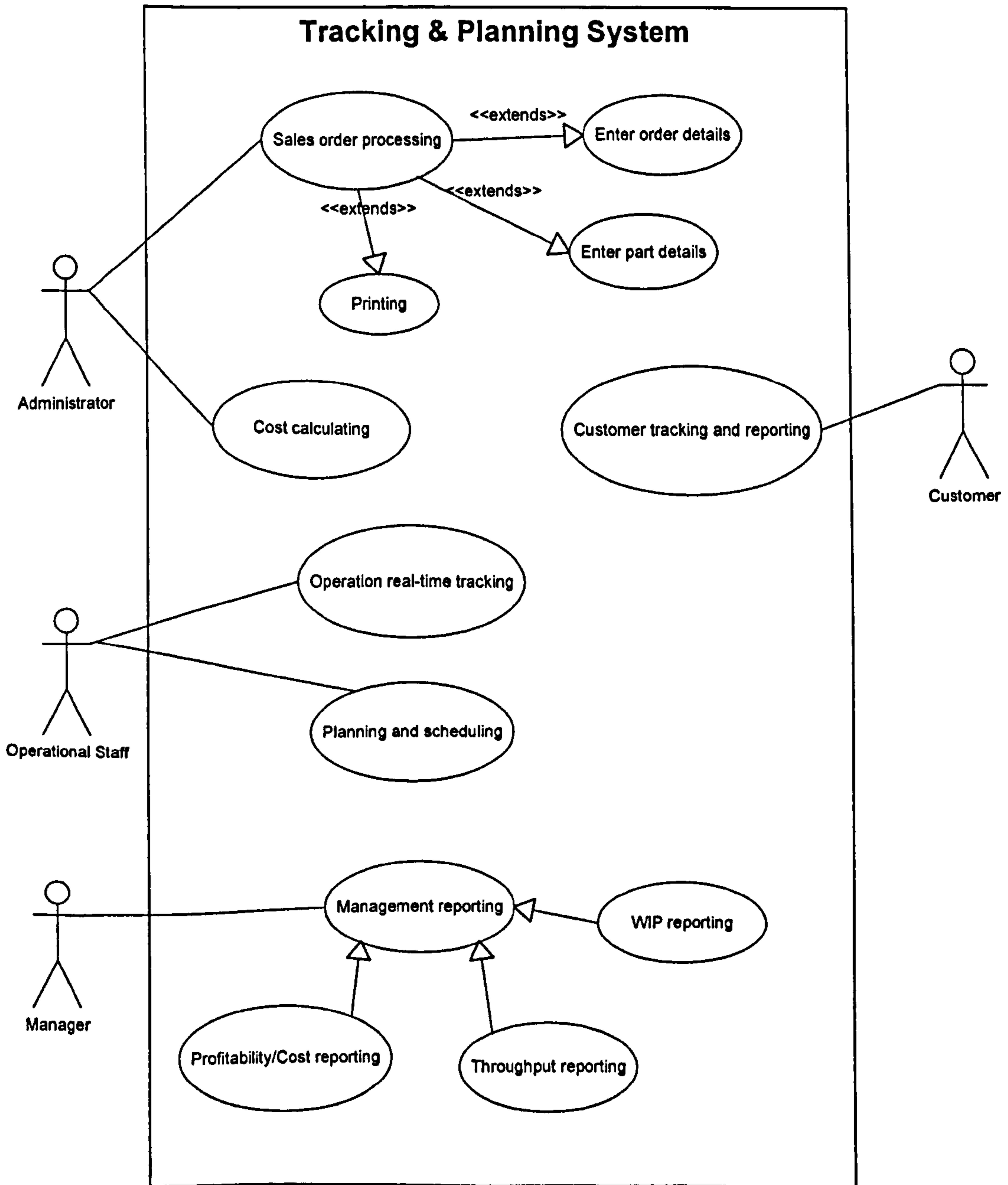


Figure A.1 Use case diagram  
(source: Requirement specification document for the RFID-based tracking and planning system)

## APPENDIX B – PHASE 3 RESULTS FOR CASE STUDY III

This appendix documents the *phase 3* results for the case study III. Through solution decomposition in *phase 2*, there are twelve solution components identified with six of them gone through *phase 3* for solution component decomposition processes.

Thereby, this document will be divided into 6 sections with each section includes the results for one of the solution components. Each section contains the identified goal and means-objectives resulted from *step 3.1* and a complete AHP-based hierarchy model resulted from *step 3.1*.

### 1. Tracking technology

Goal: *define and specify the best-fit tracking technology*

Table B.1 The means-objectives for tracking technology

Fundamental-objective	Means-objective(s)
Implementation cost	Purchasing cost, software development cost, easiness and cost of installation
Operational cost	Cost for data carrier, maintenance cost, cost for manual operation
Efficient data capturing	Data capturing time, reading range
Reliable data capturing	Data capturing accuracy, low data error rate, environmental susceptibility
Fast, real-time tracking data update to system	Data transmission media, network protocol, operational speed
Maintainability	Resource for repairing and replacement
Availability	Resource for repairing and replacement, operational stability



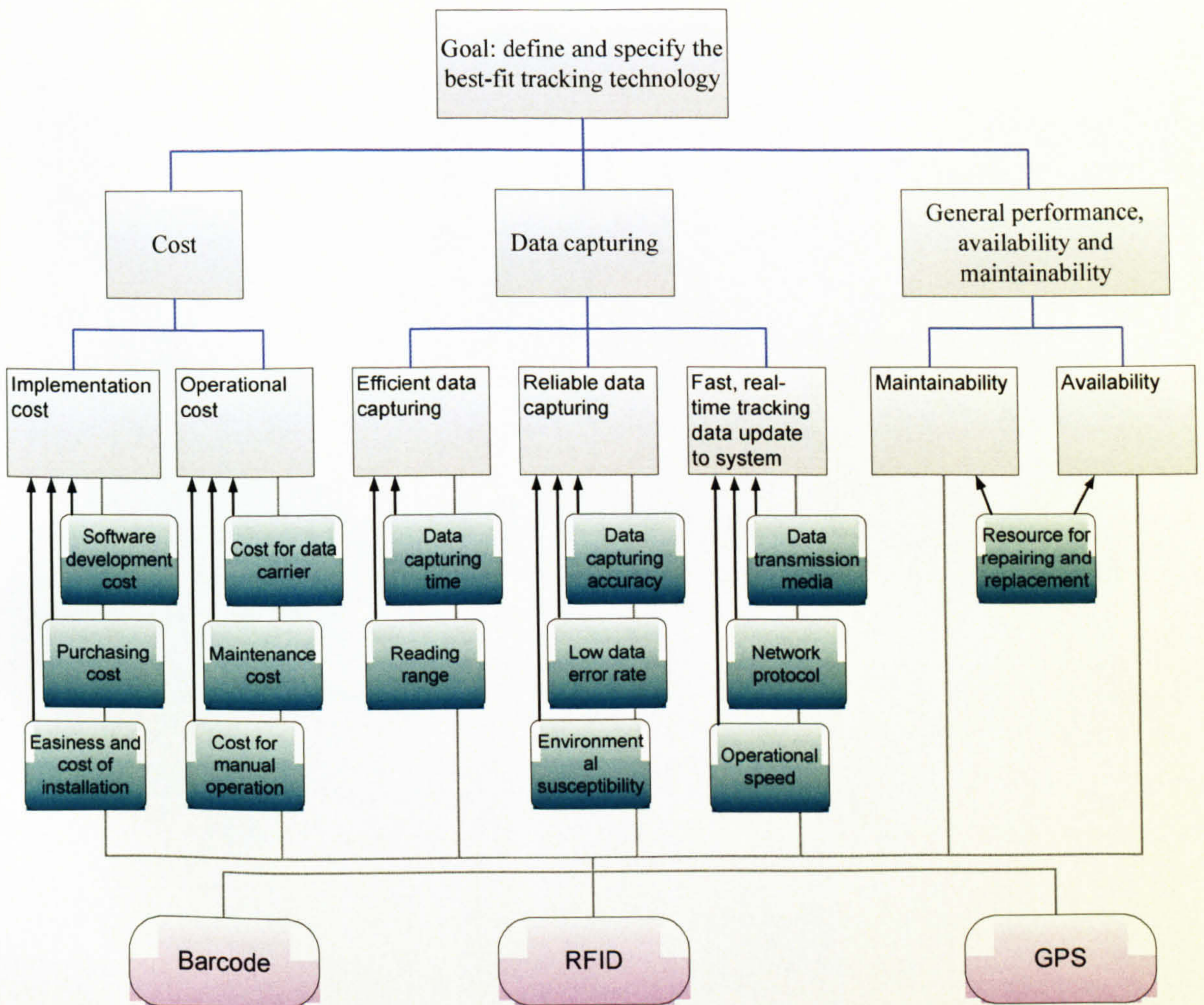


Figure B.1 The complete AHP-based hierarchy model for tracking technology

## 2. Software platform (intranet application)

Goal: *define and specify the software platform for intranet applications*

Table B.2 The means-objectives for software platform (intranet application)

Fundamental-objective	Means-objective(s)
Intranet accessibility (intranet applications)	Compatibility to various intranet-based protocols
Implementation cost	Purchase cost, setup cost
Fast, secured business data transaction (for SOP, Planning and scheduling)	Data management capability
Sufficient processing and memorial power	Low resources requirements
Efficient job card printing	Efficient serial interface, compatible to job card printer's software driver
Maintainability	Resource for repairing and replacement



Availability	Resource for repairing and replacement, operational stability
MS Windows compatible (SOP)	Compatibility to MS Windows

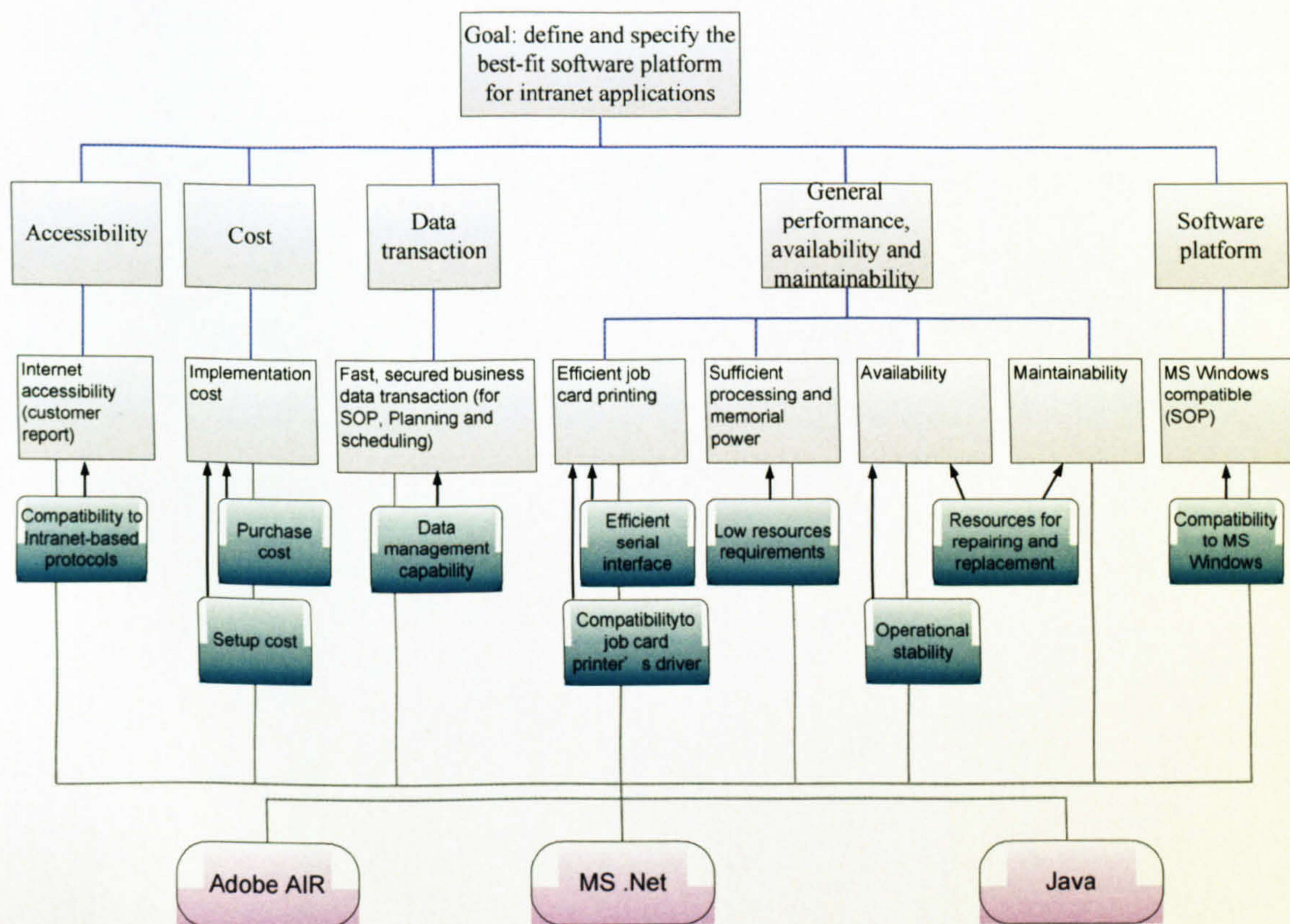


Figure B.2 The complete AHP-based hierarchy model for software platform (intranet application)

### 3. Software platform (Internet application)

Goal: *define and specify the software platform for Internet applications*

Table B.3 The means-objectives for software platform (Internet application)

Fundamental-objective	Means-objective(s)
Internet accessibility (customer report)	Compatibility to various internet-based protocols
Implementation cost	Purchase cost, setup cost
Sufficient data storage and data transaction capabilities	Capable to cope with high volume of users' access
Sufficient processing and memorial power	Low resources requirements
Maintainability	Resource for repairing and replacement



Availability	Resource for repairing and replacement, operational stability
Software platform independency (customer report)	Applications independent to client's platform, avoiding software installations on client computers

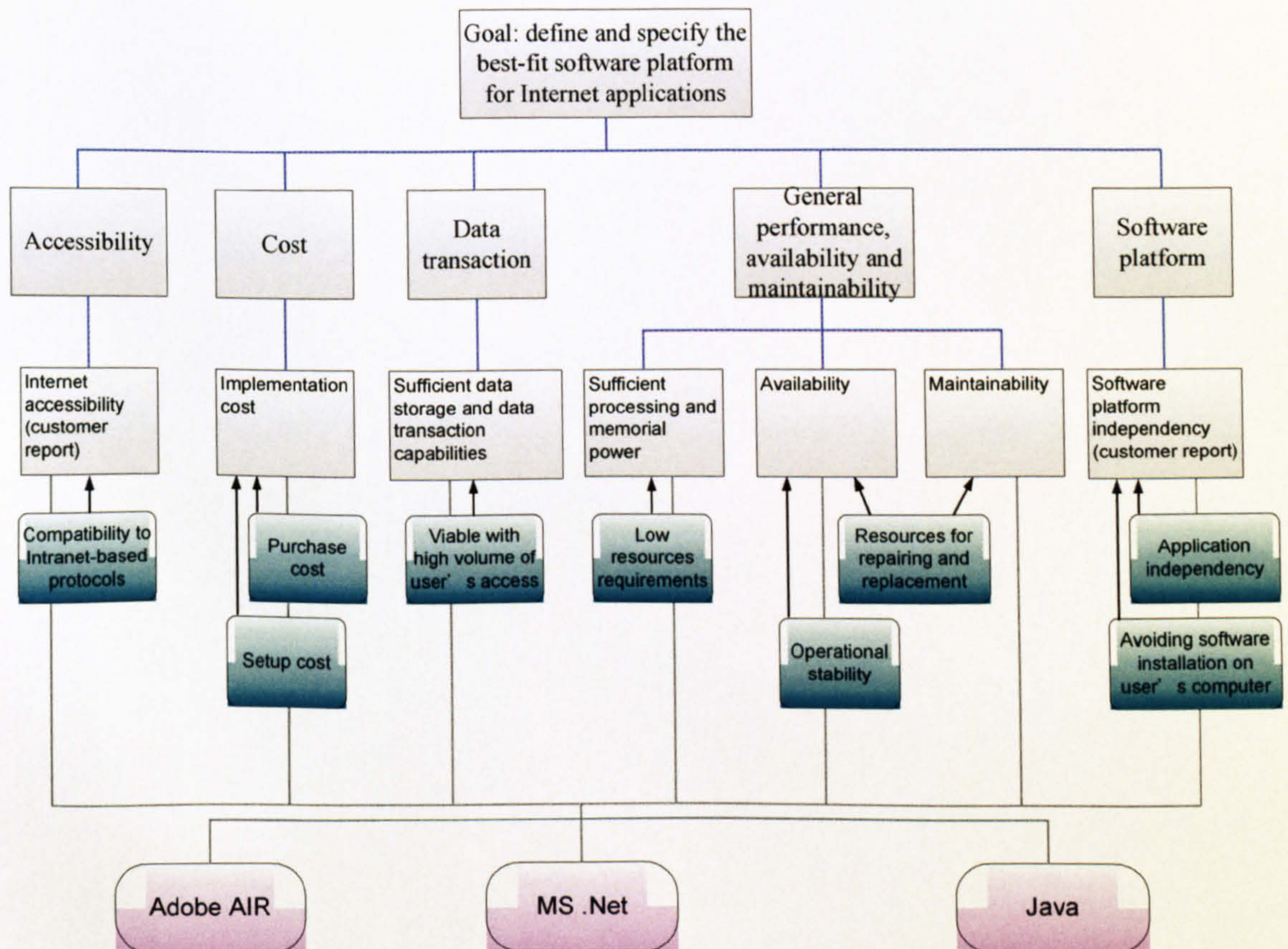


Figure B.3 The complete AHP-based hierarchy model for software platform (Internet application)

#### 4. Database management system

Goal: *define and specify the software platform for database management system*

Table B.4 The means-objectives for database management system

Fundamental-objective	Means-objective(s)
Internet accessibility (customer report)	Accessibility to Internet-based applications
Intranet accessibility (intranet applications)	Accessibility to intranet-based applications



Implementation cost	Software purchasing cost, setup cost
Operational cost	Administration cost, maintenance cost, hosting cost
Fast, real-time tracking data update to system	Efficient data interface to data capturing sub-system
Fast, secured business data transaction (for SOP, Planning and scheduling)	Capability in handling simultaneous accesses, data security
Sufficient data storage and data transaction capabilities	Efficient with huge amount of cumulative data, efficient with continuous frequent accesses
Maintainability	Resource for repairing and replacement
Availability	Resource for repairing and replacement, operational stability

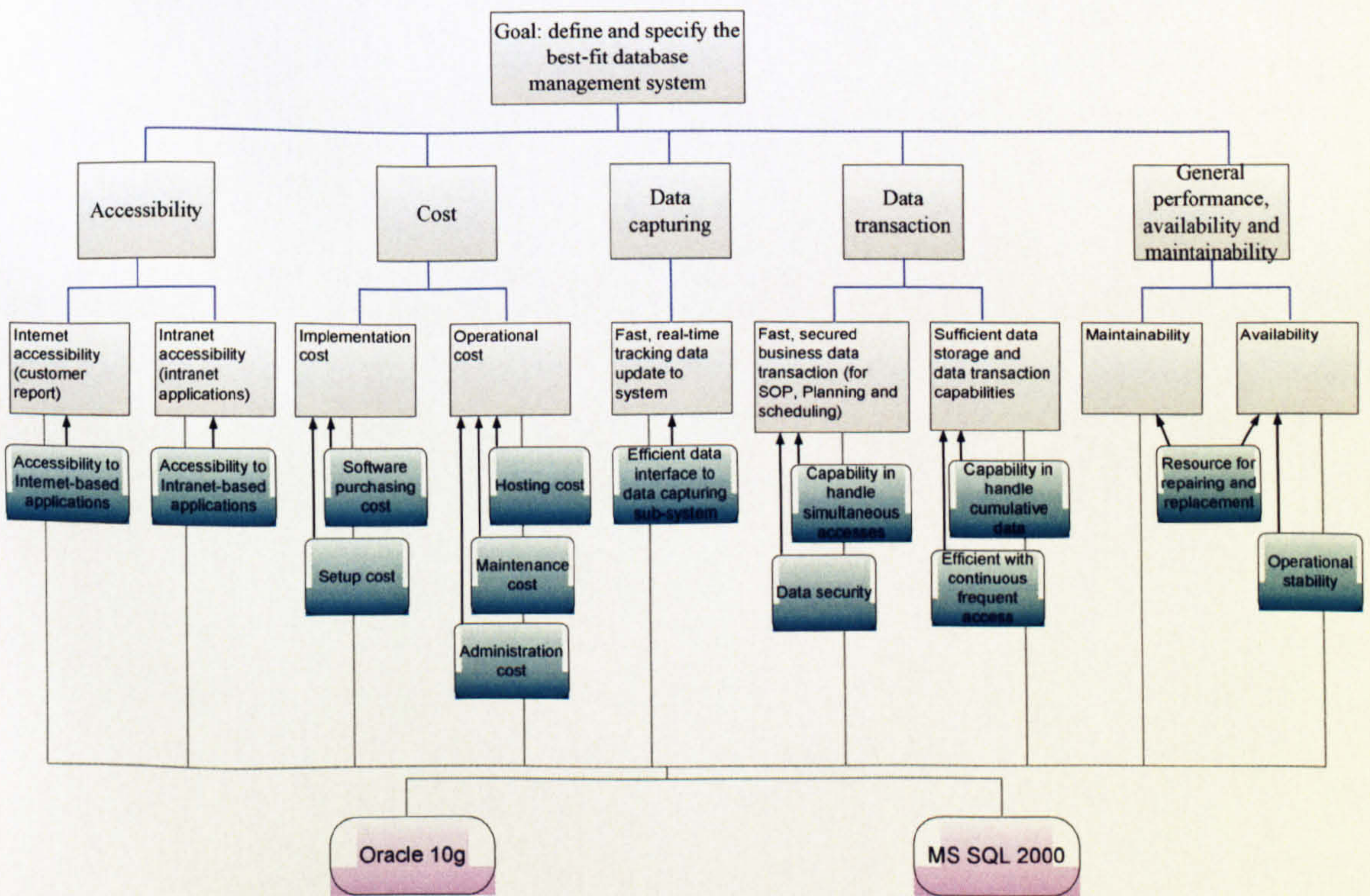


Figure B.4 The complete AHP-based hierarchy model for software platform (database management system)

### 5. User interface (customer reporting)

Goal: define and specify the user interface for customer report functionalities



Table B.5 The means-objectives for user interface (customer reporting)

Fundamental-objective	Means-objective(s)
Implementation cost	Setup cost, software development cost
Sufficient processing and memorial power	Low resources requirements
Software platform independency (customer report)	Avoiding additional software installations, accessibility by different software platform
Report content convertible to file	Direct copy/save data from user interface
Readability and usability	Efficient data presentation, conventional data format

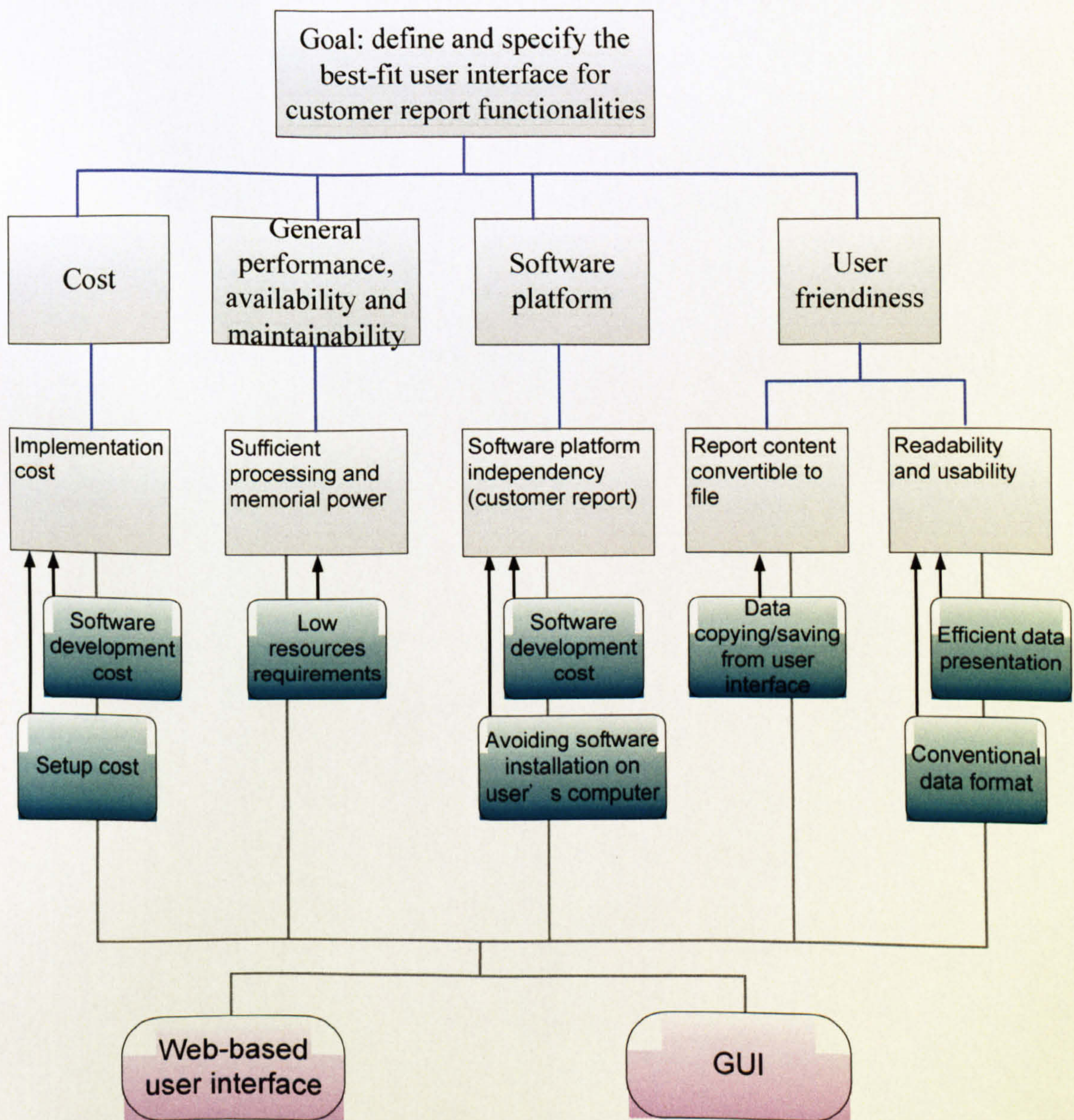


Figure B.5 The complete AHP-based hierarchy model for user interface (customer reporting)



## 6. User interface (other Intranet application)

Goal: *define and specify the user interface for Internet applications other than customer report*

Table B.6 The means-objectives for user interface (other Intranet applications)

Fundamental-objective	Means-objective(s)
Implementation cost	Setup cost, software development cost
Efficient data capturing	Enable efficient data input with keyboard, quick screen refresh
Sufficient processing and memorial power	Low resources requirements
Report content convertible to file	Direct copy/save data from user interface
Readability and usability	Efficient data presentation, conventional data format



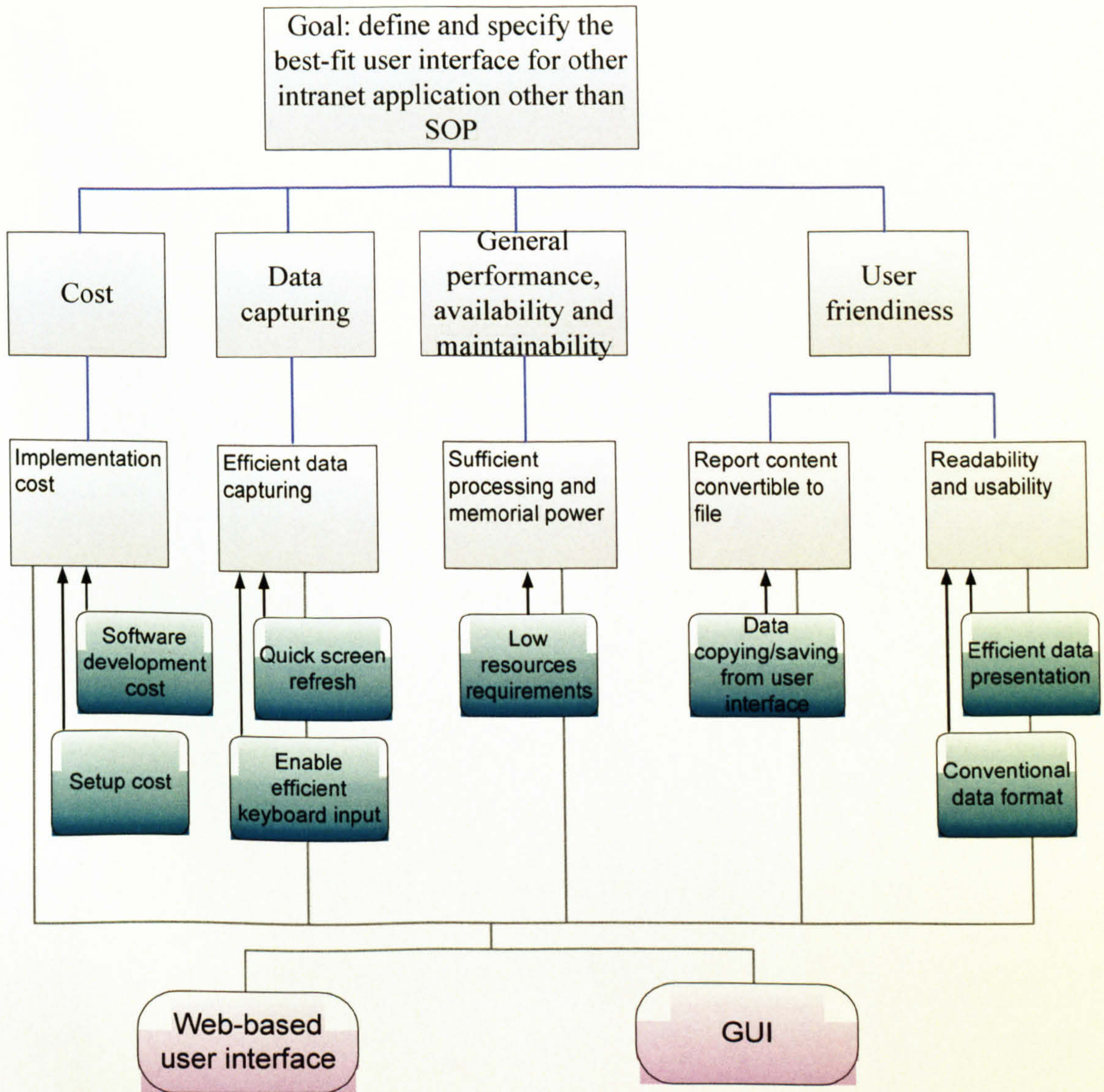


Figure B.6 The complete AHP-based hierarchy model for user interface (other Intranet applications)



## APPENDIX C - PHASE 4 RESULTS FOR CASE STUDY III

Appendix documents the *phase 4* results for the case study III. With the AHP-based hierarchy models of the six solution components produced in *phase 3*, ranking of alternatives for the solution components were generated through a series of computational processes.

This document is divided into six sections with each section includes the results for one of the solution components. Each section contains two sub-sections for *step 4.1* and *step 4.2* respectively.

The first sub-section contains the PCMs resulted from *process 4.1.1* and *process 4.1.2*, the consistency ratios as the consistency test results in *process 4.1.3*, the fuzzified PCMs resulted from *process 4.1.4*, the synthetic extents as the results of *process 4.1.5*, the weight vectors and thereby rankings of fundamental-objectives resulted from *process 4.1.6*.

Similarly, the second sub-section include the PCMs resulted from *process 4.2.1* and *process 4.2.2*, the consistency ratios as the consistency test results in *process 4.2.3*, the fuzzified PCMs resulted from *process 4.2.4*, the synthetic extents as the results of *process 4.2.5*, the weight vectors, priority weights and thereby ranking of alternatives resulted from *process 4.2.6*.

### 1. Tracking technology

#### 1.1 Step 4.1 results

##### *Process 4.1.2*

$$M_1 =$$

	$C_{11}$	$C_{12}$	$C_{13}$
$C_{11}$	1	1	3
$C_{12}$	1	1	3
$C_{13}$	1/3	1/3	1

$C_{11}$ : cost

$C_{12}$ : data capturing

$C_{13}$ : general performance, availability and maintainability



$$M_2 =$$

	$C_{21}$	$C_{22}$
$C_{21}$	1	1/5
$C_{22}$	5	1

$C_{21}$ : implementation cost

$C_{22}$ : operations cost

$$M_3 =$$

	$C_{31}$	$C_{32}$	$C_{33}$
$C_{31}$	1	1	3
$C_{32}$	1	1	3
$C_{33}$	1/3	1/3	1

$C_{31}$ : efficient data capturing

$C_{32}$ : reliable data capturing

$C_{33}$ : fast, real-time tracking data update to system

$$M_4 =$$

	$C_{41}$	$C_{42}$
$C_{41}$	1	3
$C_{42}$	1/3	1

$C_{41}$ : maintainability

$C_{42}$ : availability

### *Process 4.1.3*

$M_2$  and  $M_4$  involve only two comparing objectives and consistency test is not needed.

$$CR_1 = 0.000,$$

$$CR_2 = 0.000$$

$M_1$  and  $M_3$  are considered perfectly consistent.

### *Process 4.1.4*

$$M'_1 =$$



	C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>
C <sub>11</sub>	(1, 1, 3)	(1, 1, 3)	(1, 3, 5)
C <sub>12</sub>	1/(1, 1, 3)	(1, 1, 3)	(1, 3, 5)
C <sub>13</sub>	1/(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)

M' <sub>2</sub> =

	C <sub>21</sub>	C <sub>22</sub>
C <sub>21</sub>	(1, 1, 3)	1/(3, 5, 7)
C <sub>22</sub>	(3, 5, 7)	(1, 1, 3)

M' <sub>3</sub> =

	C <sub>31</sub>	C <sub>32</sub>	C <sub>33</sub>
C <sub>31</sub>	(1, 1, 3)	(1, 1, 3)	(1, 3, 5)
C <sub>32</sub>	1/(1, 1, 3)	(1, 1, 3)	(1, 3, 5)
C <sub>33</sub>	1/(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)

M' <sub>4</sub> =

	C <sub>41</sub>	C <sub>42</sub>
C <sub>41</sub>	(1, 1, 3)	1/(1, 3, 5)
C <sub>42</sub>	(1, 3, 5)	(1, 1, 3)

#### Process 4.1.5

$$\begin{aligned}
 S^1_1 &= (0.134, 0.429, 1.634), & S^1_2 &= (0.104, 0.429, 1.337), \\
 S^1_3 &= (0.063, 0.143, 0.347), & & \\
 S^2_1 &= (0.086, 0.167, 0.648), & S^2_2 &= (0.300, 0.833, 1.944), \\
 S^3_1 &= (0.134, 0.429, 1.634), & S^3_2 &= (0.104, 0.429, 1.337), \\
 S^3_3 &= (0.063, 0.143, 0.347), & & \\
 S^4_1 &= (0.100, 0.250, 1.250), & S^4_2 &= (0.167, 0.750, 2.500),
 \end{aligned}$$

#### Process 4.1.6

$$\begin{aligned}
 W'_1 &= (1.000, 1.000, 0.4262)^T, & W'_2 &= (0.3431, 1.000)^T, \\
 W'_3 &= (1.000, 1.000, 0.4262)^T, & W'_4 &= (0.6842, 1.000)^T. \\
 \\ 
 W_1 &= (0.4584, 0.4584, 0.1954)^T, & W_2 &= (0.3070, 0.8947)^T, \\
 W_3 &= (0.4584, 0.4584, 0.1954)^T, & W_4 &= (0.4660, 0.6811)^T.
 \end{aligned}$$



Table C.1 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	$C_{11}$ Cost	0.4584
	$C_{12}$ Data capturing	0.4584
3	$C_{13}$ General performance, availability and maintainability	0.1954
Ranking	Fundamental-objective	Weight vector
1	$C_{22}$ Operation cost	0.8947
2	$C_{31}$ Efficient data capturing	0.4626
3	$C_{21}$ Implementation cost	0.3070
Ranking	Fundamental-objective	Weight vector
1	$C_{32}$ Reliable data capturing	0.4626
2	$C_{33}$ Fast, real-time tracking data update to system	0.1859
Ranking	Fundamental-objective	Weight vector
1	$C_{42}$ Availability	0.6811
2	$C_{41}$ Maintainability	0.4660

## 1.2 Step 4.2 results

### Process 4.2.2

$M_{21} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	7	3
$A_2$	1/7	1	1/3
$A_3$	1/3	3	1

$M_{22} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	7	3
$A_2$	1/7	1	1/5
$A_3$	1/3	5	1

$M_{31} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/5	1/3
$A_2$	5	1	3
$A_3$	3	1/3	1

$M_{32} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	3	7
$A_2$	1/3	1	3
$A_3$	1/7	1/3	1

$M_{33} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/5	1/5
$A_2$	5	1	1

$M_{41} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	3	3
$A_2$	1/3	1	1



$$A_3 \quad 5 \quad 1 \quad 1$$

$$A_3 \quad 1/3 \quad 1 \quad 1$$

$M_{42} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	3	5
$A_2$	1/3	1	3
$A_3$	1/5	1/3	1

$A_1$ : Barcode

$A_2$ : RFID

$A_3$ : GPS

### Process 4.2.3

$$CR_{21} = 0.0093,$$

$$CR_{31} = 0.0477,$$

$$CR_{33} = 0.0000,$$

$$CR_{42} = 0.0477.$$

$$CR_{22} = 0.0834,$$

$$CR_{32} = 0.0093,$$

$$CR_{41} = 0.0000,$$

All matrices above are considered consistent for their consistency ratio valued less than 0.100.

### Process 4.2.4

$M'_{21} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(5, 7, 9)	(1, 3, 5)
$A_2$	1/(5, 7, 9)	(1, 1, 3)	1/(1, 3, 5)
$A_3$	1/(1, 3, 5)	(1, 3, 5)	(1, 1, 3)

$M'_{22} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(5, 7, 9)	(1, 3, 5)
$A_2$	1/(5, 7, 9)	(1, 1, 3)	1/(3, 5, 7)
$A_3$	1/(1, 3, 5)	(3, 5, 7)	(1, 1, 3)

$M'_{31} =$

	$A_1$	$A_2$	$A_3$
$A_1$			
$A_2$			
$A_3$			



$A_1$	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)
$A_2$	(3, 5, 7)	(1, 1, 3)	(1, 3, 5)
$A_3$	(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)

$M'_{32} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(1, 3, 5)	(5, 7, 9)
$A_2$	1/(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$A_3$	1/(5, 7, 9)	1/(1, 3, 5)	(1, 1, 3)

$M'_{33} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(3, 5, 7)	1/(3, 5, 7)
$A_2$	(3, 5, 7)	(1, 1, 3)	(1, 1, 3)
$A_3$	(3, 5, 7)	1/(1, 1, 3)	(1, 1, 3)

$M'_{41} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(1, 3, 5)	(1, 3, 5)
$A_2$	1/(1, 3, 5)	(1, 1, 3)	(1, 1, 3)
$A_3$	1/(1, 3, 5)	1/(1, 1, 3)	(1, 1, 3)

$M'_{42} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(1, 3, 5)	(3, 5, 7)
$A_2$	1/(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$A_3$	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)

#### *Process 4.2.5*

$$\begin{aligned}
 S^{21}_1 &= (0.205, 0.565, 1.503), & S^{21}_2 &= (0.062, 0.213, 0.725), \\
 S^{21}_3 &= (0.064, 0.222, 0.796), & & \\
 S^{22}_1 &= (0.183, 0.469, 1.110), & S^{22}_2 &= (0.108, 0.262, 0.666), \\
 S^{22}_3 &= (0.110, 0.270, 0.718), & & \\
 S^{31}_1 &= (0.072, 0.240, 0.892), & S^{31}_2 &= (0.169, 0.513, 1.606), \\
 S^{31}_3 &= (0.074, 0.247, 0.678), & & \\
 S^{32}_1 &= (0.232, 0.654, 1.617), & S^{32}_2 &= (0.073, 0.258, 0.856), \\
 S^{32}_3 &= (0.043, 0.088, 0.400), & &
 \end{aligned}$$



$$\begin{aligned}
S^{33}_1 &= (0.046, 0.091, 0.345), & S^{33}_2 &= (0.181, 0.455, 1.224), \\
S^{33}_3 &= (0.157, 0.455, 1.036), & & \\
S^{41}_1 &= (0.120, 0.600, 1.931), & S^{41}_2 &= (0.088, 0.200, 1.040), \\
S^{41}_3 &= (0.061, 0.200, 0.743), & & \\
S^{42}_1 &= (0.176, 0.605, 1.756), & S^{42}_2 &= (0.078, 0.291, 1.054), \\
S^{42}_3 &= (0.047, 0.103, 0.507). & &
\end{aligned}$$

*Process 4.2.6*

$$\begin{aligned}
W'_{21} &= (1.000, 0.596, 0.633)^T, & W'_{22} &= (1.000, 0.700, 0.729)^T, \\
W'_{31} &= (0.725, 1.000, 0.657)^T, & W'_{32} &= (1.000, 0.612, 0.228)^T, \\
W'_{33} &= (0.312, 1.000, 1.000)^T, & & \\
W'_{41} &= (1.000, 0.697, 0.609)^T, & W'_{42} &= (1.000, 0.736, 0.397)^T.
\end{aligned}$$

$$\begin{aligned}
W_{21} &= (0.5695, 0.3394, 0.3605)^T, & W_{22} &= (0.4947, 0.3463, 0.3606)^T, \\
W_{31} &= (0.3704, 0.5109, 0.3357)^T, & W_{32} &= (0.7010, 0.4290, 0.1598)^T, \\
W_{33} &= (0.1440, 0.4783, 0.4783)^T, & & \\
W_{41} &= (0.5386, 0.3754, 0.3280)^T, & W_{42} &= (0.5885, 0.4331, 0.2336)^T.
\end{aligned}$$

**Table C.2** Priority weights of alternatives with respect to cost  $C_{11}$

	$C_{21}$ Implementation cost	$C_{22}$ Operation cost	Priority weight ( $w_2$ )
Weight vector	0.3070	0.8947	
$A_1$ Barcode	0.5695	0.4947	0.6174
$A_2$ RFID	0.3394	0.3463	0.4140
$A_3$ GPS	0.3605	0.3606	0.4333

**Table C.3** Priority weights of alternatives with respect to data capturing  $C_{12}$

	$C_{31}$ Efficient data capturing	$C_{32}$ Reliable data capturing	$C_{33}$ Fast, real-time tracking data update to system	Priority weight ( $w_3$ )
Weight vector	0.4626	0.4626	0.1859	
$A_1$ Barcode	0.3704	0.7010	0.1440	0.5224
$A_2$ RFID	0.5109	0.4290	0.4783	0.5237
$A_3$ GPS	0.3357	0.1598	0.4783	0.3181



Table C.4 Priority weights of alternatives with respect to general performance, availability and maintainability  $C_{13}$

	$C_{41}$ Maintainability	$C_{42}$ Availability	Priority weight ( $w_4$ )
Weight vector	0.4660	0.6811	
$A_1$ Barcode	0.5386	0.5885	0.6518
$A_2$ RFID	0.3754	0.4331	0.4699
$A_3$ GPS	0.3280	0.2336	0.3120

Table C.5 Priority weights of alternatives with respect to goal

	$C_{11}$ Cost	$C_{12}$ Data capturing	$C_{13}$ General performance, availability and maintainability	Priority weight ( $w_1$ )
Weight vector	0.4584	0.4584	0.1954	
$A_1$ Barcode	0.6174	0.5224	0.6443	0.6484
$A_2$ RFID	0.4140	0.5237	0.4596	0.5196
$A_3$ GPS	0.4333	0.3181	0.3237	0.4077

Table C.6 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ Barcode	0.6484
2	$A_2$ RFID	0.5196
3	$A_3$ GPS	0.4077

## 2. Software platform (intranet application)

### 2.1 Step 4.1 results

#### Process 4.1.2

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$	$C_{15}$
$C_{11}$	1	5	1	1/3	5
$C_{12}$	1/5	1	1/5	1/3	1
$C_{13}$	1	5	1	1	3
$C_{14}$	3	3	1	1	5
$C_{15}$	1/5	1	1/3	1/5	1



C<sub>11</sub>: accessibility

C<sub>12</sub>: cost

C<sub>13</sub>: data transaction

C<sub>14</sub>: general performance, availability and maintainability

C<sub>15</sub>: software platform

M<sub>5</sub> =

	C <sub>51</sub>	C <sub>52</sub>	C <sub>53</sub>	C <sub>54</sub>
C <sub>51</sub>	1	3	5	7
C <sub>52</sub>	1/3	1	3	3
C <sub>53</sub>	1/5	1/3	1	3
C <sub>54</sub>	1/7	1/3	1/3	1

C<sub>51</sub>: efficient card job printing

C<sub>52</sub>: efficient processing and memorial power

C<sub>53</sub>: availability

C<sub>54</sub>: maintainability

#### *Process 4.1.3*

$$CR_1 = 0.0726,$$

$$CR_2 = 0.0662$$

M<sub>1</sub> and M<sub>2</sub> are considered consistent for their consistency ratio valued less than 0.100.

#### *Process 4.1.4*

M' <sub>1</sub> =

	C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>15</sub>
C <sub>11</sub>	(1, 1, 3)	(3, 5, 7)	(1, 1, 3)	1/(1, 3, 5)	(3, 5, 7)
C <sub>12</sub>	1/(3, 5, 7)	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)
C <sub>13</sub>	1/(1, 1, 3)	(3, 5, 7)	(1, 1, 3)	(1, 1, 3)	(1, 3, 5)
C <sub>14</sub>	(1, 3, 5)	(1, 3, 5)	1/(1, 1, 3)	(1, 1, 3)	(3, 5, 7)
C <sub>15</sub>	1/(3, 5, 7)	1/(1, 1, 3)	1/(1, 3, 5)	1/(3, 5, 7)	(1, 1, 3)

M' <sub>5</sub> =



	$C_{51}$	$C_{52}$	$C_{53}$	$C_{54}$
$C_{51}$	(1, 1, 3)	(1, 3, 5)	(3, 5, 7)	(5, 7, 9)
$C_{52}$	1/(1, 3, 5)	(1, 1, 3)	(1, 3, 5)	(1, 3, 5)
$C_{53}$	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$C_{54}$	1/(5, 7, 9)	1/(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)

*Process 4.1.5*

$$\begin{aligned}
 S^1_1 &= (0.1134, 0.2951, 0.8343), & S^1_2 &= (0.0344, 0.0654, 0.3046), \\
 S^1_3 &= (0.0876, 0.2632, 0.7548), & S^1_4 &= (0.0876, 0.3110, 0.8343), \\
 S^1_5 &= (0.0251, 0.0654, 0.1457), & & \\
 S^5_1 &= (0.1904, 0.5392, 1.4073), & S^5_2 &= (0.0609, 0.2471, 0.8209), \\
 S^5_3 &= (0.0446, 0.1528, 0.5473), & S^5_4 &= (0.0288, 0.0610, 0.3049).
 \end{aligned}$$

*Process 4.1.6*

$$\begin{aligned}
 W'_1 &= (0.9791, 0.4543, 0.9331, 1.0000, 0.1233)^T, \\
 W'_5 &= (1.0000, 0.6835, 0.4802, 0.1933)^T.
 \end{aligned}$$

$$\begin{aligned}
 W_1 &= (0.3209, 0.1489, 0.3058, 0.3278, 0.0404)^T, \\
 W_5 &= (0.5763, 0.3939, 0.2768, 0.1114)^T.
 \end{aligned}$$

Table C.7 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	$C_{14}$ General performance, availability and maintainability	0.3278
2	$C_{11}$ Accessibility	0.3209
3	$C_{13}$ Data transaction	0.3058
4	$C_{12}$ Cost	0.1489
5	$C_{15}$ Software platform	0.0404
Ranking	Fundamental-objective	Weight vector
1	$C_{51}$ Efficient card job printing	0.5763
2	$C_{52}$ Efficient processing and memorial power	0.3939
3	$C_{53}$ Availability	0.2768
4	$C_{54}$ Maintainability	0.1114



## 2.2 Step 4.2 results

### Process 4.2.2

$M_{21} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/7	1/7
$A_2$	7	1	1
$A_3$	7	1	1

$M_{31} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	5	1
$A_2$	1/5	1	1/5
$A_3$	1	5	1

$M_{41} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/7	1/5
$A_2$	7	1	3
$A_3$	5	1/3	1

$M_{51} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/7	1
$A_2$	7	1	5
$A_3$	1	1/5	1

$M_{52} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/3	1
$A_2$	3	1	3
$A_3$	1	1/3	1

$M_{53} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/3	1/3
$A_2$	3	1	1
$A_3$	3	1	1

$M_{54} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/3	1/3
$A_2$	3	1	1
$A_3$	3	1	1

$M_{61} =$

	$A_1$	$A_2$	$A_3$
$A_1$	1	1/7	1
$A_2$	7	1	7
$A_3$	1	1/7	1

$A_1$ : Adobe AIR

$A_2$ : MS .Net

$A_3$ : Java

### Process 4.2.3

$CR_{21} = 0.0000,$

$CR_{41} = 0.0834,$

$CR_{52} = 0.0000,$

$CR_{54} = 0.0000,$

$CR_{31} = 0.0000,$

$CR_{51} = 0.0193,$

$CR_{53} = 0.0000,$

$CR_{54} = 0.0000,$



$$CR_{61} = 0.0000.$$

All matrices above are considered consistent for their consistency ratio valued less than 0.100.

*Process 4.2.4*

$$M'_{21} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(5, 7, 9)	1/(5, 7, 9)
$A_2$	(5, 7, 9)	(1, 1, 3)	(1, 1, 3)
$A_3$	(5, 7, 9)	1/(1, 1, 3)	(1, 1, 3)

$$M'_{31} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(3, 5, 7)	(1, 1, 3)
$A_2$	1/(3, 5, 7)	(1, 1, 3)	1/(3, 5, 7)
$A_3$	1/(1, 1, 3)	(3, 5, 7)	(1, 1, 3)

$$M'_{41} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(5, 7, 9)	1/(3, 5, 7)
$A_2$	(5, 7, 9)	(1, 1, 3)	(1, 3, 5)
$A_3$	(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)

$$M'_{51} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(5, 7, 9)	(1, 1, 3)
$A_2$	(5, 7, 9)	(1, 1, 3)	(3, 5, 7)
$A_3$	1/(1, 1, 3)	1/(3, 5, 7)	(1, 1, 3)

$$M'_{52} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)
$A_2$	(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$A_3$	1/(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)

$$M'_{53} =$$



	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1 / (1, 3, 5)	1 / (1, 3, 5)
$A_2$	(1, 3, 5)	(1, 1, 3)	(1, 1, 3)
$A_3$	(1, 3, 5)	1 / (1, 1, 3)	(1, 1, 3)

$M'_{54} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1 / (1, 3, 5)	1 / (1, 3, 5)
$A_2$	(1, 3, 5)	(1, 1, 3)	(1, 1, 3)
$A_3$	(1, 3, 5)	1 / (1, 1, 3)	(1, 1, 3)

$M'_{61} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1 / (5, 7, 9)	(1, 1, 3)
$A_2$	(5, 7, 9)	(1, 1, 3)	(5, 7, 9)
$A_3$	1 / (1, 1, 3)	1 / (5, 7, 9)	(1, 1, 3)

#### *Process 4.2.5*

$$\begin{aligned}
 S^{21}_1 &= (0.0389, 0.0667, 0.2336), & S^{21}_2 &= (0.2229, 0.4667, 1.0305), \\
 S^{21}_3 &= (0.2017, 0.4667, 0.8931), & & \\
 S^{31}_1 &= (0.1807, 0.4545, 1.2242), & S^{31}_2 &= (0.0465, 0.0909, 0.3453), \\
 S^{31}_3 &= (0.1566, 0.4545, 1.0359), & & \\
 S^{41}_1 &= (0.0398, 0.0719, 0.2837), & S^{41}_2 &= (0.2220, 0.5890, 1.3650), \\
 S^{41}_3 &= (0.1332, 0.3391, 0.8833), & & \\
 S^{51}_1 &= (0.0715, 0.1236, 0.4926), & S^{51}_2 &= (0.3047, 0.7496, 1.5095), \\
 S^{51}_3 &= (0.0500, 0.1269, 0.3443), & & \\
 S^{52}_1 &= (0.0880, 0.2000, 1.0396), & S^{52}_2 &= (0.1200, 0.6000, 1.9307), \\
 S^{52}_3 &= (0.0613, 0.2000, 0.7426), & & \\
 S^{53}_1 &= (0.0560, 0.1429, 0.7426), & S^{53}_2 &= (0.1200, 0.4286, 1.6337), \\
 S^{53}_3 &= (0.0933, 0.4286, 1.3366), & & \\
 S^{54}_1 &= (0.0560, 0.1429, 0.7426), & S^{54}_2 &= (0.1200, 0.4286, 1.6337), \\
 S^{54}_3 &= (0.0933, 0.4286, 1.3366), & & \\
 S^{61}_1 &= (0.0672, 0.1111, 0.4260), & S^{61}_2 &= (0.3503, 0.7778, 1.4427), \\
 S^{61}_3 &= (0.0460, 0.1111, 0.2885). & &
 \end{aligned}$$



Process 4.2.6

$$W'_{21} = (0.0260, 1.0000, 1.0000)^T,$$

$$W'_{41} = (0.1066, 1.0000, 0.7258)^T,$$

$$W'_{52} = (0.6969, 1.0000, 0.6088)^T,$$

$$W'_{54} = (0.6854, 1.0000, 1.0000)^T,$$

$$W'_{31} = (1.0000, 0.3116, 1.0000)^T,$$

$$W'_{51} = (0.2308, 1.0000, 0.0597)^T,$$

$$W'_{53} = (0.6854, 1.0000, 1.0000)^T,$$

$$W'_{61} = (0.1019, 1.0000, 0.0000)^T.$$

$$W_{21} = (0.0130, 0.4998, 0.4998)^T,$$

$$W_{41} = (0.0693, 0.6501, 0.4719)^T,$$

$$W_{52} = (0.3754, 0.5387, 0.3280)^T,$$

$$W_{54} = (0.2775, 0.4049, 0.4049)^T,$$

$$W_{31} = (0.4769, 0.1486, 0.4769)^T,$$

$$W_{51} = (0.2184, 0.9462, 0.0565)^T,$$

$$W_{53} = (0.2775, 0.4049, 0.4049)^T,$$

$$W_{61} = (0.1009, 0.9897, 0.0000)^T.$$

Table C.8 Priority weights of alternatives with respect to accessibility  $C_{11}$

	$C_{21}$ Intranet accessibility (intranet applications)	Priority weight ( $w_2$ )
Weight vector	1	
$A_1$ Adobe AIR	0.0130	0.0130
$A_2$ MS .Net	0.4998	0.4998
$A_3$ Java	0.4998	0.4998

Table C.9 Priority weights of alternatives with respect to cost  $C_{12}$

	$C_{31}$ Implementation cost	Priority weight ( $w_3$ )
Weight vector	1	
$A_1$ Adobe AIR	0.4769	0.4769
$A_2$ MS .Net	0.1486	0.1486
$A_3$ Java	0.4769	0.4769

Table C.10 Priority weights of alternatives with respect to data transaction  $C_{13}$

	$C_{41}$ Fast, secured business data transaction (for SOP, Planning and scheduling)	Priority weight ( $w_4$ )
Weight vector	1	
$A_1$ Adobe AIR	0.0693	0.0693
$A_2$ MS .Net	0.6501	0.6501
$A_3$ Java	0.4719	0.4719



Table C.11 Priority weights of alternatives with respect to general performance, availability and maintainability  $C_{14}$

	$C_{51}$ Efficient job card printing	$C_{52}$ Sufficient processing and memorial power	$C_{53}$ Availability
Weight vector	0.5763	0.3939	0.2768
$A_1$ Adobe AIR	0.2184	0.3754	0.2775
$A_2$ MS .Net	0.9462	0.5387	0.4049
$A_3$ Java	0.0565	0.3280	0.4049
	$C_{54}$ Maintainability	Priority weight ( $w_5$ )	
Weight vector	0.1114		
$A_1$ Adobe AIR	0.2775	0.3815	
$A_2$ MS .Net	0.4049	0.9147	
$A_3$ Java	0.4049	0.3189	

Table C.12 Priority weights of alternatives with respect to software platform  $C_{15}$

	$C_{61}$ MS Windows compatible (SOP)	Priority weight ( $w_6$ )
Weight vector	1	
$A_1$ Adobe AIR	0.1009	0.1009
$A_2$ MS .Net	0.9897	0.9897
$A_3$ Java	0.0000	0.0000

Table C.13 Priority weights of alternatives with respect to goal

	$C_{11}$ Accessibility	$C_{12}$ Cost	$C_{13}$ Data transaction
Weight vector	0.3209	0.1489	0.3058
$A_1$ Adobe AIR	0.0130	0.4769	0.0693
$A_2$ MS .Net	0.4998	0.1486	0.6501
$A_3$ Java	0.4998	0.4769	0.4719
	$C_{14}$ General performance, availability and maintainability	$C_{15}$ Software platform	Priority weight ( $w_1$ )
Weight vector	0.3278	0.0404	
$A_1$ Adobe AIR	0.3815	0.1009	0.2255
$A_2$ MS .Net	0.9147	0.9897	0.7211
$A_3$ Java	0.3189	0.0000	0.4802



Table C.14 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_i$ )
1	$A_2$ MS .Net	0.7211
2	$A_3$ Java	0.4802
3	$A_1$ Adobe AIR	0.2255

### 3. Software platform (internet application)

#### 3.1 Step 4.1 results

##### Process 4.1.2

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$	$C_{15}$
$C_{11}$	1	7	3	3	7
$C_{12}$	1/7	1	1/3	1/5	1/3
$C_{13}$	1/3	3	1	1/3	1
$C_{14}$	1/3	5	3	1	5
$C_{15}$	1/7	3	1	1/5	1

$C_{11}$ : accessibility

$C_{12}$ : cost

$C_{13}$ : data transaction

$C_{14}$ : general performance, availability and maintainability

$C_{15}$ : software platform

$M_5 =$

	$C_{51}$	$C_{52}$	$C_{53}$
$C_{51}$	1	1/3	1
$C_{52}$	3	1	3
$C_{53}$	1	1/3	1

$C_{51}$ : efficient processing and memorial power

$C_{52}$ : availability

$C_{53}$ : maintainability



*Process 4.1.3*

$$CR_1 = 0.087557,$$

$$CR_2 = 0.0000$$

$M_1$  and  $M_2$  are considered consistent for their consistency ratio valued less than 0.100.

*Process 4.1.4*

$$M'_1 =$$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$	$C_{15}$
$C_{11}$	(1, 1, 3)	(5, 7, 9)	(1, 3, 5)	(1, 3, 5)	(5, 7, 9)
$C_{12}$	1/(5, 7, 9)	(1, 1, 3)	1/(1, 3, 5)	1/(3, 5, 7)	1/(1, 3, 5)
$C_{13}$	1/(1, 3, 5)	(1, 3, 5)	(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)
$C_{14}$	1/(1, 3, 5)	(3, 5, 7)	(1, 3, 5)	(1, 1, 3)	(3, 5, 7)
$C_{15}$	1/(5, 7, 9)	(1, 3, 5)	1/(1, 1, 3)	1/(3, 5, 7)	(1, 1, 3)

$$M'_5 =$$

	$C_{51}$	$C_{52}$	$C_{53}$
$C_{51}$	(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)
$C_{52}$	(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$C_{53}$	1/(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)

*Process 4.1.5*

$$S^l_1 = (0.1584, 0.4343, 1.0748),$$

$$S^l_2 = (0.0202, 0.0416, 0.1919),$$

$$S^l_3 = (0.0414, 0.1172, 0.4507),$$

$$S^l_4 = (0.0999, 0.2964, 0.7975),$$

$$S^l_5 = (0.0315, 0.1105, 0.3305),$$

$$S^s_1 = (0.0985, 0.2000, 1.0396),$$

$$S^s_2 = (0.1343, 0.6000, 1.9307),$$

$$S^s_3 = (0.0687, 0.2000, 0.3465).$$

*Process 4.1.6*

$$W'_1 = (1.0000, 0.0785, 0.4797, 0.8225, 0.3471)^T,$$

$$W'_5 = (0.6936, 1.0000, 0.3466)^T.$$

$$W_1 = (0.4918, 0.0386, 0.2359, 0.4045, 0.1707)^T,$$

$$W_5 = (0.4332, 0.6245, 0.2165)^T.$$



Table C.15 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	C <sub>11</sub> Accessibility	0.4918
2	C <sub>14</sub> General performance, availability and maintainability	0.4045
3	C <sub>13</sub> Data transaction	0.2359
4	C <sub>15</sub> Software platform	0.1707
5	C <sub>12</sub> Cost	0.0386
Ranking	Fundamental-objective	Weight vector
1	C <sub>52</sub> Availability	0.6245
2	C <sub>51</sub> Efficient processing and memorial power	0.4332
3	C <sub>53</sub> Maintainability	0.2165

### 3.2 Step 4.2 results

#### Process 4.2.2

M<sub>21</sub> =

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>
A <sub>1</sub>	1	1	1
A <sub>2</sub>	1	1	1
A <sub>3</sub>	1	1	1

M<sub>31</sub> =

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>
A <sub>1</sub>	1	5	1
A <sub>2</sub>	1/5	1	1/5
A <sub>3</sub>	1	5	1

M<sub>41</sub> =

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>
A <sub>1</sub>	1	1	1
A <sub>2</sub>	1	1	1
A <sub>3</sub>	1	1	1

M<sub>51</sub> =

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>
A <sub>1</sub>	1	1/3	1
A <sub>2</sub>	3	1	3
A <sub>3</sub>	1	1/3	1

M<sub>52</sub> =

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>
A <sub>1</sub>	1	1/3	1/3
A <sub>2</sub>	3	1	1
A <sub>3</sub>	3	1	1

M<sub>53</sub> =

	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>
A <sub>1</sub>	1	1/3	1/3
A <sub>2</sub>	3	1	1
A <sub>3</sub>	3	1	1

M<sub>61</sub> =



	$A_1$	$A_2$	$A_3$
$A_1$	1	1/5	1
$A_2$	5	1	5
$A_3$	1	1/5	1

$A_1$ : Adobe AIR

$A_2$ : MS .Net

$A_3$ : Java

### Process 4.2.3

$$CR_{21} = 0.0000,$$

$$CR_{41} = 0.0000,$$

$$CR_{52} = 0.0000,$$

$$CR_{61} = 0.0000.$$

$$CR_{31} = 0.0000,$$

$$CR_{51} = 0.0000,$$

$$CR_{53} = 0.0000,$$

All matrices above are considered perfectly consistent for their consistency ratio valued 0.0000.

### Process 4.2.4

$$M'_{21} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)	(1, 1, 3)
$A_3$	1/(1, 1, 3)	1/(1, 1, 3)	(1, 1, 3)

$$M'_{31} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(3, 5, 7)	(1, 1, 3)
$A_2$	1/(3, 5, 7)	(1, 1, 3)	1/(3, 5, 7)
$A_3$	1/(1, 1, 3)	(3, 5, 7)	(1, 1, 3)

$$M'_{41} =$$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)	(1, 1, 3)
$A_3$	1/(1, 1, 3)	1/(1, 1, 3)	(1, 1, 3)



$M'_{51} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)
$A_2$	(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$A_3$	1/(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)

$M'_{52} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(1, 3, 5)	1/(1, 3, 5)
$A_2$	(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$A_3$	(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)

$M'_{53} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(1, 3, 5)	1/(1, 3, 5)
$A_2$	(1, 3, 5)	(1, 1, 3)	(1, 1, 3)
$A_3$	(1, 3, 5)	1/(1, 1, 3)	(1, 1, 3)

$M'_{61} =$

	$A_1$	$A_2$	$A_3$
$A_1$	(1, 1, 3)	1/(3, 5, 7)	(1, 1, 3)
$A_2$	(3, 5, 7)	(1, 1, 3)	(3, 5, 7)
$A_3$	1/(1, 1, 3)	1/(3, 5, 7)	(1, 1, 3)

#### Process 4.2.5

$$\begin{aligned} S^{21}_1 &= (0.1429, 0.3333, 1.2857), & S^{21}_2 &= (0.1111, 0.3333, 1.0000), \\ S^{21}_3 &= (0.0794, 0.3333, 0.7143), & & \\ S^{31}_1 &= (0.1807, 0.4545, 1.2242), & S^{31}_2 &= (0.0465, 0.0909, 0.3453), \\ S^{31}_3 &= (0.1566, 0.4545, 1.0359), & & \\ S^{41}_1 &= (0.1429, 0.3333, 1.2857), & S^{41}_2 &= (0.1111, 0.3333, 1.0000), \\ S^{41}_3 &= (0.0794, 0.3333, 0.7143), & & \\ S^{51}_1 &= (0.0880, 0.2000, 1.0396), & S^{51}_2 &= (0.1200, 0.6000, 1.9307), \\ S^{51}_3 &= (0.0613, 0.2000, 0.7426), & & \\ S^{52}_1 &= (0.0519, 0.1282, 0.7576), & S^{52}_2 &= (0.1111, 0.5385, 1.9697), \\ S^{52}_3 &= (0.0815, 0.3333, 1.3636), & & \\ S^{53}_1 &= (0.0519, 0.1429, 0.7426), & S^{53}_2 &= (0.1111, 0.4286, 1.9307), \end{aligned}$$



$$S^5_3 = (0.0864, 0.4286, 1.3366),$$

$$S^6_1 = (0.0722, 0.1429, 0.5612),$$

$$S^6_3 = (0.0722, 0.1429, 0.5612).$$

$$S^6_2 = (0.2360, 0.7143, 1.5063),$$

*Process 4.2.6*

$$W'_{21} = (1.0000, 1.0000, 1.0000)^T,$$

$$W'_{41} = (1.0000, 1.0000, 1.0000)^T,$$

$$W'_{52} = (0.6118, 1.0000, 0.8593)^T,$$

$$W'_{61} = (0.3627, 1.0000, 0.3627)^T.$$

$$W'_{31} = (1.0000, 0.3116, 1.0000)^T,$$

$$W'_{51} = (0.6969, 1.0000, 0.6088)^T,$$

$$W'_{53} = (0.6885, 1.0000, 1.0000)^T,$$

$$W_{21} = (0.3333, 0.3333, 0.3333)^T,$$

$$W_{41} = (0.3333, 0.3333, 0.3333)^T,$$

$$W_{52} = (0.2896, 0.4733, 0.4067)^T,$$

$$W_{61} = (0.2872, 0.7917, 0.2872)^T.$$

$$W_{31} = (0.4769, 0.1486, 0.4769)^T,$$

$$W_{51} = (0.3754, 0.5387, 0.3280)^T,$$

$$W_{53} = (0.2783, 0.4042, 0.4042)^T,$$

Table C.16 Priority weights of alternatives with respect to accessibility  $C_{11}$

	$C_{21}$ Intranet accessibility (intranet applications)	Priority weight ( $w_2$ )
Weight vector	1	
$A_1$ Adobe AIR	0.3333	0.3333
$A_2$ MS .Net	0.3333	0.3333
$A_3$ Java	0.3333	0.3333

Table C.17 Priority weights of alternatives with respect to cost  $C_{12}$

	$C_{31}$ Implementation cost	Priority weight ( $w_3$ )
Weight vector	1	
$A_1$ Adobe AIR	0.4769	0.4769
$A_2$ MS .Net	0.1486	0.1486
$A_3$ Java	0.4769	0.4769

Table C.19 Priority weights of alternatives with respect to data transaction  $C_{13}$

	$C_{41}$ Sufficient data storage and data transaction capabilities	Priority weight ( $w_4$ )
Weight vector	1	
$A_1$ Adobe AIR	0.3333	0.3333
$A_2$ MS .Net	0.3333	0.3333



$A_3$ Java	0.3333	0.3333
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Table C.20 Priority weights of alternatives with respect to general performance, availability and maintainability  $C_{14}$

	$C_{51}$ Sufficient processing and memorial power	$C_{52}$ Availability	$C_{53}$ Maintainability	Priority weight ( $w_5$ )
Weight vector	0.4332	0.6245	0.2165	
$A_1$ Adobe AIR	0.3754	0.2896	0.2783	0.4037
$A_2$ MS .Net	0.5387	0.4733	0.4042	0.6164
$A_3$ Java	0.3280	0.4067	0.4042	0.4836

Table C.21 Priority weights of alternatives with respect to software platform  $C_{15}$

	$C_{61}$ MS Windows compatible (SOP)	Priority weight ( $w_6$ )
Weight vector	1	
$A_1$ Adobe AIR	0.2872	0.2872
$A_2$ MS .Net	0.7917	0.7917
$A_3$ Java	0.2872	0.2872

Table C.22 Priority weights of alternatives with respect to goal

	$C_{11}$ Accessibility	$C_{12}$ Cost	$C_{13}$ Data transaction
Weight vector	0.4918	0.0386	0.2359
$A_1$ Adobe AIR	0.3333	0.4769	0.3333
$A_2$ MS .Net	0.3333	0.1486	0.3333
$A_3$ Java	0.3333	0.4769	0.3333
	$C_{14}$ General performance, availability and maintainability	$C_{15}$ Software platform	Priority weight ( $w_1$ )
Weight vector	0.4045	0.1707	
$A_1$ Adobe AIR	0.4037	0.2872	0.4733
$A_2$ MS .Net	0.6164	0.7917	0.6328
$A_3$ Java	0.4836	0.2872	0.5056

Table C.23 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
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1	$A_2$ MS .Net	0.6328
2	$A_3$ Java	0.5056
3	$A_1$ Adobe AIR	0.4733

## 4. Database management system

### 4.1 Step 4.1 results

#### Process 4.1.2

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$	$C_{15}$
$C_{11}$	1	1/5	1/3	1	1/5
$C_{12}$	5	1	3	5	1
$C_{13}$	3	1/3	1	3	1/3
$C_{14}$	1	1/5	1/3	1	1/3
$C_{15}$	5	1	3	3	1

$C_{11}$ : accessibility

$C_{12}$ : cost

$C_{13}$ : data capturing

$C_{14}$ : data transaction

$C_{15}$ : general performance, availability and maintainability

$M_2 =$

	$C_{21}$	$C_{22}$
$C_{21}$	1	1
$C_{22}$	1	1

$C_{21}$ : internet accessibility (customer report)

$C_{22}$ : intranet accessibility (intranet applications)

$M_3 =$

	$C_{31}$	$C_{32}$
$C_{31}$	1	1/5
$C_{32}$	5	1



**C<sub>31</sub>: implementation cost**

**C<sub>32</sub>: operational cost**

**M<sub>5</sub> =**

	<b>C<sub>51</sub></b>	<b>C<sub>52</sub></b>
<b>C<sub>51</sub></b>	1	1
<b>C<sub>52</sub></b>	1	1

**C<sub>51</sub>: fast, secured business data transaction (for SOP, Planning and scheduling)**

**C<sub>52</sub>: sufficient data storage and data transaction capabilities**

**M<sub>6</sub> =**

	<b>C<sub>61</sub></b>	<b>C<sub>62</sub></b>
<b>C<sub>61</sub></b>	1	1/5
<b>C<sub>62</sub></b>	5	1

**C<sub>61</sub>: maintainability**

**C<sub>62</sub>: availability**

### *Process 4.1.3*

M<sub>2</sub>, M<sub>3</sub>, M<sub>5</sub> and M<sub>6</sub> involve only two comparing objectives and consistency test is not needed.

$$CR_1 = 0.0333$$

M<sub>1</sub> and M<sub>2</sub> are considered consistent for their consistency ratio valued less than 0.100.

### *Process 4.1.4*

**M' <sub>1</sub> =**

	<b>C<sub>11</sub></b>	<b>C<sub>12</sub></b>	<b>C<sub>13</sub></b>	<b>C<sub>14</sub></b>	<b>C<sub>15</sub></b>
<b>C<sub>11</sub></b>	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)	1/(3, 5, 7)
<b>C<sub>12</sub></b>	(3, 5, 7)	(1, 1, 3)	(1, 3, 5)	(3, 5, 7)	(1, 1, 3)
<b>C<sub>13</sub></b>	(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)	(1, 3, 5)	1/(1, 3, 5)
<b>C<sub>14</sub></b>	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)	1/(1, 3, 5)
<b>C<sub>15</sub></b>	(3, 5, 7)	1/(1, 1, 3)	(1, 3, 5)	(1, 3, 5)	(1, 1, 3)



$$M'_2 =$$

	$C_{21}$	$C_{22}$
$C_{21}$	$(1, 1, 3)$	$(1, 1, 3)$
$C_{22}$	$1/(1, 1, 3)$	$(1, 1, 3)$

$$M'_3 =$$

	$C_{31}$	$C_{32}$
$C_{31}$	$(1, 1, 3)$	$(3, 5, 7)$
$C_{32}$	$1/(3, 5, 7)$	$(1, 1, 3)$

$$M'_5 =$$

	$C_{51}$	$C_{52}$
$C_{51}$	$(1, 1, 3)$	$(1, 1, 3)$
$C_{52}$	$1/(1, 1, 3)$	$(1, 1, 3)$

$$M'_6 =$$

	$C_{61}$	$C_{62}$
$C_{61}$	$(1, 1, 3)$	$(3, 5, 7)$
$C_{62}$	$1/(3, 5, 7)$	$(1, 1, 3)$

#### *Process 4.1.5*

$S^1_1 = (0.0323, 0.0662, 0.3226),$	$S^1_2 = (0.1169, 0.3635, 1.0521),$
$S^1_3 = (0.0442, 0.1858, 0.6313),$	$S^1_4 = (0.0330, 0.0695, 0.3507),$
$S^1_5 = (0.0823, 0.3150, 0.8838),$	
$S^2_1 = (0.2000, 0.5000, 1.8000),$	$S^2_2 = (0.1333, 0.5000, 1.2000),$
$S^3_1 = (0.2857, 0.7500, 1.8750),$	$S^3_2 = (0.0952, 0.2500, 0.7500),$
$S^5_1 = (0.2000, 0.5000, 1.8000),$	$S^5_2 = (0.1333, 0.5000, 1.2000),$
$S^6_1 = (0.3000, 0.8333, 1.9444),$	$S^6_2 = (0.0857, 0.1667, 0.6481).$

#### *Process 4.1.6*

$W'_1 = (0.4091, 1.0000, 0.7432, 0.9406, 0.9406)^T,$	
$W'_2 = (1.0000, 1.0000)^T,$	$W'_3 = (1.0000, 0.4815)^T,$
$W'_5 = (1.0000, 1.0000)^T,$	$W'_6 = (1.0000, 0.3431)^T.$

$W_1 = (0.1172, 0.2866, 0.2130, 0.2696, 0.2696)^T,$	
$W_2 = (0.5000, 0.5000)^T,$	$W_3 = (0.8118, 0.3909)^T,$



$$W_5 = (0.5000, 0.5000)^T,$$

$$W_6 = (0.8947, 0.3070)^T.$$

Table C.24 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	$C_{12}$ Cost	0.2866
2	$C_{14}$ Data transaction	0.2696
	$C_{15}$ General performance, availability and maintainability	0.2696
4	$C_{13}$ Data capturing	0.2130
5	$C_{11}$ Accessibility	0.1172
Ranking	Fundamental-objective	Weight vector
1	$C_{21}$ Internet accessibility (customer report)	0.5000
	$C_{22}$ Intranet accessibility (intranet applications)	0.5000
Ranking	Fundamental-objective	Weight vector
1	$C_{31}$ Implementation cost	0.8118
2	$C_{32}$ Operational cost	0.3909
Ranking	Fundamental-objective	Weight vector
1	$C_{51}$ Fast, secured business data transaction (for SOP, Planning and scheduling)	0.5000
	$C_{52}$ Sufficient data storage and data transaction capabilities	0.5000
Ranking	Fundamental-objective	Weight vector
1	$C_{61}$ Maintainability	0.8947
2	$C_{62}$ Availability	0.3070

## 4.2 Step 4.2 results

### Process 4.2.2

$M_{21} =$

	$A_1$	$A_2$
$A_1$	1	1
$A_2$	1	1

$M_{22} =$

	$A_1$	$A_2$
$A_1$	1	1
$A_2$	1	1



$$M_{31} =$$

	$A_1$	$A_2$
$A_1$	1	3
$A_2$	1/3	1

$$M_{32} =$$

	$A_1$	$A_2$
$A_1$	1	1
$A_2$	1	1

$$M_{41} =$$

	$A_1$	$A_2$
$A_1$	1	3
$A_2$	1/3	1

$$M_{51} =$$

	$A_1$	$A_2$
$A_1$	1	1
$A_2$	1	1

$$M_{52} =$$

	$A_1$	$A_2$
$A_1$	1	1
$A_2$	1	1

$$M_{61} =$$

	$A_1$	$A_2$
$A_1$	1	5
$A_2$	1/5	1

$$M_{62} =$$

	$A_1$	$A_2$
$A_1$	1	1/9
$A_2$	9	1

$A_1$ : Oracle 10g  
 $A_2$ : MS SQL 2000

### Process 4.2.3

Since there are only two comparing alternatives and consistency test is not needed.

### Process 4.2.4

$$M'_{21} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)

$$M'_{22} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)



$$M'_{31} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 3, 5)$
$A_2$	$1/(1, 3, 5)$	$(1, 1, 3)$

$$M'_{32} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 1, 3)$
$A_2$	$1/(1, 1, 3)$	$(1, 1, 3)$

$$M'_{41} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 3, 5)$
$A_2$	$1/(1, 3, 5)$	$(1, 1, 3)$

$$M'_{51} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 1, 3)$
$A_2$	$1/(1, 1, 3)$	$(1, 1, 3)$

$$M'_{52} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 1, 3)$
$A_2$	$1/(1, 1, 3)$	$(1, 1, 3)$

$$M'_{61} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(3, 5, 7)$
$A_2$	$1/(3, 5, 7)$	$(1, 1, 3)$

$$M'_{62} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(7, 7, 9)$
$A_2$	$1/(7, 7, 9)$	$(1, 1, 3)$

*Process 4.2.5*



$$\begin{aligned}
S^{21}_1 &= (0.2000, 0.5000, 1.8000), & S^{21}_2 &= (0.1333, 0.5000, 1.2000), \\
S^{22}_1 &= (0.2000, 0.5000, 1.8000), & S^{22}_2 &= (0.1333, 0.5000, 1.2000), \\
S^{31}_1 &= (0.1667, 0.7500, 2.5000), & S^{31}_2 &= (0.1000, 0.2500, 1.2500), \\
S^{32}_1 &= (0.2000, 0.5000, 1.8000), & S^{32}_2 &= (0.1333, 0.5000, 1.2000), \\
S^{41}_1 &= (0.1667, 0.7500, 2.5000), & S^{41}_2 &= (0.1000, 0.2500, 1.2500), \\
S^{51}_1 &= (0.2000, 0.5000, 1.8000), & S^{51}_2 &= (0.1333, 0.5000, 1.2000), \\
S^{52}_1 &= (0.2000, 0.5000, 1.8000), & S^{52}_2 &= (0.1333, 0.5000, 1.2000), \\
S^{61}_1 &= (0.3000, 0.8333, 1.9444), & S^{61}_2 &= (0.0857, 0.1667, 0.6481), \\
S^{62}_1 &= (0.5283, 0.8750, 1.3171), & S^{62}_2 &= (0.0734, 0.1250, 0.3449).
\end{aligned}$$

*Process 4.2.6*

$$\begin{aligned}
W'_{21} &= (1.0000, 1.0000)^T, & W'_{22} &= (1.0000, 1.0000)^T, \\
W'_{31} &= (1.0000, 0.6842)^T, & W'_{32} &= (1.0000, 1.0000)^T, \\
W'_{41} &= (1.0000, 0.6842)^T, & & \\
W'_{51} &= (1.0000, 1.0000)^T, & W'_{52} &= (1.0000, 1.0000)^T, \\
W'_{61} &= (1.0000, 0.3431)^T, & W'_{62} &= (1.0000, 0.0000)^T.
\end{aligned}$$

$$\begin{aligned}
W_{21} &= (0.5000, 0.5000)^T, & W_{22} &= (0.5000, 0.5000)^T, \\
W_{31} &= (0.6811, 0.4660)^T, & W_{32} &= (0.5000, 0.5000)^T, \\
W_{41} &= (0.6811, 0.4660)^T, & & \\
W_{51} &= (0.5000, 0.5000)^T, & W_{52} &= (0.5000, 0.5000)^T, \\
W_{61} &= (0.8947, 0.3070)^T, & W_{62} &= (0.5000, 0.5000)^T.
\end{aligned}$$

Table C.25 Priority weights of alternatives with respect to accessibility  $C_{11}$

	$C_{21}$ Internet accessibility (customer report)	$C_{21}$ Intranet accessibility (intranet applications)	Priority weight ( $w_2$ )
Weight vector	0.5000	0.5000	
$A_1$ Oracle 10g	0.5000	0.5000	0.5000
$A_2$ MS SQL 2000	0.5000	0.5000	0.5000

Table C.26 Priority weights of alternatives with respect to cost  $C_{12}$

	$C_{31}$ Implementation cost	$C_{32}$ Operational cost	Priority weight ( $w_3$ )
Weight vector	0.8118	0.3909	
$A_1$ Oracle 10g	0.6811	0.5000	0.7484



$A_2$ MS SQL 2000	0.4660	0.5000	0.5737
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Table C.27 Priority weights of alternatives with respect to data capturing  $C_{13}$

	$C_{41}$ Fast, real-time tracking data update to system	Priority weight ( $w_4$ )
Weight vector	1	
$A_1$ Oracle 10g	0.6811	0.6811
$A_2$ MS SQL 2000	0.4660	0.4660

Table C.28 Priority weights of alternatives with respect to data transaction  $C_{14}$

	$C_{51}$ Fast, secured business data transaction (for SOP, Planning and scheduling)	$C_{52}$ Sufficient data storage and data transaction capabilities	Priority weight ( $w_5$ )
Weight vector	0.5000	0.5000	
$A_1$ Oracle 10g	0.5000	0.5000	0.5000
$A_2$ MS SQL 2000	0.5000	0.5000	0.5000

Table C.29 Priority weights of alternatives with respect to general performance, availability and maintainability  $C_{15}$

	$C_{61}$ Maintainability	$C_{62}$ Availability	Priority weight ( $w_6$ )
Weight vector	0.8947	0.3070	
$A_1$ Oracle 10g	0.8947	0.5000	0.9540
$A_2$ MS SQL 2000	0.3070	0.5000	0.4282

Table C.30 Priority weights of alternatives with respect to goal

	$C_{11}$ Accessibility	$C_{12}$ Cost	$C_{13}$ Data capturing
Weight vector	0.1172	0.2866	0.2130
$A_1$ Oracle 10g	0.5000	0.7484	0.6811
$A_2$ MS SQL 2000	0.5000	0.5737	0.4660
	$C_{14}$ Data transaction	$C_{15}$ General performance, availability and maintainability	Priority weight ( $w_1$ )
Weight vector	0.2696	0.2696	



$A_1$ Oracle 10g	0.5000	0.9540	0.8102
$A_2$ MS SQL 2000	0.5000	0.4282	0.5725

Table C.31 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ Oracle 10g	0.8102
2	$A_2$ MS SQL 2000	0.5725

## 5. User interface (customer reporting)

### 5.1 Step 4.1 results

#### *Process 4.1.2*

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
$C_{11}$	1	1/5	1/3	1/7
$C_{12}$	5	1	5	1
$C_{13}$	3	1/5	1	1/7
$C_{14}$	7	1	7	1

$C_{11}$ : cost

$C_{12}$ : general performance, availability and maintainability

$C_{13}$ : software platform

$C_{14}$ : user friendliness

$M_5 =$

	$C_{51}$	$C_{52}$
$C_{51}$	1	1/5
$C_{52}$	5	1

$C_{51}$ : report content convertible to file

$C_{52}$ : readability and usability

#### *Process 4.1.3*



$M_5$  involves only two comparing objectives and consistency test is not needed.

$$CR_1 = 0.0954.$$

$M_1$  is considered consistent for their consistency ratio valued less than 0.100.

*Process 4.1.4*

$$M'_1 =$$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
$C_{11}$	(1, 1, 3)	1 / (3, 5, 7)	1 / (1, 3, 5)	1 / (5, 7, 9)
$C_{12}$	(3, 5, 7)	(1, 1, 3)	(3, 5, 7)	(1, 1, 3)
$C_{13}$	(1, 3, 5)	1 / (3, 5, 7)	(1, 1, 3)	1 / (5, 7, 9)
$C_{14}$	(5, 7, 9)	1 / (1, 1, 3)	(5, 7, 9)	(1, 1, 3)

$$M'_5 =$$

	$C_{51}$	$C_{52}$
$C_{51}$	(1, 1, 3)	1 / (3, 5, 7)
$C_{52}$	(3, 5, 7)	(1, 1, 3)

*Process 4.1.5*

$$S^1_1 = (0.0264, 0.0493, 0.1967), \quad S^1_2 = (0.1453, 0.3527, 0.8680),$$

$$S^1_3 = (0.0409, 0.1277, 0.3703), \quad S^1_4 = (0.2058, 0.4703, 0.9548),$$

$$S^5_1 = (0.0857, 0.1667, 0.6481), \quad S^5_2 = (0.3000, 0.8333, 1.9444),$$

*Process 4.1.6*

$$W'_1 = (0.0000, 0.8492, 0.3244, 1.0000)^T, \quad W'_5 = (0.3431, 1.0000)^T.$$

$$W_1 = (0.0000, 0.4650, 0.1776, 0.5475)^T, \quad W_5 = (0.3070, 0.8947)^T.$$

Table C.32 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	$C_{14}$ User friendliness	0.5475
2	$C_{12}$ General performance, availability and maintainability	0.4650
3	$C_{13}$ Software platform	0.1776



4	$C_{11}$ Cost	0.0000
Ranking	Fundamental-objective	Weight vector
1	$C_{52}$ Readability and usability	0.8947
2	$C_{51}$ Report content convertible to file	0.3070

## 5.2 Step 4.2 results

### Process 4.2.2

$M_{21} =$

	$A_1$	$A_2$
$A_1$	1	7
$A_2$	1/7	1

$M_{31} =$

	$A_1$	$A_2$
$A_1$	1	1/7
$A_2$	7	1

$M_{41} =$

	$A_1$	$A_2$
$A_1$	1	7
$A_2$	1/7	1

$M_{51} =$

	$A_1$	$A_2$
$A_1$	1	5
$A_2$	1/5	1

$M_{52} =$

	$A_1$	$A_2$
$A_1$	1	3
$A_2$	1/3	1

$A_1$ : Web-based user interface

$A_2$ : GUI

### Process 4.2.3

Since there are only two comparing alternatives and consistency test is not needed.

### Process 4.2.4

$M'_{21} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(5, 7, 9)



$$A_2 \quad 1/(5, 7, 9) \quad (1, 1, 3)$$

$$M'_{31} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$1/(5, 7, 9)$
$A_2$	$(5, 7, 9)$	$(1, 1, 3)$

$$M'_{41} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(5, 7, 9)$
$A_2$	$1/(5, 7, 9)$	$(1, 1, 3)$

$$M'_{51} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(3, 5, 7)$
$A_2$	$1/(3, 5, 7)$	$(1, 1, 3)$

$$M'_{52} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 3, 5)$
$A_2$	$1/(1, 3, 5)$	$(1, 1, 3)$

#### *Process 4.2.5*

$S^{21}_1 = (0.3947, 0.8750, 1.6875),$	$S^{21}_2 = (0.0731, 0.1250, 0.4500),$
$S^{31}_1 = (0.0731, 0.1250, 0.4500),$	$S^{31}_2 = (0.3947, 0.8750, 1.6875),$
$S^{41}_1 = (0.3947, 0.8750, 1.6875),$	$S^{41}_2 = (0.0731, 0.1250, 0.4500),$
$S^{51}_1 = (0.3000, 0.8333, 1.9444),$	$S^{51}_2 = (0.0857, 0.1667, 0.6481),$
$S^{52}_1 = (0.1667, 0.7500, 2.5000),$	$S^{52}_2 = (0.1000, 0.2500, 1.2500).$

#### *Process 4.2.6*

$W'_{21} = (1.0000, 0.0686)^T,$	$W'_{31} = (0.0686, 1.0000)^T,$
$W'_{41} = (1.0000, 0.0686)^T,$	$W'_{51} = (1.0000, 0.3431)^T,$
$W'_{52} = (1.0000, 0.6842)^T.$	

$W_{21} = (0.9953, 0.0683)^T,$	$W_{31} = (0.0683, 0.9953)^T,$
$W_{41} = (0.9953, 0.0683)^T,$	$W_{51} = (0.8947, 0.3070)^T,$



$$W_{52} = (0.6811, 0.4660)^T.$$

Table C.33 Priority weights of alternatives with respect to cost  $C_{11}$

	$C_{21}$ Implementation cost	Priority weight ( $w_2$ )
Weight vector	1	
$A_1$ Web-based user interface	0.9953	0.9953
$A_2$ GUI	0.0683	0.0683

Table C.34 Priority weights of alternatives with respect to general performance, availability and maintainability  $C_{12}$

	$C_{31}$ Sufficient processing and memorial power	Priority weight ( $w_3$ )
Weight vector	1	
$A_1$ Web-based user interface	0.0683	0.0683
$A_2$ GUI	0.9953	0.9953

Table C.35 Priority weights of alternatives with respect to software platform  $C_{13}$

	$C_{41}$ Software platform independency (customer report)	Priority weight ( $w_4$ )
Weight vector	1	
$A_1$ Web-based user interface	0.9953	0.9953
$A_2$ GUI	0.0683	0.0683

Table C.36 Priority weights of alternatives with respect to user friendliness  $C_{14}$

	$C_{51}$ Report content convertible to file	$C_{52}$ Readability and usability	Priority weight ( $w_5$ )
Weight vector	0.3070	0.8947	
$A_1$ Web-based user interface	0.8947	0.6811	0.8841
$A_2$ GUI	0.3070	0.4660	0.5112

Table C.37 Priority weights of alternatives with respect to goal

	$C_{11}$ Cost	$C_{12}$ General performance, availability and maintainability	$C_{13}$ Software platform
--	---------------	--	----------------------------



Weight vector	0.0000	0.4650	0.1776
$A_1$ Web-based user interface	0.9953	0.0683	0.9953
$A_2$ GUI	0.0683	0.9953	0.0683
	$C_{14}$ User friendliness	Priority weight ( $w_1$ )	
Weight vector	0.5475		
$A_1$ Web-based user interface	0.8841	0.6926	
$A_2$ GUI	0.5112	0.7548	

Table C.38 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_2$ GUI	0.7548
2	$A_1$ Web-based user interface	0.6926

## 6. User interface (other internet application)

### 6.1 Step 4.1 results

#### Process 4.1.2

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
$C_{11}$	1	1/5	1/5	1/3
$C_{12}$	5	1	1	5
$C_{13}$	5	1	1	5
$C_{14}$	3	1/5	1/5	1

$C_{11}$ : cost

$C_{12}$ : data capturing

$C_{13}$ : general performance, availability and maintainability

$C_{14}$ : user friendliness

$M_5 =$

	$C_{51}$	$C_{52}$
$C_{51}$	1	1/5



C<sub>52</sub> 5 1

C<sub>21</sub>: report content convertible to file

C<sub>22</sub>: readability and usability

### Process 4.1.3

M<sub>5</sub> involves only two comparing objectives and consistency test is not needed.

$$CR_1 = 0.0828.$$

M<sub>1</sub> is considered consistent for their consistency ratio valued less than 0.100.

### Process 4.1.4

M'<sub>1</sub> =

	C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>
C <sub>11</sub>	(1, 1, 3)	1/(3, 5, 7)	1/(3, 5, 7)	1/(1, 3, 5)
C <sub>12</sub>	(3, 5, 7)	(1, 1, 3)	(1, 1, 3)	(3, 5, 7)
C <sub>13</sub>	(3, 5, 7)	1/(1, 1, 3)	(1, 1, 3)	(3, 5, 7)
C <sub>14</sub>	(1, 3, 5)	1/(3, 5, 7)	1/(3, 5, 7)	(1, 1, 3)

M'<sub>5</sub> =

	C <sub>51</sub>	C <sub>52</sub>
C <sub>51</sub>	(1, 1, 3)	1/(3, 5, 7)
C <sub>52</sub>	(3, 5, 7)	(1, 1, 3)

### Process 4.1.5

$$\begin{aligned} S^1_1 &= (0.0289, 0.0591, 0.2443), & S^1_2 &= (0.1558, 0.4091, 1.0469), \\ S^1_3 &= (0.1429, 0.3818, 0.9422), & S^1_4 &= (0.0445, 0.1500, 0.4536), \\ S^5_1 &= (0.0857, 0.1667, 0.6481), & S^5_2 &= (0.3000, 0.8333, 1.9444), \end{aligned}$$

### Process 4.1.6

$$W'_1 = (0.2017, 1.0000, 0.9665, 0.5348)^T, W'_5 = (0.3431, 1.0000)^T.$$

$$W_1 = (0.0892, 0.4423, 0.4275, 0.2366)^T, W_5 = (0.3070, 0.8947)^T.$$



Table C.39 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	C <sub>12</sub> Data capturing	0.4423
2	C <sub>13</sub> General performance, availability and maintainability	0.4275
3	C <sub>14</sub> User friendliness	0.2366
4	C <sub>11</sub> Cost	0.0892
Ranking	Fundamental-objective	Weight vector
1	C <sub>52</sub> Readability and usability	0.8947
2	C <sub>51</sub> Report content convertible to file	0.3070

## 6.2 Step 4.2 results

### Process 4.2.2

$$M_{21} = \begin{matrix} & A_1 & A_2 \\ A_1 & 1 & 1/7 \\ A_2 & 7 & 1 \end{matrix}$$

$$M_{31} = \begin{matrix} & A_1 & A_2 \\ A_1 & 1 & 1/7 \\ A_2 & 7 & 1 \end{matrix}$$

$$M_{41} = \begin{matrix} & A_1 & A_2 \\ A_1 & 1 & 1/5 \\ A_2 & 5 & 1 \end{matrix}$$

$$M_{51} = \begin{matrix} & A_1 & A_2 \\ A_1 & 1 & 1/5 \\ A_2 & 5 & 1 \end{matrix}$$

$$M_{52} = \begin{matrix} & A_1 & A_2 \\ A_1 & 1 & 1/5 \\ A_2 & 5 & 1 \end{matrix}$$

A<sub>1</sub>: Web-based user interface

A<sub>2</sub>: GUI

### Process 4.2.3



All matrices above involve only two comparing objectives and consistency test is not needed.

*Process 4.2.4*

$$M'_{21} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(5, 7, 9)
$A_2$	1/(5, 7, 9)	(1, 1, 3)

$$M'_{31} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(5, 7, 9)
$A_2$	1/(5, 7, 9)	(1, 1, 3)

$$M'_{41} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

$$M'_{51} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

$$M'_{52} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

*Process 4.2.5*

$S^{21}_1 = (0.3947, 0.8750, 1.6875),$	$S^{21}_2 = (0.0731, 0.1250, 0.4500),$
$S^{31}_1 = (0.3947, 0.8750, 1.6875),$	$S^{31}_2 = (0.0731, 0.1250, 0.4500),$
$S^{41}_1 = (0.3000, 0.8333, 1.9444),$	$S^{41}_2 = (0.0857, 0.1667, 0.6481),$
$S^{51}_1 = (0.3000, 0.8333, 1.9444),$	$S^{51}_2 = (0.0857, 0.1667, 0.6481),$
$S^{52}_1 = (0.3000, 0.8333, 1.9444),$	$S^{52}_2 = (0.0857, 0.1667, 0.6481).$

Process 4.2.6

$$W'_{21} = (1.0000, 0.0686)^T, \quad W'_{31} = (1.0000, 0.0686)^T,$$

$$W'_{41} = (1.0000, 0.3431)^T, \quad W'_{51} = (1.0000, 0.3431)^T,$$

$$W'_{52} = (1.0000, 0.3431)^T.$$

$$W_{21} = (0.9953, 0.0683)^T, \quad W_{31} = (0.9953, 0.0683)^T,$$

$$W_{41} = (0.8947, 0.3070)^T, \quad W_{51} = (0.8947, 0.3070)^T,$$

$$W_{52} = (0.8947, 0.3070)^T.$$

Table C.40 Priority weights of alternatives with respect to cost  $C_{11}$

	$C_{21}$ Implementation cost	Priority weight ( $w_2$ )
Weight vector	1	
$A_1$ Web-based user interface	0.9953	0.9953
$A_2$ GUI	0.0683	0.0683

Table C.41 Priority weights of alternatives with respect to data capturing  $C_{12}$

	$C_{31}$ Efficient data capturing	Priority weight ( $w_3$ )
Weight vector	1	
$A_1$ Web-based user interface	0.9953	0.9953
$A_2$ GUI	0.0683	0.0683

Table C.42 Priority weights of alternatives with respect to general performance, availability and maintainability  $C_{13}$

	$C_{41}$ Sufficient processing and memorial power	Priority weight ( $w_4$ )
Weight vector	1	
$A_1$ Web-based user interface	0.8947	0.8947
$A_2$ GUI	0.3070	0.3070

Table C.43 Priority weights of alternatives with respect to user friendliness  $C_{14}$

	$C_{51}$ Report content convertible to file	$C_{52}$ Readability and usability	Priority weight ( $w_5$ )
Weight vector	0.3070	0.8947	
$A_1$ Web-based	0.8947	0.8947	1.0752



user interface			
$A_2$ GUI	0.3070	0.3070	0.3689

Table C.44 Priority weights of alternatives with respect to goal

	$C_{11}$ Cost	$C_{12}$ Data capturing	$C_{13}$ General performance, availability and maintainability
Weight vector	0.0892	0.4423	0.4275
$A_1$ Web-based user interface	0.9953	0.9953	0.8947
$A_2$ GUI	0.0683	0.0683	0.3070
	$C_{14}$ User friendliness	Priority weight ( $w_1$ )	
Weight vector	0.2366		
$A_1$ Web-based user interface	1.0752	1.1659	
$A_2$ GUI	0.3689	0.2548	

Table C.45 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ Web-based user interface	1.1659
2	$A_2$ GUI	0.2548

## **APPENDIX D – QUESTIONNAIRE DESIGN FOR CASE STUDY III**

This appendix includes thirteen unfilled questionnaires designed for carrying out the TSS methodology in case study III. The questionnaires 1-x were designed for surveying the relative importance of fundamental-objectives in *process 4.1.1*; the questionnaires 2-x were designed for surveying relative effectiveness of alternatives in *process 4.2.1*; the questionnaire 3 was designed for surveying the relative importance of solution components in *process 5.1.1*.



# Questionnaire 1-1

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study III.)

## Solution component: Tracking technology

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 8

Duration: \_\_\_\_\_

## Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data Capturing
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
General Performance, availability & maintainability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data Capturing

## Section II – Level 2 *Cost* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
<b>Implementation cost</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Operational cost</b>

## Section III – Level 2 *Data Capturing* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
<b>Efficient data capturing</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Reliable data capturing</b>
<b>Efficient data capturing</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Fast, real-time updating tracking data</b>
<b>Reliable data capturing</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Fast, real-time updating tracking data</b>

## Section IV – Level 2 *General Performance, Availability and Maintainability* Factors Comparison

<b>Maintainability</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Availability</b>
------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------



## Questionnaire 1-2

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study III.)

### Solution component: Software platform (intranet application)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 16

Duration: \_\_\_\_\_

### Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Cost
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data transaction
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform

Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data transaction
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform
Data transaction	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Data transaction	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform
General Performance, availability & maintainability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform

**Section II – Level 2 General performance, availability and maintainability Factors Comparison**

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Efficient job card printing	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Efficient processing & memorial power
Efficient job card printing	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Availability
Efficient job card printing	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Maintainability
Efficient Processing & memorial	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Availability



power										
Efficient Processing & memorial power	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Maintainability
Availability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Maintainability

### Questionnaire 1-3

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study III.)

#### Solution component: software platform (Internet application)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 13

Duration: \_\_\_\_\_

### Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Cost
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data transaction
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform



Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data transaction
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform
Data transaction	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Data transaction	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform
General performance, availability & maintainability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform

**Section II – Level 2 General performance, availability and maintainability Factors Comparison**

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Efficient Processing & memorial power	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Availability
Efficient Processing & memorial power	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Maintainability
Availability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Maintainability

## Questionnaire 1-4

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study III.)

### Solution component: database management system

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 14

Duration: \_\_\_\_\_

### Section I – Level 1 *Goal* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Cost
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data capturing
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data transaction
Accessibility	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability



Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data capturing
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data transaction
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Data capturing	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data transaction
Data capturing	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Data transaction	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability

### Section II – Level 2 Accessibility Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Internet accessibility (customer report)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Intranet accessibility (intranet application)

### Section III – Level 2 Cost Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Implementation cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Operational cost

### Section IV – Level 2 Data transaction Comparison

<b>Fast, secured business data transaction</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>		Sufficient data storage & data transaction capabilities
--	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	--	--

**Section V – Level 2 *General performance, availability and maintainability* Comparison**

<b>Maintainability</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>		Availability
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## Questionnaire 1-5

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study III.)

### Solution component: user interface (customer reporting)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 7

Duration: \_\_\_\_\_

### Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User friendliness
General Performance	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform

General performance	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User friendliness
Software platform	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User friendliness

**Section II – Level 2 *User friendliness* Factors Comparison**

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Report content convertible to file	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Readability & usability



## Questionnaire 1-6

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study III.)

### Solution component: user interface (other Intranet application)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 7

Duration: \_\_\_\_\_

### Section I – Level 1 *Goal* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data capturing
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User friendliness
Data capturing	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	General performance, availability & maintainability

<b>Data capturing</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>User friendliness</b>
<b>General Performance, availability &amp; maintainability</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>User friendliness</b>

### Section II – Level 2 *User friendliness* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
<b>Report content convertible to file</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Readability &amp; usability</b>



## Questionnaire 2-1

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study III.)

### Solution component: Tracking technology

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 21

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Implementation cost*

Means-objectives: Software development cost, purchasing cost, easiness and cost of installation

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID
Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS

1.3	RFID	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	GPS
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

**Section II – Comparison against criteria *Operational cost***

Means-objectives: Cost for data carrier, maintenance cost, cost for manual operation

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID
2	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS
3	RFID	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS

**Section III – Comparison against criteria *Efficient data capturing***

Means-objectives: Data capturing time, reading range

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID
2	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS
3	RFID	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS

**Section IV – Comparison against criteria *Reliable data capturing***



Means-objectives: Data capturing accuracy, low data error rate, environmental susceptibility

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1.1	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID
1.2	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS
1.3	RFID	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS

**Section V – Comparison against criteria *Fast, real-time tracking data update to system***

Means-objectives: Data transmission, network protocol

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
2.1	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID
2.2	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS
2.3	RFID	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS

**Section VI – Comparison against criteria *Maintainability***

Means-objectives: Resource for repairing and replacement

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID
2	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS
3	RFID	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS

**Section VII – Comparison against criteria *Availability***

Means-objectives: Resource for repairing and replacement

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID
2	Barcode	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS
3	RFID	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GPS



## Questionnaire 2-2

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study III.)

### Solution component: software platform (intranet application)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 24

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Internet accessibility* (customer report)

Means-objectives: Compatibility to various intranet-based protocols

Remarks: \_\_\_\_\_  
\_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1-1	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
1-2	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
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**Section II – Comparison against criteria *Implementation cost***

Means-objectives: Purchase cost, setup cost

Remarks: \_\_\_\_\_  
\_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
W	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section III – Comparison against criteria *Fast, secured business data transaction (for SOP, Planning and scheduling)***

Means-objectives: Data management capability

Remarks: \_\_\_\_\_  
\_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
W	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section IV – Comparison against criteria *Efficient job card printing***



Means-objectives: Efficient serial interface, compatible to job card printer's software driver

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
W	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section V – Comparison against criteria *Sufficient processing and memorial power***

Means-objectives: Low resources requirements

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
W	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section VI – Comparison against criteria *Availability***

Means-objectives: Resource for repairing and replacement, operational stability

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section VII – Comparison against criteria *Maintainability***

Means-objectives: Resource for repairing and replacement

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section VIII – Comparison against criteria *MS Windows compatible (SOP)***

Means-objectives: Compatibility to MS Windows

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net



N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

## Questionnaire 2-3

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study III.)

### Solution component: software platform (internet application)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 21

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Internet accessibility (customer report)*

Means-objectives: Compatibility to various internet-based protocols

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java



W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
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**Section II – Comparison against criteria *Implementation cost***

Means-objectives: Purchase cost, setup cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
W	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section III – Comparison against criteria *Sufficient data storage and data transaction capabilities***

Means-objectives: Capable to cope with high volume of users' access

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
W	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
W	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section IV – Comparison against criteria *Sufficient processing and***

**memorial power**

Means-objectives: Low resources requirements

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
4.1	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
4.2	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
4.3	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section V – Comparison against criteria *Availability***

Means-objectives: Resource for repairing and replacement, operational stability

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
5.1	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
5.2	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
5.3	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section VI – Comparison against criteria *Maintainability***

Means-objectives: Resource for repairing and replacement

Remarks: \_\_\_\_\_  
 \_\_\_\_\_



		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
i	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
w	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

**Section VII – Comparison against criteria *Software platform independency (customer report)***

Means-objectives: Applications independent to client's platform, avoiding software installations on client computers

Remarks: \_\_\_\_\_  
\_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
i	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS .Net
N	Adobe AIR	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java
w	MS .Net	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Java

## Questionnaire 2-4

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study III.)

### Solution component: database management system

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 10

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Internet accessibility* (*customer report*)

Means-objectives: Accessibility to Internet-based applications

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	
Oracle 10g	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	MS SQL 2000



**Section II – Comparison against criteria *Intranet accessibility (intranet applications)***

Means-objectives: Accessibility to intranet-based applications

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section III – Comparison against criteria *Implementation cost***

Means-objectives: Software purchasing cost, setup cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section IV – Comparison against criteria *Operational cost***

Means-objectives: Administration cost, maintenance cost, hosting cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section V – Comparison against criteria *Fast, real-time tracking data***

*update to system*

Means-objectives: Efficient data interface to data capturing sub-system

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section VI – Comparison against criteria *Fast, secured business data transaction (for SOP, Planning and scheduling)***

Means-objectives: Capability in handling simultaneous accesses, data security

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section VII – Comparison against criteria *Sufficient data storage and data transaction capabilities***

Means-objectives: Efficient with huge amount of cumulative data, efficient with continuous frequent accesses

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000



**Section VIII – Comparison against criteria *Sufficient processing and memorial power***

Means-objectives: Low resources requirements

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section IX – Comparison against criteria *Maintainability***

Means-objectives: Resource for repairing and replacement

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section X – Comparison against criteria *Availability***

Means-objectives: Resource for repairing and replacement, operational stability

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

## Questionnaire 2-5

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study III.)

### Solution component: user interface (customer reporting)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 5

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Implementation cost*

Means-objectives: Setup cost, software development cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI



**Section II – Comparison against criteria *Sufficient processing and memorial power***

Means-objectives: Low resources requirements

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
2.1	Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

**Section III – Comparison against criteria *Software platform independency (customer report)***

Means-objectives: Avoiding additional software installations, accessibility by different software platform

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
3.1	Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

**Section IV – Comparison against criteria *Report content convertible to file***

Means-objectives: Direct copy/save data from user interface

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	

4.1	Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI
-----	--------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	---------------------------------	-----

**Section V – Comparison against criteria *Readability & usability***

Means-objectives: Efficient data presentation, conventional data format

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
5.1	Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI



## Questionnaire 2-6

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study III.)

### Solution component: user interface (other Intranet application)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 5

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Implementation cost*

Means-objectives: Setup cost, software development cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

**Section II – Comparison against criteria *Efficient data capturing***

Means-objectives: Enable efficient data input with keyboard, quick screen refresh

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
2.1 Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

**Section III – Comparison against criteria *Sufficient processing and memorial power***

Means-objectives: Low resources requirements

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
3.1 Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

**Section IV – Comparison against criteria *Report content convertible to file***

Means-objectives: Direct copy/save data from user interface

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
4.1 Web-based user	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI



interface		
-----------	--	--

**Section V – Comparison against criteria *Readability & usability***

Means-objectives: Efficient data presentation, conventional data format

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
S-1 Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

### Questionnaire 3

(This questionnaire is designed for *process 5.1.1* of the TSS methodology for case study III.)

Please answer all questions. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 15

Duration: \_\_\_\_\_

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform (intranet app.)
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform (Internet app.)
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Database management system
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (customer reporting)
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (other intranet app.)



Software platform (intranet app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Software platform (Internet app.)
Software platform (intranet app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Database management system
Software platform (intranet app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (customer reporting)
Software platform (intranet app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (other intranet app.)
Software platform (Internet app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Database management system
Software platform (Internet app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (customer reporting)
Software platform (Internet app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (other intranet app.)
Database management system	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (customer reporting)
Database management system	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (other intranet app.)
User interface (customer reporting)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (other intranet app.)



# APPENDIX E – MS EXCEL SPREADSHEET DESIGN

MS Excel spreadsheets were designed for support the mathematical computations required by the proposed TSS methodology. This appendix briefly introduces the setup and screenshots.

## 1. Spreadsheet 1 – consistency ratio

This spreadsheet was designed for calculation of eigenvector, principle eigenvalue, consistency index, and finally consistency ratio. With the necessary inputs (matrix, size of matrix  $n$ , and the random consistency index  $RI$ ) entered into the Inputs section, the results (eigenvector, principal eigenvalue, consistency index  $CI$ , and consistency ratio  $CR$ ) will thereby come out and presented in the Answers section. Below is the screenshot of the spreadsheet for a matrix sized 3 x 3.

The screenshot shows a Microsoft Excel spreadsheet with the following data:

Microsoft Excel - eigen_vector.xls												
File Edit View Insert Format Tools Data Window Help												
Type a question for help												
A28												
1	<b>Inputs</b>											
2		matrix A			n	RI						
3		1.000	1.000	3.000	3	0.58						
4		1.000	1.000	3.000								
5		0.333	0.333	1.000								
7	<b>Variables</b>											
8	sum	2.333	2.333	7.000								
9	1/sum	0.429	0.429	0.143								
10		matrix B										
11		0.429	0.429	0.429								
12		0.429	0.429	0.429								
13		0.143	0.143	0.143								
16	<b>Answers</b>											
17		eigenvector			principal eigenvalue							
18		0.429			3							
19		0.429			CI		CR					
20		0.143			0		0					

Figure E.1 Operation screen of spreadsheet 1



## 2. Spreadsheet 2 – Synthetic extent and weight vector

This spreadsheet was designed for calculation of synthetic extent and weight vector in crisp value. With the necessary inputs (matrix in triangular fuzzy numbers) entered into the Inputs section, the results (synthetic extent and weight vector) will thereby come out and presented in the Answers section. Note that the  $V$  variables in the Variable section require manual input for 1 and 0 for the conditions defined by equation:

$$V(S_b \geq S_a) = \begin{cases} 1, & m_b \geq m_a, \\ 0, & l_a \geq u_b \\ (l_a - u_b) / [(m_b - u_b) - (m_a - l_a)], & \text{others.} \end{cases}$$

Below is the screenshot of the spreadsheet for a matrix sized 3 x 3.

The screenshot shows a Microsoft Excel spreadsheet titled "synthetic extent and weight vectors\_alternatives.xls". The spreadsheet is divided into three main sections: Inputs, Variables, and Answers.

**Inputs Section (Rows 2-5):** A 3x3 matrix of triangular fuzzy numbers. The columns are labeled  $l$ ,  $m$ , and  $u$ . The values are:

	$l$	$m$	$u$
1	1.000	0.143	1.000
2	3.000	1.000	1.000
3	1.000	0.200	1.000

**Variables Section (Rows 7-13):** Contains variables  $1/Q$ ,  $P$ , and  $Q$ . The  $1/Q$  section has values 9.343, 17.533, and 29.667. The  $P$  section has values 2.143, 4.200, 8.333; 5.000, 9.000, 15.000; and 2.200, 4.333, 6.333. The  $Q$  section has values 0.107, 0.057, and 0.034. To the right,  $V$  variables are calculated for comparisons between  $S1, S2, S3$ .

**Answers Section (Rows 17-21):** Shows the Synthetic extent ( $S$ ) and Weight vector ( $d'(C_i)$ ). The Synthetic extent values are:

	$l$	$m$	$u$
S1	0.229	0.240	0.281
S2	0.535	0.513	0.506
S3	0.235	0.247	0.213

The Weight vector values are:

$d'(C1)$	0.000
$d'(C2)$	1.000
$d'(C3)$	0.000

Figure E.2 Operation screen of spreadsheet 2



## APPENDIX F – MATLAB PROGRAMME SCRIPT

Software Maplab v.7.1 was employed during case-based testing. This appendix list the contents of m file that was created for the work, and then briefly introduce it.

### 1. Script file: s2ni.m

#### *Code:*

```
function y = s2ni(u, i);  
b=1e-10 * i;  
y = u ./ (norm(u).^2 + b);
```

#### *Descriptions:*

This script provides function to fulfill squared 2-norm normalization for a given array or matrix.

There are 2 parameters in the function: the matrix of any dimension to be process and the size of normalization bias.

Note that the 'b' in the code means the normalization bias which is typically chosen to be a small positive constant (e.g.  $1 \times 10^{-10}$  or 1e-10) in order to prevent potential division by 0. When used, the second parameter can always be 1 in order to use the 1e-10 as the normalization bias by default. However, the second parameter provides options to time the normalization bias.

#### *Operation screenshots:*

The following screenshots show that an 1-d matrix was first created and then employed the function defined in the script for solution.



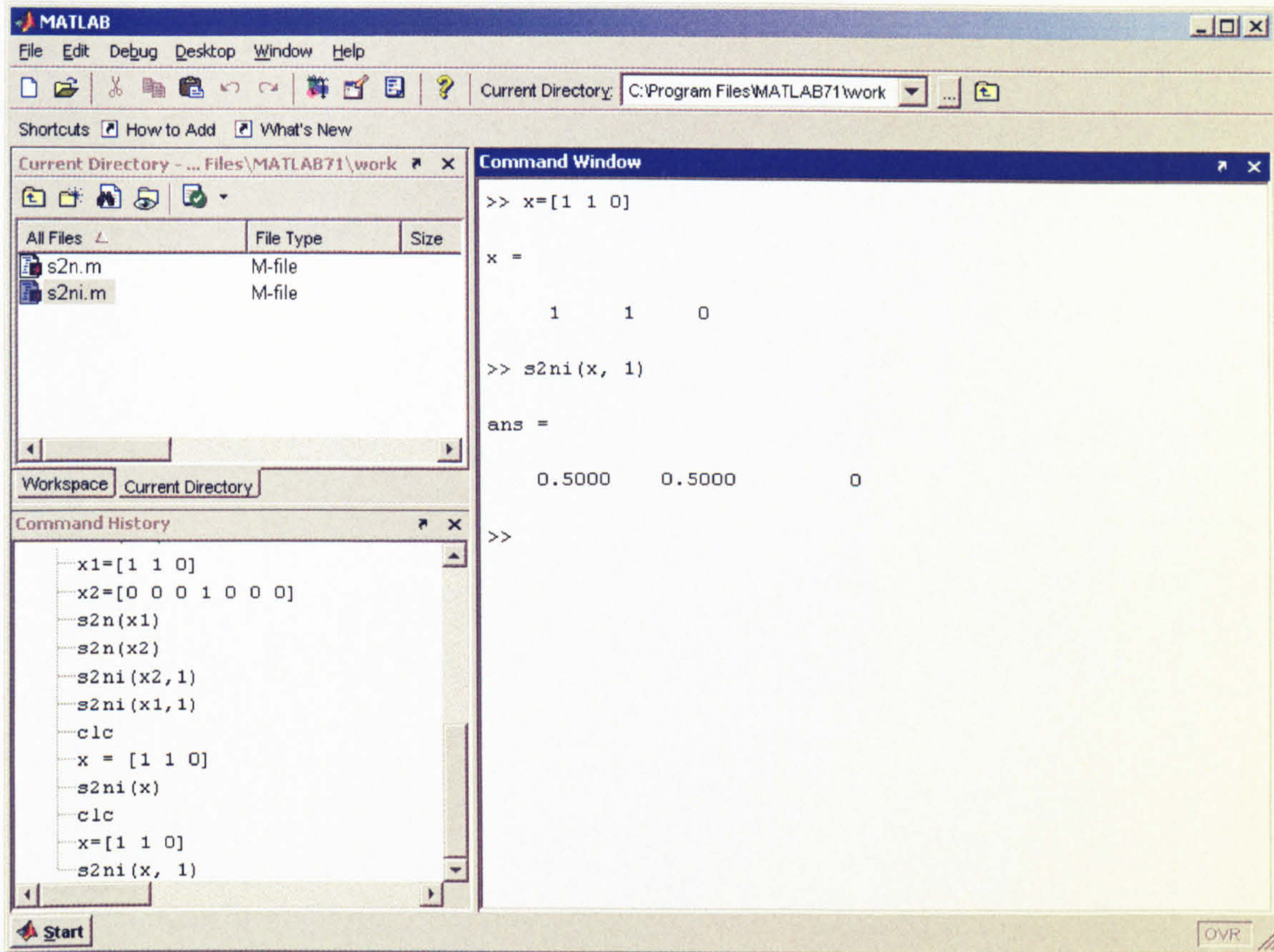


Figure F.1 Demonstration of normalization function defined by s2ni.m



## APPENDIX G - PHASE 3 RESULTS FOR CASE STUDY IV

This appendix documents the *phase 3* results for the case study IV. Through solution decomposition in *phase 2*, there are nine solution components identified with six of them gone through *phase 3* for solution component decomposition processes.

Thereby, this document will be divided into 6 sections with each section includes the results for one of the solution components. Each section contains the identified goal and means-objectives resulted from *step 3.1* and a complete AHP-based hierarchy model resulted from *step 3.1*.

### 1. Tracking technology

*Goal: define and specify the best-fit tracking technology*

Table G.1 The means-objectives for tracking technology

Fundamental-objective	Means-objective(s)
Fixed cost	Hardware purchase cost, setup cost, software development cost
Variable cost	Vehicle-based purchase cost (e.g. cost for data carrier), maintenance cost, labour cost for manual operations
Effective live tracking data update to database	Connectivity from tracking device to data modem, connectivity from data modem to remote server
Effective location tracking	Location tracking accuracy, low data error rate
Maintainability	Less need for collection of mobile devices during maintenance, low breakdown/operational failure rate
Availability	Influence by environmental factors (e.g. weather), geographical tracking coverage, low breakdown/operational failure rate



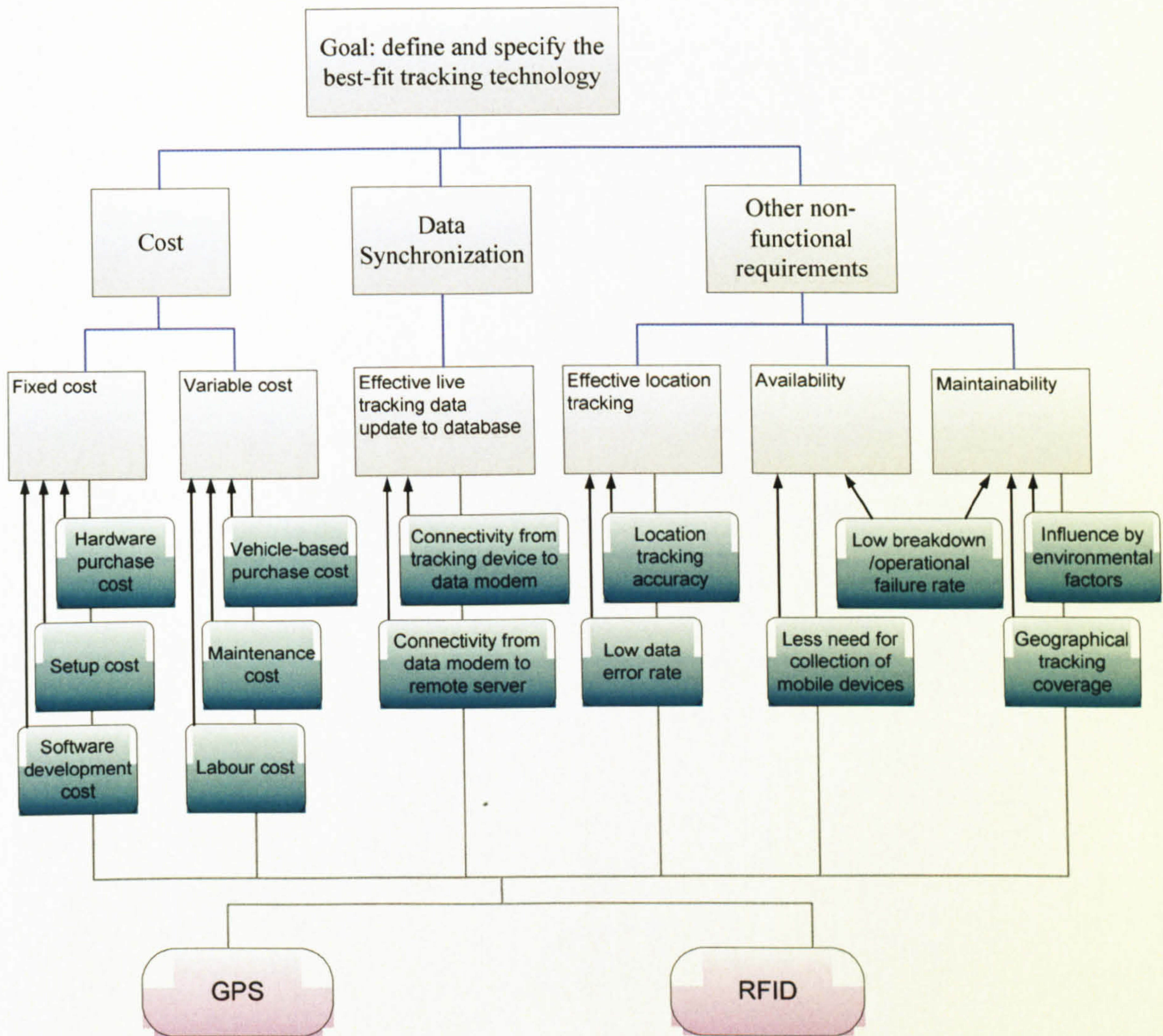


Figure G.1 The complete AHP-based hierarchy model for tracking technology

## 2. PDA software platform

Goal: *define and specify the best-fit PDA software platform*

Table G.2 The means-objectives for PDA software platform

Fundamental-objective	Means-objective(s)
Effective data presentation	Rich graphical interface, quick screen refresh rate, short loading time
Fixed cost	PDA purchase cost, software development cost
Variable cost	Maintenance cost
Effective live tracking data update to database	Connectivity to tracking devices, connectivity to remote server
Effective live job data update to	Connectivity to remote server



database	
Maintainability	Quality of support from provider
Availability	Operational stability
Sufficient processing and memorial power	High processing and memorial performance

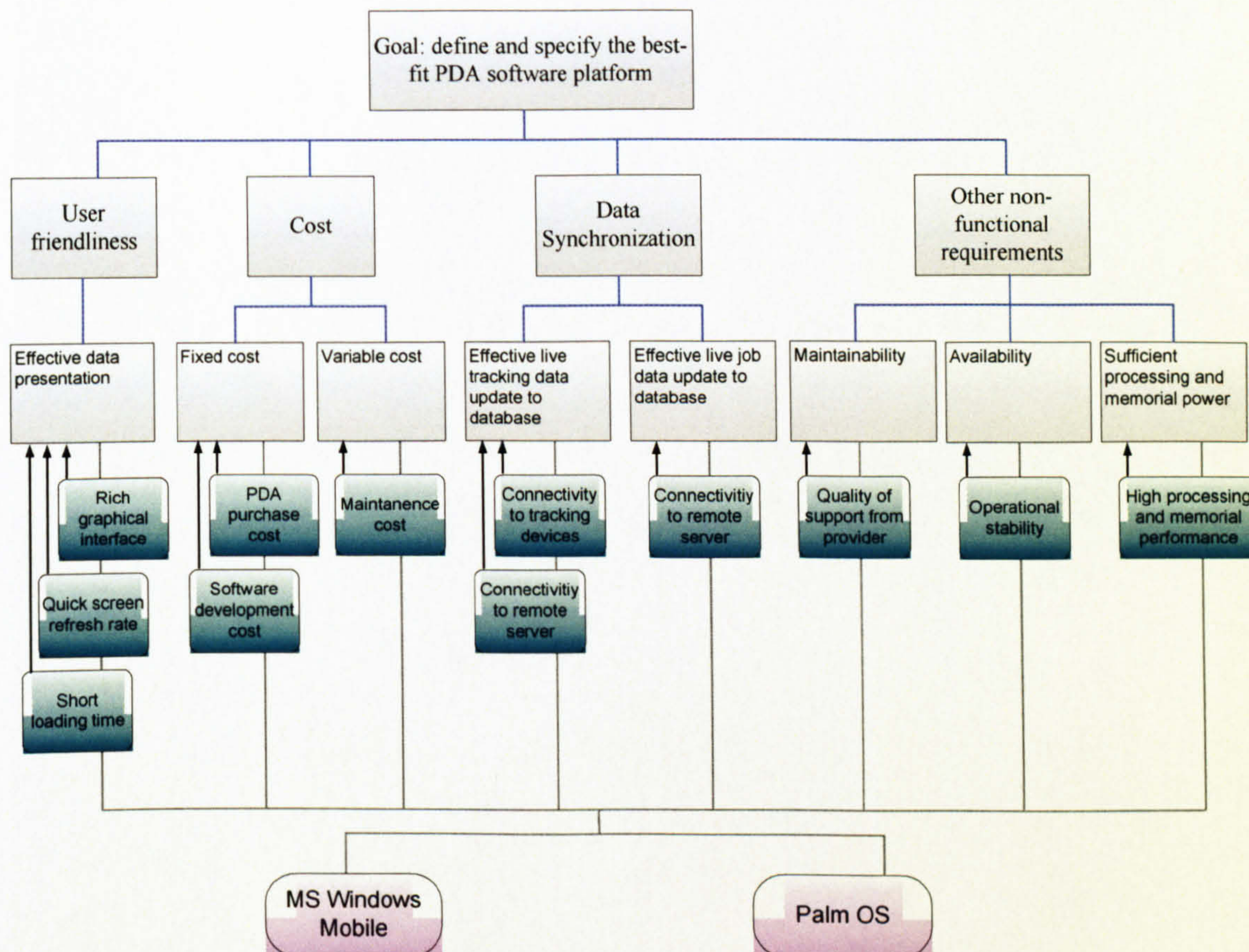


Figure G.2 The complete AHP-based hierarchy model for PDA software platform

### 3. Database management system

Goal: *define and specify the best-fit database managemet system*

Table G.3 The means-objctives for database management system

Fundamental-objective	Means-objective(s)
Fixed cost	Software purchasing cost, setup cost
Variable cost	Administration cost, maintenance cost
Effective live tracking data update to database	Effective data interface to applications
Effective live job data update to	Effective data interface to applications



database	
Effective data integration to legacy system	Capability in handling continuous frequent data import
Maintainability	Low breakdown rate, easy-to-upgrade
Availability	Operational stability
Sufficient processing and memorial power	Being efficient with huge amount of data transaction and data storage
Sufficient data storage and data transaction capabilities	Capability in handling huge amount of historical data, capability to handling continuous frequent accesses
Secured data transaction	Data security

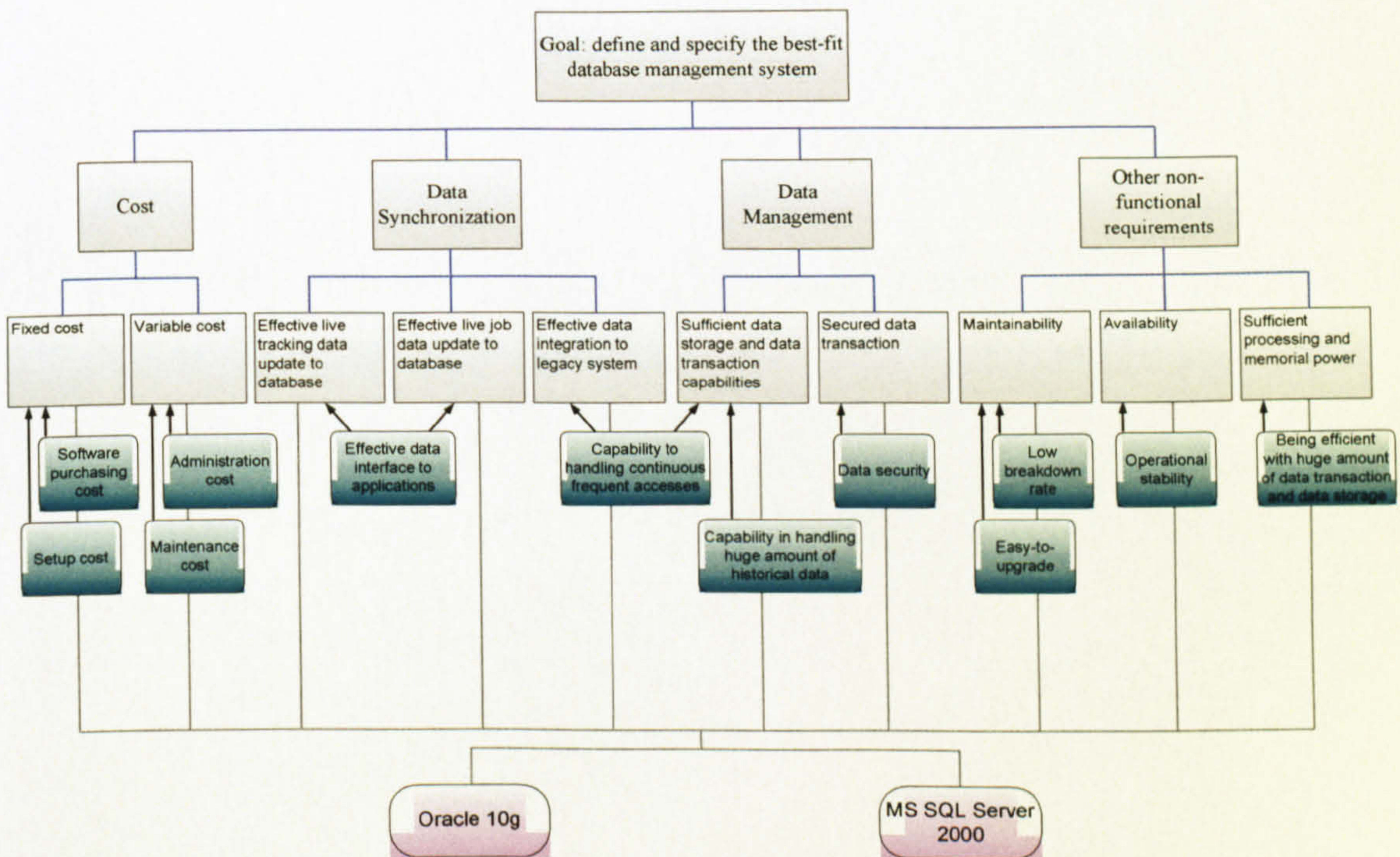


Figure G.3 The complete AHP-based hierarchy model for database management system

#### 4. User interface (portal applications)

Goal: *define and specify the best-fit user interface (portal applications)*

Table G.4 The means-objectives for user interface (portal applications)

Fundamental-objective	Means-objective(s)
User friendly vehicle tracking	OS independent for access of application, avoid



functionalities for public user	additional software installation, conventional reading format
Effective data presentation	Rich content presentation, quick screen refresh rate, short loading time
Sufficient processing and memorial power	Low resources requirements to server
Effective location tracking	Rich content presentation, tracking automatic information refreshing

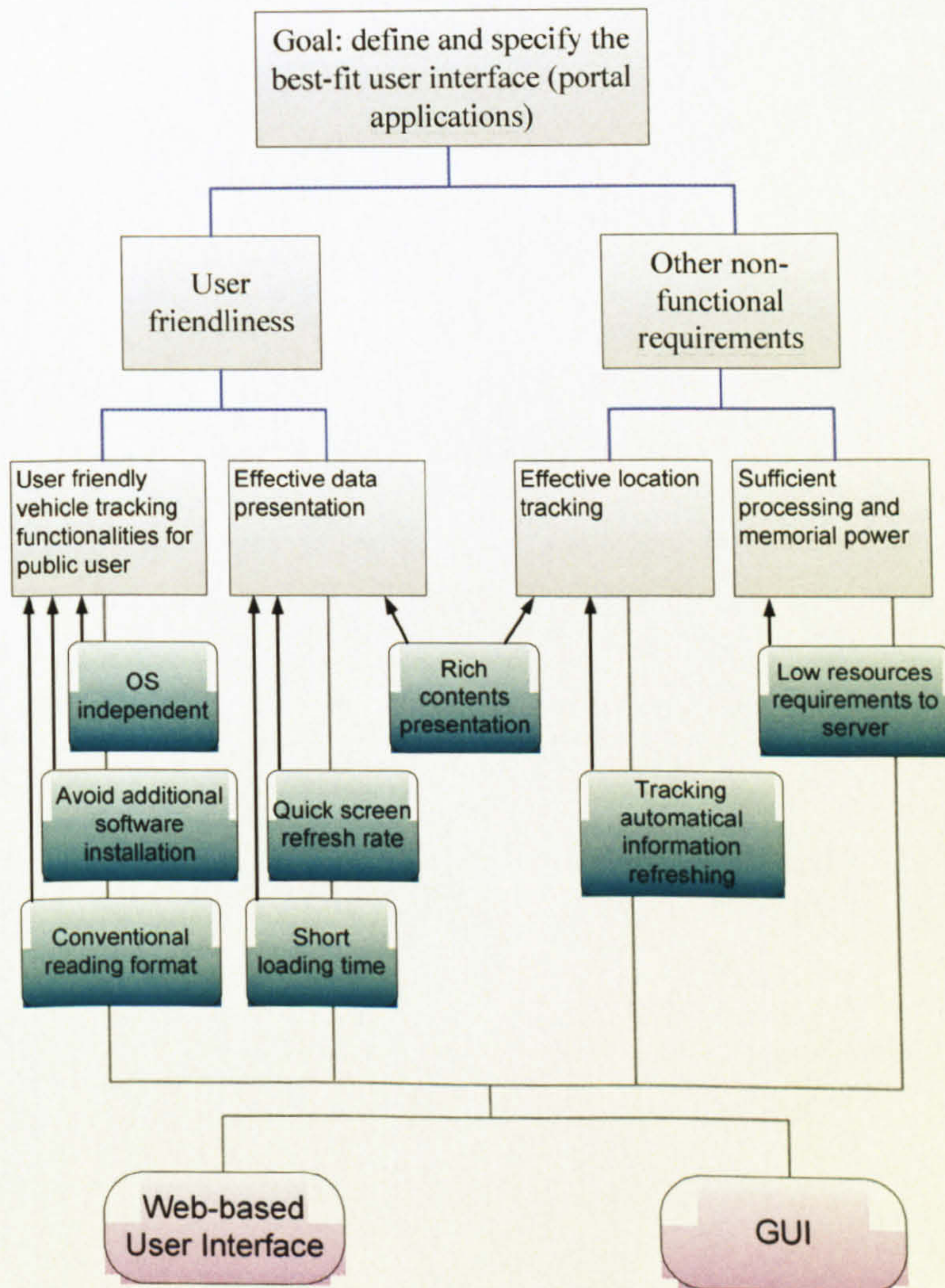


Figure G.4 The complete AHP-based hierarchy model for user interface (portal applications)

## 5. User interface (PDA applications)

Goal: *define and specify the best-fit user interface (PDA applications)*



Table G.5 The means-objectives for user interface (PDA applications)

Fundamental-objective	Means-objective(s)
User friendly user interface for PDA applicaitons	Efficient use of screen space, avoid horizontal scroll bar
Effective data presentation	Rich content presentation, quick screen refresh rate, short loading time
Sufficient processing and memorial power	Low resources requirement to server
Effective location tracking	Capability to manage tracking device and remote server connectivity status on screen

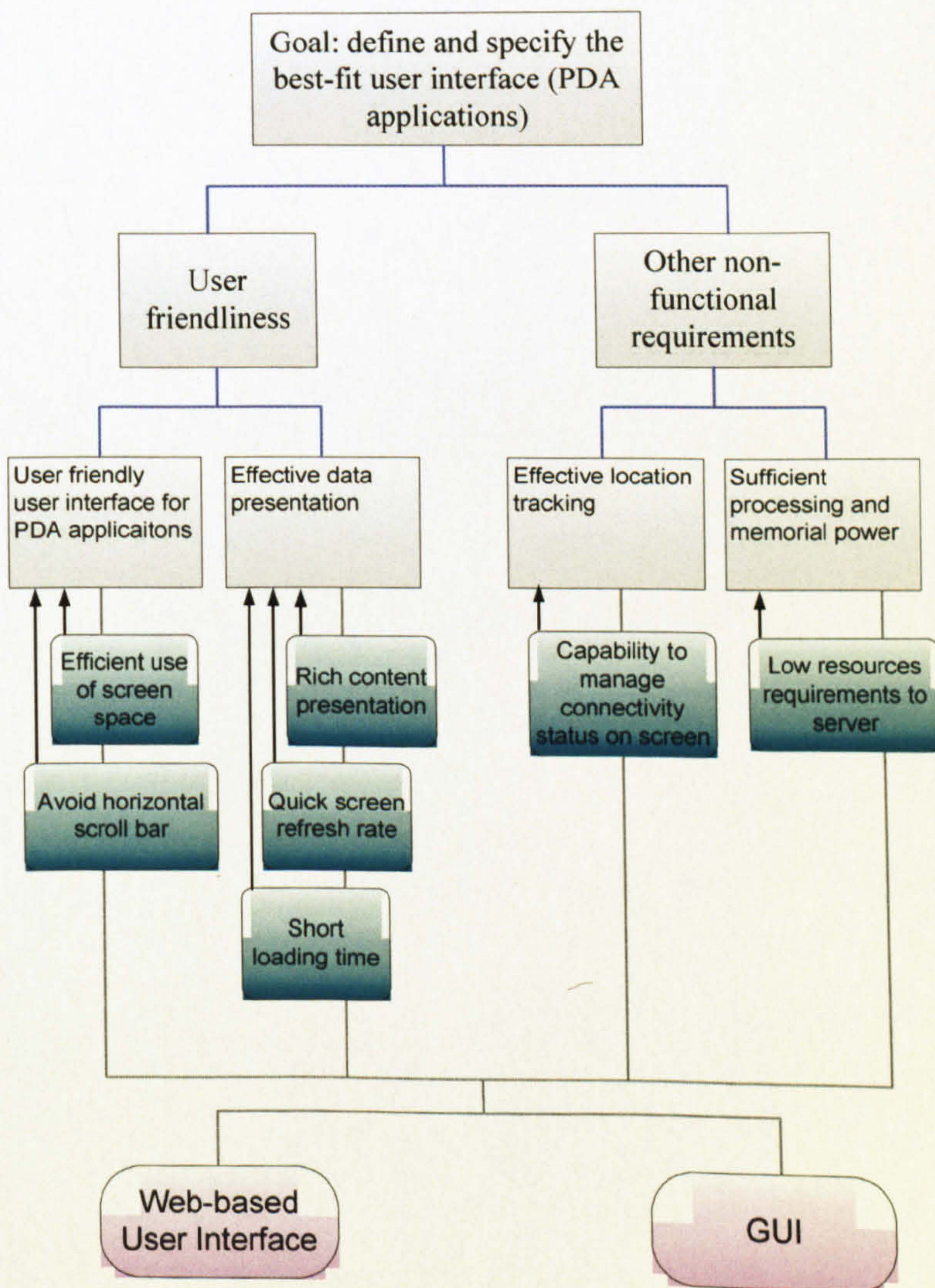


Figure G.5 The complete AHP-based hierarchy model for user interface (PDA applications)



## 6. GIS technology

Goal: *define and specify the best-fit GIS technology*

Table G.6 The means-objectives for GIS technology

Fundamental-objective	Means-objective(s)
User friendly vehicle tracking functionalities for public user	Map readability, ETA (Estimated Time of Arrival), distance calculation
Effective data presentation	Map zooming, fast screen refresh
Fixed cost	Software purchase cost (include geographical data purchase cost if any), software integration cost
Variable cost	Service subscription cost, maintenance cost
Effective data integration to legacy system	Geocoding and reverse geocoding for address data integration
Maintainability	Quality of support from provider
Availability	Operational stability
Sufficient processing and memorial power	Low resource requirement to server
Secured data transaction	Managed geographical data protection

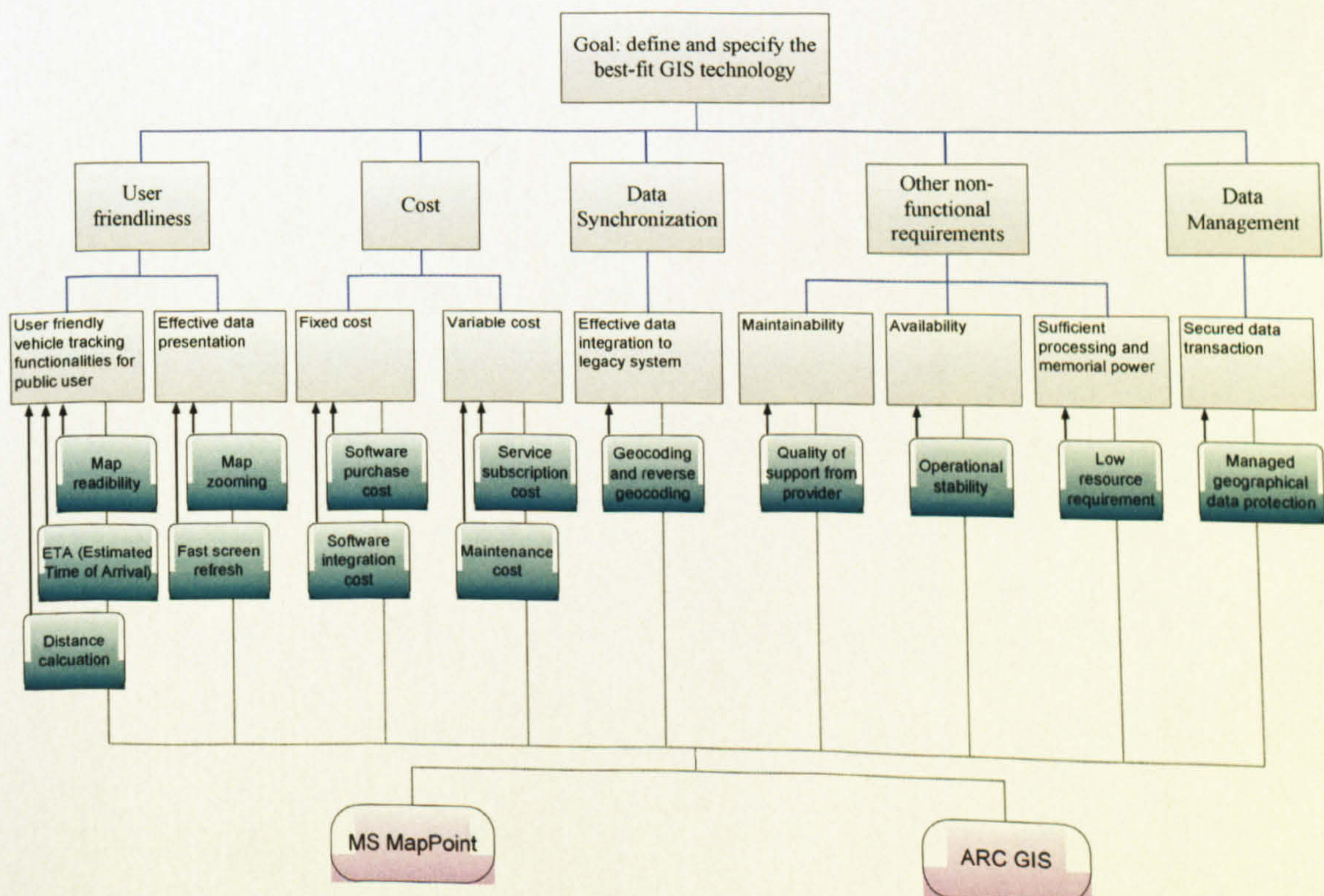


Figure G.6 The complete AHP-based hierarchy model for GIS technology



## APPENDIX H – PHASE 4 RESULTS FOR CASE STUDY IV

*Appendix H* documents the *phase 4* results for the case study IV. With the AHP-based hierarchy models of the six solution components produced in *phase 3*, ranking of alternatives for the solution components were generated through a series of computational processes.

This document is divided into six sections with each section includes the results for one of the solution components. Each section contains two sub-sections for *step 4.1* and *step 4.2* respectively.

The first sub-section contains the PCMs resulted from *process 4.1.1* and *process 4.1.2*, the consistency ratios as the consistency test results in *process 4.1.3*, the fuzzified PCMs resulted from *process 4.1.4*, the synthetic extents as the results of *process 4.1.5*, the weight vectors and thereby rankings of fundamental-objectives resulted from *process 4.1.6*.

Similarly, the second sub-section include the PCMs resulted from *process 4.2.1* and *process 4.2.2*, the consistency ratios as the consistency test results in *process 4.2.3*, the fuzzified PCMs resulted from *process 4.2.4*, the synthetic extents as the results of *process 4.2.5*, the weight vectors, priority weights and thereby ranking of alternatives resulted from *process 4.2.6*.

### 1. Tracking technology

#### 1.1 Step 4.1 results

##### *Process 4.1.2*

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$
$C_{11}$	1	3	1/3
$C_{12}$	1/3	1	1/5
$C_{13}$	3	5	1

$C_{11}$ : cost

$C_{12}$ : data synchronization

$C_{13}$ : other non-functional requirements

$M_2 =$

	$C_{21}$	$C_{22}$
$C_{21}$	1	1/5
$C_{22}$	5	1

$C_{21}$ : fixed cost

$C_{22}$ : variable cost

$M_3 =$

	$C_{31}$
$C_{31}$	1

$C_{31}$ : effective live tracking data update to database

$M_4 =$

	$C_{41}$	$C_{42}$	$C_{43}$
$C_{41}$	1	3	1
$C_{42}$	1/3	1	1/3
$C_{43}$	1	3	1

$C_{41}$ : effective location tracking

$C_{42}$ : availability

$C_{43}$ : maintainability

### *Process 4.1.3*

$M_1$  and  $M_2$  involve less than 3 objectives and consistency test is not needed.

$$CR_1 = 0.0478,$$

$$CR_4 = 0.000$$

$M_1$  and  $M_4$  are considered consistent for their consistency ratio valued less than 0.100.

### *Process 4.1.4*

$M'_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$
$C_{11}$	(1, 1, 3)	(1, 3, 5)	1 / (1, 3, 5)



$$\begin{array}{lll}
 C_{12} & 1/(1, 3, 5) & (1, 1, 3) & 1/(3, 5, 7) \\
 C_{13} & (1, 3, 5) & (3, 5, 7) & (1, 1, 3)
 \end{array}$$

$$M'_2 =$$

$$\begin{array}{ll}
 & C_{21} & C_{22} \\
 C_{21} & (1, 1, 3) & 1/(3, 5, 7) \\
 C_{22} & (3, 5, 7) & (1, 1, 3)
 \end{array}$$

$$M'_4 =$$

$$\begin{array}{lll}
 & C_{41} & C_{42} & C_{43} \\
 C_{41} & (1, 1, 3) & (1, 3, 5) & (1, 1, 3) \\
 C_{42} & 1/(1, 3, 5) & (1, 1, 3) & 1/(1, 3, 5) \\
 C_{43} & 1/(1, 1, 3) & (1, 3, 5) & (1, 1, 3)
 \end{array}$$

#### Process 4.1.5

$$\begin{array}{ll}
 S^1_1 = (0.0776, 0.2915, 1.0535), & S^1_2 = (0.0474, 0.1031, 0.5072), \\
 S^1_3 = (0.1765, 0.6054, 1.7559), & \\
 S^2_1 = (0.0857, 0.1667, 0.6481), & S^2_2 = (0.3000, 0.8333, 1.9444), \\
 S^4_1 = (0.1200, 0.4286, 1.6337), & S^4_2 = (0.0560, 0.1429, 0.7426), \\
 S^4_3 = (0.0933, 0.4286, 1.3366). &
 \end{array}$$

#### Process 4.1.6

$$\begin{array}{ll}
 W'_1 = (0.7364, 0.3971, 1.0000)^T, & W'_2 = (0.3431, 1.0000)^T, \\
 W'_4 = (1.0000, 0.6854, 1.0000)^T. &
 \end{array}$$

$$\begin{array}{ll}
 W_1 = (0.4332, 0.2336, 0.5882)^T, & W_2 = (0.3070, 0.8947)^T, \\
 W_4 = (0.4049, 0.2775, 0.4049)^T. &
 \end{array}$$

Table H.1 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	$C_{13}$ Other non-functional requirements	0.5882
2	$C_{11}$ Cost	0.4332
3	$C_{12}$ Data synchronization	0.2336
Ranking	Fundamental-objective	Weight vector
1	$C_{22}$ Variable cost	0.8947



2	C <sub>21</sub> Fixed cost	0.3070
Ranking	Fundamental-objective	Weight vector
1	C <sub>41</sub> Effective location tracking	0.4049
	C <sub>43</sub> Maintainability	0.4049
3	C <sub>42</sub> Availability	0.2775

## 1.2 Step 4.2 results

### Process 4.2.2

$$M_{21} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1/3 \\ A_2 & 3 & 1 \end{array}$$

$$M_{22} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 5 \\ A_2 & 1/5 & 1 \end{array}$$

$$M_{31} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1/3 \\ A_2 & 3 & 1 \end{array}$$

$$M_{41} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 7 \\ A_2 & 1/7 & 1 \end{array}$$

$$M_{42} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1/3 \\ A_2 & 3 & 1 \end{array}$$

$$M_{43} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 3 \\ A_2 & 1/3 & 1 \end{array}$$

A<sub>1</sub>: GPS  
A<sub>2</sub>: RFID

### Process 4.2.3

As there are only two alternatives, the PCMs regarded always consistent.

### Process 4.2.4

$$M'_{21} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & (1, 1, 3) & 1/(1, 3, 5) \end{array}$$



$$A_2 \quad (1, 3, 5) \quad (1, 1, 3)$$

$$M'_{22} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(3, 5, 7)$
$A_2$	$1/(3, 5, 7)$	$(1, 1, 3)$

$$M'_{31} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$1/(1, 3, 5)$
$A_2$	$(1, 3, 5)$	$(1, 1, 3)$

$$M'_{41} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(5, 7, 9)$
$A_2$	$1/(5, 7, 9)$	$(1, 1, 3)$

$$M'_{42} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$1/(1, 3, 5)$
$A_2$	$(1, 3, 5)$	$(1, 1, 3)$

$$M'_{43} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 3, 5)$
$A_2$	$1/(1, 3, 5)$	$(1, 1, 3)$

### ***Process 4.2.5***

$S^{21}_1 = (0.1000, 0.2500, 1.2500),$	$S^{21}_2 = (0.1667, 0.7500, 2.5000),$
$S^{22}_1 = (0.3000, 0.8333, 1.9444),$	$S^{22}_2 = (0.0857, 0.1667, 0.6481),$
$S^{31}_1 = (0.1000, 0.2500, 1.2500),$	$S^{31}_2 = (0.1667, 0.7500, 2.5000),$
$S^{41}_1 = (0.3947, 0.8750, 1.6875),$	$S^{41}_2 = (0.0731, 0.1250, 0.4500),$
$S^{42}_1 = (0.1000, 0.2500, 1.2500),$	$S^{42}_2 = (0.1667, 0.7500, 2.5000),$
$S^{43}_1 = (0.1667, 0.7500, 2.5000),$	$S^{43}_2 = (0.1000, 0.2500, 1.2500).$

### ***Process 4.2.6***



$$W'_{21} = (1.0000, 1.2632)^T,$$

$$W'_{31} = (1.0000, 1.2632)^T,$$

$$W'_{42} = (1.0000, 1.2632)^T,$$

$$W'_{22} = (1.0000, 0.3431)^T,$$

$$W'_{41} = (1.0000, 0.0686)^T,$$

$$W'_{43} = (1.0000, 0.6842)^T.$$

$$W_{21} = (0.3853, 0.4867)^T,$$

$$W_{31} = (0.3853, 0.4867)^T,$$

$$W_{42} = (0.3853, 0.4867)^T,$$

$$W_{22} = (0.8947, 0.3069)^T,$$

$$W_{41} = (0.9953, 0.0687)^T,$$

$$W_{43} = (0.6813, 0.4660)^T.$$

Table H.2 Priority weights of alternatives with respect to cost  $C_{11}$

	$C_{21}$ Fixed cost	$C_{22}$ Variable cost	Priority weight ( $w_2$ )
Weight vector	0.3070	0.8947	
$A_1$ GPS	0.3853	0.8947	0.9188
$A_2$ RFID	0.4867	0.3069	0.4240

Table H.3 Priority weights of alternatives with respect to other non-functional requirements  $C_{12}$

	$C_{31}$ Effective live tracking data update to database	Priority weight ( $w_3$ )
Weight vector	1	
$A_1$ GPS	0.3853	0.3853
$A_2$ RFID	0.4867	0.4867

Table H.4 Priority weights of alternatives with respect to data synchronization  $C_{13}$

	$C_{41}$ Effective location tracking	$C_{42}$ Availability	$C_{43}$ Maintainability	Priority weight ( $w_4$ )
Weight vector	0.4049	0.2775	0.4049	
$A_1$ GPS	0.9953	0.3853	0.6813	0.7858
$A_2$ RFID	0.0687	0.4867	0.4660	0.3516

Table H.5 Priority weights of alternatives with respect to goal

	$C_{11}$ Cost	$C_{12}$ Data synchronization	$C_{13}$ Other non-functional requirements	Priority weight ( $w_1$ )
Weight vector	0.4332	0.2336	0.5882	
$A_1$ GPS	0.9188	0.3853	0.7858	0.9502
$A_2$ RFID	0.4240	0.4867	0.3516	0.5042



Table H.6 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ GPS	0.9502
2	$A_2$ RFID	0.5042

## 2. PDA software platform

### 2.1 Step 4.1 results

#### *Process 4.1.2*

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
$C_{11}$	1	1/5	1/3	1
$C_{12}$	5	1	3	5
$C_{13}$	3	1/3	1	3
$C_{14}$	1	1/5	1/3	1

$C_{11}$ : user friendliness

$C_{12}$ : cost

$C_{13}$ : data synchronization

$C_{14}$ : other non-functional requirements

$M_2 =$

	$C_{21}$
$C_{21}$	1

$C_{21}$ : effective data presentation

$M_3 =$

	$C_{31}$	$C_{32}$
$C_{31}$	1	3
$C_{32}$	1/3	1

$C_{31}$ : fixed cost

$C_{32}$ : variable cost



$$M_4 =$$

	$C_{41}$	$C_{42}$
$C_{41}$	1	1/5
$C_{42}$	5	1

$C_{41}$ : effective live tracking data update to database

$C_{42}$ : effective live job data update to database

$$M_5 =$$

	$C_{51}$	$C_{52}$	$C_{53}$
$C_{51}$	1	5	1/3
$C_{52}$	1/5	1	7
$C_{53}$	3	1/7	1

$C_{51}$ : maintainability

$C_{52}$ : availability

$C_{53}$ : sufficient processing and memorial power

### *Process 4.1.3*

$M_2$ ,  $M_3$  and  $M_4$  involve less than 3 objectives and consistency test is not needed.

$$CR_1 = 0.0260,$$

$$CR_5 = 0.0834$$

$M_1$  and  $M_5$  are considered consistent for their consistency ratio valued less than 0.100.

### *Process 4.1.4*

$$M'_1 =$$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
$C_{11}$	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)
$C_{12}$	(3, 5, 7)	(1, 1, 3)	(1, 3, 5)	(3, 5, 7)
$C_{13}$	(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$C_{14}$	1/(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)

$$M'_3 =$$

	$C_{31}$	$C_{32}$
--	----------	----------



$$C_{31} \quad (1, 1, 3) \quad (1, 3, 5)$$

$$C_{32} \quad 1/(1, 3, 5) \quad (1, 1, 3)$$

$$M'_4 =$$

	$C_{41}$	$C_{42}$
$C_{41}$	$(1, 1, 3)$	$1/(3, 5, 7)$
$C_{42}$	$(3, 5, 7)$	$(1, 1, 3)$

$$M'_5 =$$

	$C_{51}$	$C_{52}$	$C_{53}$
$C_{51}$	$(1, 1, 3)$	$(3, 5, 7)$	$1/(1, 3, 5)$
$C_{52}$	$1/(3, 5, 7)$	$(1, 1, 3)$	$(5, 7, 9)$
$C_{53}$	$(1, 3, 5)$	$1/(5, 7, 9)$	$(1, 1, 3)$

#### Process 4.1.5

$S^1_1 = (0.048, 0.096, 0.482),$	$S^1_2 = (0.164, 0.530, 1.446),$
$S^1_3 = (0.066, 0.278, 0.920),$	$S^1_4 = (0.034, 0.096, 0.350),$
$S^3_1 = (0.167, 0.750, 2.500),$	$S^3_2 = (0.100, 0.250, 1.250),$
$S^4_1 = (0.086, 0.167, 0.648),$	$S^4_2 = (0.300, 0.833, 1.944),$
$S^5_1 = (0.133, 0.339, 0.883),$	$S^5_2 = (0.195, 0.439, 0.990),$
$S^5_3 = (0.067, 0.222, 0.658).$	

#### Process 4.1.6

$W'_1 = (0.4223, 1.0000, 0.7495, 0.2999)^T,$	$W'_3 = (1.0000, 0.6842)^T,$
$W'_4 = (0.3431, 1.0000)^T,$	$W'_5 = (0.8732, 1.0000, 0.6809)^T.$

$W_1 = (0.2308, 0.5464, 0.4096, 0.1639)^T,$	$W_3 = (0.6811, 0.4660)^T,$
$W_4 = (0.3070, 0.8947)^T,$	$W_5 = (0.3923, 0.4492, 0.3059)^T.$

Table H.7 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
1	$C_{12}$ Cost	0.5464
2	$C_{13}$ Data synchronization	0.4096
3	$C_{11}$ User friendliness	0.2308
	$C_{14}$ Other non-functional	0.1639



	requirements	
Ranking	Fundamental-objective	Weight vector
1	C <sub>31</sub> Fixed cost	0.6811
2	C <sub>32</sub> Variable cost	0.4660
Ranking	Fundamental-objective	Weight vector
1	C <sub>42</sub> Effective live job data update to database	0.8947
2	C <sub>41</sub> Effective live tracking data update to database	0.3070
Ranking	Fundamental-objective	Weight vector
1	C <sub>52</sub> Availability	0.4492
2	C <sub>51</sub> Maintainability	0.3923
3	C <sub>53</sub> Sufficient processing and memorial power	0.3059

## 2.2 Step 4.2 results

### Process 4.2.2

$$M_{21} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1 \\ A_2 & 1 & 1 \end{array}$$

$$M_{31} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1 \\ A_2 & 1 & 1 \end{array}$$

$$M_{32} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 3 \\ A_2 & 1/3 & 1 \end{array}$$

$$M_{41} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 3 \\ A_2 & 1/3 & 1 \end{array}$$

$$M_{42} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 3 \\ A_2 & 1/3 & 1 \end{array}$$

$$M_{51} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 5 \\ A_2 & 1/5 & 1 \end{array}$$

$$M_{52} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1/5 \end{array}$$

$$M_{53} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1 \end{array}$$



$A_2$  5 1

$A_2$  1 1

$A_1$ : MS Windows Mobile

$A_2$ : Palm OS

**Process 4.2.3**

As there are only two alternatives, the PCMs are regarded always consistent.

**Process 4.2.4**

$M'_{21} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)

$M'_{31} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)

$M'_{32} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 3, 5)
$A_2$	1/(1, 3, 5)	(1, 1, 3)

$M'_{41} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 3, 5)
$A_2$	1/(1, 3, 5)	(1, 1, 3)

$M'_{42} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(1, 3, 5)
$A_2$	1/(1, 3, 5)	(1, 1, 3)

$M'_{51} =$

	$A_1$	$A_2$
--	-------	-------



$$A_1 \quad (1, 1, 3) \quad (3, 5, 7)$$

$$A_2 \quad 1/(3, 5, 7) \quad (1, 1, 3)$$

$$M'_{52} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$1/(3, 5, 7)$
$A_2$	$(3, 5, 7)$	$(1, 1, 3)$

$$M'_{53} =$$

	$A_1$	$A_2$
$A_1$	$(1, 1, 3)$	$(1, 1, 3)$
$A_2$	$1/(1, 1, 3)$	$(1, 1, 3)$

### ***Process 4.2.5***

$$S^{21}_1 = (0.2000, 0.5000, 1.8000), \quad S^{21}_2 = (0.1333, 0.5000, 1.2000),$$

$$S^{31}_1 = (0.2000, 0.5000, 1.8000), \quad S^{31}_2 = (0.1333, 0.5000, 1.2000),$$

$$S^{32}_1 = (0.1667, 0.7500, 2.5000), \quad S^{32}_2 = (0.1000, 0.2500, 1.2500),$$

$$S^{41}_1 = (0.1667, 0.7500, 2.5000), \quad S^{41}_2 = (0.1000, 0.2500, 1.2500),$$

$$S^{42}_1 = (0.1500, 0.5000, 1.6667), \quad S^{42}_2 = (0.1500, 0.5000, 1.6667),$$

$$S^{51}_1 = (0.3000, 0.8333, 1.9444), \quad S^{51}_2 = (0.0857, 0.1667, 0.6481),$$

$$S^{52}_1 = (0.0857, 0.1667, 0.6481), \quad S^{52}_2 = (0.3000, 0.8333, 1.9444),$$

$$S^{53}_1 = (0.2000, 0.5000, 1.8000), \quad S^{53}_2 = (0.1333, 0.5000, 1.2000).$$

### ***Process 4.2.6***

$$W'_{21} = (1.0000, 1.0000)^T,$$

$$W'_{32} = (1.0000, 0.6842)^T,$$

$$W'_{42} = (1.0000, 1.0000)^T,$$

$$W'_{52} = (0.3431, 1.0000)^T,$$

$$W'_{31} = (1.0000, 1.0000)^T,$$

$$W'_{41} = (1.0000, 0.6842)^T,$$

$$W'_{51} = (1.0000, 0.3431)^T,$$

$$W'_{53} = (1.0000, 1.0000)^T.$$

$$W_{21} = (0.5000, 0.5000)^T,$$

$$W_{32} = (0.6813, 0.4660)^T,$$

$$W_{42} = (0.5000, 0.5000)^T,$$

$$W_{52} = (0.3069, 0.8947)^T,$$

$$W_{31} = (0.5000, 0.5000)^T,$$

$$W_{41} = (0.6813, 0.4660)^T,$$

$$W_{51} = (0.8947, 0.3069)^T,$$

$$W_{53} = (0.5000, 0.5000)^T.$$



Table H.8 Priority weights of alternatives with respect to user friendliness  $C_{11}$

	$C_{21}$ Effective data presentation	Priority weight ( $w_3$ )
Weight vector	1	
$A_1$ MS Windows Mobile	0.5000	0.5000
$A_2$ Palm OS	0.5000	0.5000

Table H.9 Priority weights of alternatives with respect to cost  $C_{12}$

	$C_{31}$ Fixed cost	$C_{32}$ Variable cost	Priority weight ( $w_3$ )
Weight vector	0.6811	0.4660	
$A_1$ MS Windows Mobile	0.5000	0.6813	0.6580
$A_2$ Palm OS	0.5000	0.4660	0.5577

Table H.10 Priority weights of alternatives with respect to data synchronization  $C_{13}$

	$C_{41}$ Effective live tracking data update to database	$C_{42}$ Effective live job data update to database	Priority weight ( $w_4$ )
Weight vector	0.3070	0.8947	
$A_1$ MS Windows Mobile	0.6813	0.5000	0.6565
$A_2$ Palm OS	0.4660	0.5000	0.5904

Table H.11 Priority weights of alternatives with respect to other non-functional requirements  $C_{14}$

	$C_{51}$ Maintainability	$C_{52}$ Availability	$C_{53}$ Sufficient processing and memorial power	Priority weight ( $w_4$ )
Weight vector	0.3923	0.4492	0.3059	
$A_1$ MS Windows Mobile	0.8947	0.3069	0.5000	0.6418
$A_2$ Palm OS	0.3069	0.8947	0.5000	0.6752



Table H.12 Priority weights of alternatives with respect to goal

	$C_{11}$ User friendliness	$C_{12}$ Cost	$C_{13}$ Data synchronization	$C_{14}$ Other non-functional requirements	Priority weight ( $w_1$ )
Weight vector	0.2308	0.5464	0.4096	0.1639	
$A_1$ MS Windows Mobile	0.5000	0.6580	0.6565	0.6418	0.8490
$A_2$ Palm OS	0.5000	0.5577	0.5904	0.6752	0.7726

Table H.13 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ MS Windows Mobile	0.8490
2	$A_2$ Palm OS	0.7726

### 3. Database management system

#### 3.1 Step 4.1 results

##### *Process 4.1.2*

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
$C_{11}$	1	1/3	1/5	1/3
$C_{12}$	3	1	3	1
$C_{13}$	5	1/3	1	3
$C_{14}$	3	1	1/3	1

$C_{11}$ : cost

$C_{12}$ : data synchronization

$C_{13}$ : data management

$C_{14}$ : other non-functional requirements

$M_2 =$

$C_{21}$	$C_{22}$
----------	----------



$C_{21}$	1	1/5
$C_{22}$	5	1

$C_{21}$ : fixed cost

$C_{22}$ : variable cost

$M_3 =$

	$C_{31}$	$C_{32}$	$C_{33}$
$C_{31}$	1	1	1/5
$C_{32}$	1	1	1/5
$C_{33}$	5	5	1

$C_{31}$ : effective live tracking data update to database

$C_{32}$ : effective live job data update to database

$C_{33}$ : effective data integration to legacy system

$M_4 =$

	$C_{41}$	$C_{42}$
$C_{41}$	1	5
$C_{42}$	1/5	1

$C_{41}$ : sufficient data storage and data transaction capabilities

$C_{42}$ : secured data transaction

$M_5 =$

	$C_{51}$	$C_{52}$	$C_{53}$
$C_{51}$	1	1/5	1/3
$C_{52}$	5	1	3
$C_{53}$	3	1/3	1

$C_{51}$ : maintainability

$C_{52}$ : availability

$C_{53}$ : sufficient processing and memorial power

### ***Process 4.1.3***

$M_2$  and  $M_4$  involve less than 3 objectives and consistency test is not needed.



$$CR_1 = 0.023,$$

$$CR_3 = 0.000,$$

$$CR_5 = 0.048$$

$M_1, M_3$  and  $M_5$  are considered consistent for their consistency ratio valued less than 0.100.

#### *Process 4.1.4*

$$M'_1 =$$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$
$C_{11}$	(1, 1, 3)	1/(1, 3, 5)	1/(3, 5, 7)	1/(1, 3, 5)
$C_{12}$	(1, 3, 5)	(1, 1, 3)	(1, 3, 5)	(1, 1, 3)
$C_{13}$	(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)	(1, 3, 5)
$C_{14}$	(1, 3, 5)	1/(1, 1, 3)	1/(1, 3, 5)	(1, 1, 3)

$$M'_2 =$$

	$C_{21}$	$C_{22}$
$C_{21}$	(1, 1, 3)	1/(3, 5, 7)
$C_{22}$	(3, 5, 7)	(1, 1, 3)

$$M'_3 =$$

	$C_{31}$	$C_{32}$	$C_{33}$
$C_{31}$	(1, 1, 3)	(1, 1, 3)	1/(3, 5, 7)
$C_{32}$	(1, 1, 3)	(1, 1, 3)	1/(3, 5, 7)
$C_{33}$	(3, 5, 7)	(3, 5, 7)	(1, 1, 3)

$$M'_4 =$$

	$C_{41}$	$C_{42}$
$C_{41}$	(1, 1, 3)	(3, 5, 7)
$C_{42}$	1/(3, 5, 7)	(1, 1, 3)

$$M'_5 =$$

	$C_{51}$	$C_{52}$	$C_{53}$
$C_{51}$	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)
$C_{52}$	(3, 5, 7)	(1, 1, 3)	(1, 3, 5)
$C_{53}$	(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)

#### *Process 4.1.5*



$$\begin{aligned}
S^1_1 &= (0.0326, 0.0761, 0.4017), & S^1_2 &= (0.0845, 0.3261, 1.2052), \\
S^1_3 &= (0.1099, 0.3804, 1.2052), & S^1_4 &= (0.0535, 0.2174, 0.7532), \\
S^2_1 &= (0.0857, 0.1667, 0.6481), & S^2_2 &= (0.3000, 0.8333, 1.9444), \\
S^3_1 &= (0.0722, 0.1429, 0.5612), & S^3_2 &= (0.0722, 0.1429, 0.5612), \\
S^3_3 &= (0.2360, 0.7143, 1.5063), & & \\
S^4_1 &= (0.3000, 0.8333, 1.9444), & S^4_2 &= (0.0857, 0.1667, 0.6481), \\
S^5_1 &= (0.0474, 0.1031, 0.5072), & S^5_2 &= (0.1765, 0.6054, 1.7559), \\
S^5_3 &= (0.0776, 0.2915, 1.0535). & &
\end{aligned}$$

**Process 4.1.6**

$$\begin{aligned}
W'_1 &= (0.4895, 0.9527, 1.0000, 0.7978)^T, & W'_2 &= (0.3431, 1.0000)^T, \\
W'_3 &= (0.3627, 0.3627, 1.0000)^T, & W'_4 &= (1.0000, 0.3431)^T, \\
W'_5 &= (0.3971, 1.0000, 0.7364)^T. & &
\end{aligned}$$

$$\begin{aligned}
W_1 &= (0.1758, 0.3422, 0.3592, 0.2866)^T, & W_2 &= (0.3070, 0.8947)^T, \\
W_3 &= (0.2872, 0.2872, 0.7917)^T, & W_4 &= (0.8947, 0.3070)^T, \\
W_5 &= (0.2336, 0.5882, 0.4332)^T. & &
\end{aligned}$$

**Table H.14 Ranking for fundamental-objectives**

Ranking	Fundamental-objective	Weight vector
1	C <sub>13</sub> Data management	0.3592
2	C <sub>12</sub> Data synchronization	0.3422
3	C <sub>14</sub> Other non-functional requirements	0.2866
4	C <sub>11</sub> Cost	0.1758
Ranking	Fundamental-objective	Weight vector
1	C <sub>22</sub> Variable cost	0.8947
2	C <sub>21</sub> Fixed cost	0.3070
Ranking	Fundamental-objective	Weight vector
1	C <sub>33</sub> Effective data integration to legacy system	0.7917
2	C <sub>31</sub> Effective live tracking data update to database	0.2872
	C <sub>32</sub> Effective live job data update to database	0.2872
Ranking	Fundamental-objective	Weight vector
1	C <sub>41</sub> Sufficient data storage and data	0.8947



	transaction capabilities	
2	C <sub>42</sub> Secured data transaction	0.3070
Ranking	Fundamental-objective	Weight vector
1	C <sub>52</sub> Availability	0.5882
2	C <sub>53</sub> Sufficient processing and memorial power	0.4332
3	C <sub>51</sub> Maintainability	0.2336

### 3.2 Step 4.2 results

#### Process 4.2.2

$$M_{21} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	5
A <sub>2</sub>	1/5	1

$$M_{22} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	7
A <sub>2</sub>	1/7	1

$$M_{31} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	1
A <sub>2</sub>	1	1

$$M_{32} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	9
A <sub>2</sub>	1/9	1

$$M_{33} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	9
A <sub>2</sub>	1/9	1

$$M_{41} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	1
A <sub>2</sub>	1	1

$$M_{42} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	1
A <sub>2</sub>	1	1

$$M_{51} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	9
A <sub>2</sub>	1/9	1

$$M_{52} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	9
A <sub>2</sub>	1/9	1

$$M_{53} =$$

	A <sub>1</sub>	A <sub>2</sub>
A <sub>1</sub>	1	7
A <sub>2</sub>	1/7	1



$A_1$ : Oracle 10g

$A_2$ : MS SQL 2000

### *Process 4.2.3*

As there are only two alternatives, the PCMs are regarded always consistent.

### *Process 4.2.4*

$M'_{21} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

$M'_{22} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(5, 7, 9)
$A_2$	1/(5, 7, 9)	(1, 1, 3)

$M'_{31} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)

$M'_{32} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(7, 9, 9)
$A_2$	(7, 9, 9)	(1, 1, 3)

$M'_{33} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(7, 9, 9)
$A_2$	(7, 9, 9)	(1, 1, 3)

$M'_{41} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)



$$M'_{42} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)

$$M'_{51} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(7, 9, 9)
$A_2$	(7, 9, 9)	(1, 1, 3)

$$M'_{52} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(7, 9, 9)
$A_2$	(7, 9, 9)	(1, 1, 3)

$$M'_{53} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(5, 7, 9)
$A_2$	1/(5, 7, 9)	(1, 1, 3)

### Process 4.2.5

$$\begin{aligned} S^{21}_1 &= (0.3000, 0.8333, 1.9444), \\ S^{22}_1 &= (0.3947, 0.8750, 1.6875), \\ S^{31}_1 &= (0.2000, 0.5000, 1.8000), \\ S^{32}_1 &= (0.5283, 0.9000, 1.3171), \\ S^{33}_1 &= (0.5283, 0.9000, 1.3171), \\ S^{41}_1 &= (0.2000, 0.5000, 1.8000), \\ S^{42}_1 &= (0.2000, 0.5000, 1.8000), \\ S^{51}_1 &= (0.5283, 0.9000, 1.3171), \\ S^{52}_1 &= (0.5283, 0.9000, 1.3171), \\ S^{53}_1 &= (0.3947, 0.8750, 1.6875), \end{aligned}$$

$$\begin{aligned} S^{21}_2 &= (0.0857, 0.1667, 0.6481), \\ S^{22}_2 &= (0.0731, 0.1250, 0.4500), \\ S^{31}_2 &= (0.1333, 0.5000, 1.2000), \\ S^{32}_2 &= (0.0734, 0.1000, 0.3449), \\ S^{33}_2 &= (0.0734, 0.1000, 0.3449), \\ S^{41}_2 &= (0.1333, 0.5000, 1.2000), \\ S^{42}_2 &= (0.1333, 0.5000, 1.2000), \\ S^{51}_2 &= (0.0734, 0.1000, 0.3449), \\ S^{52}_2 &= (0.0734, 0.1000, 0.3449), \\ S^{53}_2 &= (0.0731, 0.1250, 0.4500). \end{aligned}$$

### Process 4.2.6

$$\begin{aligned} W'_{21} &= (1.0000, 0.3431)^T, \\ W'_{31} &= (1.0000, 1.0000)^T, \end{aligned}$$

$$\begin{aligned} W'_{22} &= (1.0000, 0.0686)^T, \\ W'_{32} &= (1.0000, 0.0000)^T, \end{aligned}$$



$$W'_{33} = (1.0000, 0.0000)^T,$$

$$W'_{41} = (1.0000, 1.0000)^T,$$

$$W'_{51} = (1.0000, 0.0000)^T,$$

$$W'_{43} = (1.0000, 0.0686)^T.$$

$$W'_{42} = (1.0000, 1.0000)^T,$$

$$W'_{52} = (1.0000, 0.0000)^T,$$

$$W_{21} = (0.8947, 0.3070)^T,$$

$$W_{31} = (0.5000, 0.5000)^T,$$

$$W_{33} = (1.0000, 0.0000)^T,$$

$$W_{41} = (0.5000, 0.5000)^T,$$

$$W_{51} = (1.0000, 0.0000)^T,$$

$$W_{53} = (0.9953, 0.0683)^T.$$

$$W_{22} = (0.9953, 0.0683)^T,$$

$$W_{32} = (1.0000, 0.0000)^T,$$

$$W_{42} = (0.5000, 0.5000)^T,$$

$$W_{52} = (1.0000, 0.0000)^T,$$

Table H.15 Priority weights of alternatives with respect to cost  $C_{11}$

	$C_{21}$ Fixed cost	$C_{22}$ Variable cost	Priority weight ( $w_2$ )
Weight vector	0.3070	0.8947	
$A_1$ Oracle 10g	0.8947	0.9953	1.1652
$A_2$ MS SQL 2000	0.3070	0.0683	0.1554

Table H.16 Priority weights of alternatives with respect to data synchronization  $C_{12}$

	$C_{31}$ Effective live tracking data update to database	$C_{32}$ Effective live job data update to database	$C_{33}$ Effective data integration to legacy system	Priority weight ( $w_3$ )
Weight vector	0.2872	0.2872	0.7917	
$A_1$ Oracle 10g	0.5000	1.0000	1.0000	1.2225
$A_2$ MS SQL 2000	0.5000	0.0000	0.0000	0.1436

Table H.17 Priority weights of alternatives with respect to data management  $C_{13}$

	$C_{41}$ Sufficient data storage and data transaction capabilities	$C_{42}$ Secured data transaction	Priority weight ( $w_4$ )
Weight vector	0.8947	0.3070	
$A_1$ Oracle 10g	0.5000	0.5000	0.6009
$A_2$ MS SQL 2000	0.5000	0.5000	0.6009



Table H.18 Priority weights of alternatives with respect to other non-functional requirements  $C_{14}$

	$C_{51}$ Maintainability	$C_{52}$ Availability	$C_{53}$ Sufficient processing and memorial power	Priority weight ( $w_5$ )
Weight vector	0.2336	0.5882	0.4332	
$A_1$ Oracle 10g	1.0000	1.0000	0.9953	0.6009
$A_2$ MS SQL 2000	0.0000	0.0000	0.0683	0.0296

Table H.19 Priority weights of alternatives with respect to goal

	$C_{11}$ Cost	$C_{12}$ Data synchronization	$C_{13}$ Data management
Weight vector	0.1758	0.3422	0.3592
$A_1$ Oracle 10g	1.1652	1.2225	0.6009
$A_2$ MS SQL 2000	0.1554	0.1436	0.6009
	$C_{14}$ Other non-functional requirements	Priority weight ( $w_1$ )	
Weight vector	0.2866		
$A_1$ Oracle 10g	0.6009	1.0112	
$A_2$ MS SQL 2000	0.0296	0.3008	

Table H.20 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ Oracle 10g	1.0112
2	$A_2$ MS SQL 2000	0.3008

## 4. User interface (portal applications)

### 4.1 Step 4.1 results

#### Process 4.1.2

$$M_1 = \begin{matrix} & C_{11} & C_{12} \end{matrix}$$



$$\begin{array}{l}
 C_{11} \quad 1 \quad 5 \\
 C_{12} \quad 1/5 \quad 1
 \end{array}$$

$C_{11}$ : user friendliness

$C_{12}$ : other non-functional requirements

$$\begin{array}{l}
 M_2 = \\
 \quad C_{21} \quad C_{22} \\
 C_{21} \quad 1 \quad 3 \\
 C_{22} \quad 1/3 \quad 1
 \end{array}$$

$C_{21}$ : user friendly vehicle tracking functionalities for public user

$C_{22}$ : effective data presentation

$$\begin{array}{l}
 M_3 = \\
 \quad C_{31} \quad C_{32} \\
 C_{31} \quad 1 \quad 1/3 \\
 C_{32} \quad 3 \quad 1
 \end{array}$$

$C_{21}$ : sufficient processing and memorial power

$C_{22}$ : effective location tracking

### ***Process 4.1.3***

As all of the matrices are in two dimensions only, they are regarded always consistent.

### ***Process 4.1.4***

$$\begin{array}{l}
 M'_1 = \\
 \quad C_{11} \quad C_{12} \\
 C_{11} \quad (1, 1, 3) \quad (3, 5, 7) \\
 C_{12} \quad 1/(3, 5, 7) \quad (1, 1, 3)
 \end{array}$$

$$\begin{array}{l}
 M'_2 = \\
 \quad C_{21} \quad C_{22} \\
 C_{21} \quad (1, 1, 3) \quad (1, 3, 5) \\
 C_{22} \quad 1/(1, 3, 5) \quad (1, 1, 3)
 \end{array}$$



$M'_3 =$

	$C_{31}$	$C_{32}$
$C_{31}$	(1, 1, 3)	1 / (1, 3, 5)
$C_{32}$	(1, 3, 5)	(1, 1, 3)

**Process 4.1.5**

$$S^1_1 = (0.3000, 0.8333, 1.9444), \quad S^1_2 = (0.0857, 0.1667, 0.6481),$$

$$S^2_1 = (0.1667, 0.7500, 2.5000), \quad S^2_2 = (0.1000, 0.2500, 1.2500),$$

$$S^3_1 = (0.1000, 0.2500, 1.2500), \quad S^3_2 = (0.1667, 0.7500, 2.5000).$$

**Process 4.1.6**

$$W'_1 = (1.0000, 0.3431)^T, \quad W'_2 = (1.0000, 0.6842)^T,$$

$$W'_3 = (0.6842, 1.0000)^T.$$

$$W_1 = (0.8947, 0.3070)^T, \quad W_2 = (0.6811, 0.4660)^T,$$

$$W_3 = (0.4660, 0.6811)^T.$$

Table H.21 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
2	$C_{11}$ User friendliness	0.8947
3	$C_{12}$ Other non-functional requirements	0.3070
Ranking	Fundamental-objective	Weight vector
1	$C_{22}$ User friendly vehicle tracking functionalities for public user	0.6811
2	$C_{21}$ Effective data presentation	0.4660
Ranking	Fundamental-objective	Weight vector
1	$C_{32}$ Effective location tracking	0.6811
2	$C_{31}$ Sufficient processing and memorial power	0.4660



## 4.2 Step 4.2 results

### Process 4.2.2

$$M_{21} =$$

	$A_1$	$A_2$
$A_1$	1	9
$A_2$	1/9	1

$$M_{22} =$$

	$A_1$	$A_2$
$A_1$	1	1/3
$A_2$	3	1

$$M_{31} =$$

	$A_1$	$A_2$
$A_1$	1	1/5
$A_2$	5	1

$$M_{32} =$$

	$A_1$	$A_2$
$A_1$	1	3
$A_2$	1/3	1

$A_1$ : Web-based UI

$A_2$ : GUI

### Process 4.2.3

As there are only two alternatives, the PCMs are regarded always consistent.

### Process 4.2.4

$$M'_{21} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(7, 9, 9)
$A_2$	1/(7, 9, 9)	(1, 1, 3)

$$M'_{22} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(1, 3, 5)
$A_2$	(1, 3, 5)	(1, 1, 3)

$$M'_{31} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(3, 5, 7)
$A_2$	(3, 5, 7)	(1, 1, 3)



$M'_{32} =$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 3, 5)
$A_2$	1/(1, 3, 5)	(1, 1, 3)

**Process 4.2.5**

$$\begin{aligned}
 S^{21}_1 &= (0.5283, 0.9000, 1.3171), & S^{21}_2 &= (0.0734, 0.1000, 0.3449), \\
 S^{22}_1 &= (0.1000, 0.2500, 1.2500), & S^{22}_2 &= (0.1667, 0.7500, 2.5000), \\
 S^{31}_1 &= (0.0857, 0.1667, 0.6481), & S^{31}_2 &= (0.3000, 0.8333, 1.9444), \\
 S^{32}_1 &= (0.1667, 0.7500, 2.5000), & S^{32}_2 &= (0.1000, 0.2500, 1.2500).
 \end{aligned}$$

**Process 4.2.6**

$$\begin{aligned}
 W'_{21} &= (1.0000, 0.0000)^T, & W'_{22} &= (0.6842, 1.0000)^T, \\
 W'_{31} &= (0.3431, 1.0000)^T, & W'_{32} &= (1.0000, 0.6842)^T. \\
 \\ 
 W_{21} &= (1.0000, 0.0000)^T, & W_{22} &= (0.4660, 0.6811)^T, \\
 W_{31} &= (0.3070, 0.8947)^T, & W_{32} &= (0.6811, 0.4660)^T.
 \end{aligned}$$

**Table H.22 Priority weights of alternatives with respect to user friendliness  $C_{11}$**

	$C_{21}$ Effective data presentation	$C_{22}$ User friendly vehicle tracking functionalities for public user	Priority weight ( $w_2$ )
Weight vector	0.4660	0.6811	
$A_1$ Web-based UI	1.0000	0.4660	0.7834
$A_2$ GUI	0.0000	0.6811	0.3174

**Table H.23 Priority weights of alternatives with respect to other non-functional requirements  $C_{12}$**

	$C_{31}$ Sufficient processing and memorial power	$C_{32}$ Effective location tracking	Priority weight ( $w_3$ )
Weight vector	0.4660	0.6811	
$A_1$ Web-based UI	0.3070	0.6811	0.6070
$A_2$ GUI	0.8947	0.4660	0.7343



Table H.24 Priority weights of alternatives with respect to goal

	$C_{11}$ User friendliness	$C_{12}$ Other non-functional requirements	Priority weight ( $w_1$ )
Weight vector	0.8947	0.3070	
$A_1$ Web-based UI	0.7834	0.6070	0.8873
$A_2$ GUI	0.3174	0.7343	0.5094

Table H.25 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ Web-based UI	0.8873
2	$A_2$ GUI	0.5094

## 5. User interface (PDA applications)

### 5.1 Step 4.1 results

#### *Process 4.1.2*

$$M_1 = \begin{array}{cc} & C_{11} & C_{12} \\ C_{11} & 1 & 5 \\ C_{12} & 1/5 & 1 \end{array}$$

$C_{11}$ : user friendliness

$C_{12}$ : other non-functional requirements

$$M_2 = \begin{array}{cc} & C_{21} & C_{22} \\ C_{21} & 1 & 1 \\ C_{22} & 1 & 1 \end{array}$$

$C_{21}$ : user friendly UI for PDA application

$C_{22}$ : effective data presentation

$$M_3 =$$



	$C_{31}$	$C_{32}$
$C_{31}$	1	1/3
$C_{32}$	3	1

$C_{21}$ : sufficient processing and memorial power

$C_{22}$ : effective location tracking

### ***Process 4.1.3***

As all of the matrices are in two dimensions only, they are regarded always consistent.

### ***Process 4.1.4***

$M'_1 =$

	$C_{11}$	$C_{12}$
$C_{11}$	(1, 1, 3)	(3, 5, 7)
$C_{12}$	1/(3, 5, 7)	(1, 1, 3)

$M'_2 =$

	$C_{21}$	$C_{22}$
$C_{21}$	(1, 1, 3)	(1, 1, 3)
$C_{22}$	1/(1, 1, 3)	(1, 1, 3)

$M'_3 =$

	$C_{31}$	$C_{32}$
$C_{31}$	(1, 1, 3)	1/(1, 3, 5)
$C_{32}$	(1, 3, 5)	(1, 1, 3)

### ***Process 4.1.5***

$$\begin{aligned}
 S^1_1 &= (0.3000, 0.8333, 1.9444), & S^1_2 &= (0.0857, 0.1667, 0.6481), \\
 S^2_1 &= (0.2000, 0.5000, 1.8000), & S^2_2 &= (0.1333, 0.5000, 1.2000), \\
 S^3_1 &= (0.1000, 0.2500, 1.2500), & S^3_2 &= (0.1667, 0.7500, 2.5000).
 \end{aligned}$$

### ***Process 4.1.6***

$$\begin{aligned}
 W'_1 &= (1.0000, 0.3431)^T, & W'_2 &= (1.0000, 1.0000)^T, \\
 W'_3 &= (0.6842, 1.0000)^T.
 \end{aligned}$$



$$W_1 = (0.8947, 0.3070)^T,$$

$$W_3 = (0.4660, 0.6811)^T.$$

$$W_2 = (0.5000, 0.5000)^T,$$

Table H.26 Ranking for fundamental-objectives

Ranking	Fundamental-objective	Weight vector
2	$C_{11}$ User friendliness	0.8947
3	$C_{12}$ Other non-functional requirements	0.3070
Ranking	Fundamental-objective	Weight vector
1	$C_{21}$ Effective data presentation	0.5000
	$C_{22}$ User friendly UI for PDA application	0.5000
Ranking	Fundamental-objective	Weight vector
1	$C_{32}$ Effective location tracking	0.6811
2	$C_{31}$ Sufficient processing and memorial power	0.4660

## 5.2 Step 4.2 results

### Process 4.2.2

$$M_{21} =$$

	$A_1$	$A_2$
$A_1$	1	1/5
$A_2$	5	1

$$M_{22} =$$

	$A_1$	$A_2$
$A_1$	1	1/7
$A_2$	7	1

$$M_{31} =$$

	$A_1$	$A_2$
$A_1$	1	1/5
$A_2$	5	1

$$M_{32} =$$

	$A_1$	$A_2$
$A_1$	1	3
$A_2$	1/3	1

$A_1$ : Web-based UI

$A_2$ : GUI

### Process 4.2.3



As there are only two alternatives, the PCMs are regarded always consistent.

**Process 4.2.4**

$$M'_{21} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(3, 5, 7)
$A_2$	(3, 5, 7)	(1, 1, 3)

$$M'_{22} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(5, 7, 9)
$A_2$	(5, 7, 9)	(1, 1, 3)

$$M'_{31} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(3, 5, 7)
$A_2$	(3, 5, 7)	(1, 1, 3)

$$M'_{32} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 3, 5)
$A_2$	1/(1, 3, 5)	(1, 1, 3)

**Process 4.2.5**

$$\begin{aligned}
 S^{21}_1 &= (0.0857, 0.1667, 0.6481), & S^{21}_2 &= (0.3000, 0.8333, 1.9444), \\
 S^{22}_1 &= (0.0731, 0.1250, 0.4500), & S^{22}_2 &= (0.3947, 0.8750, 1.6875), \\
 S^{31}_1 &= (0.0857, 0.1667, 0.6481), & S^{31}_2 &= (0.3000, 0.8333, 1.9444), \\
 S^{32}_1 &= (0.1667, 0.7500, 2.5000), & S^{32}_2 &= (0.1000, 0.2500, 1.2500).
 \end{aligned}$$

**Process 4.2.6**

$$\begin{aligned}
 W'_{21} &= (0.3431, 1.0000)^T, & W'_{22} &= (0.0686, 1.0000)^T, \\
 W'_{31} &= (0.3431, 1.0000)^T, & W'_{32} &= (1.0000, 0.6842)^T. \\
 \\ 
 W_{21} &= (0.3070, 0.8947)^T, & W_{22} &= (0.0683, 0.9953)^T, \\
 W_{31} &= (0.3070, 0.8947)^T, & W_{32} &= (0.6811, 0.4660)^T.
 \end{aligned}$$



Table H.27 Priority weights of alternatives with respect to user friendliness  $C_{11}$

	$C_{21}$ Effective data presentation	$C_{22}$ User friendly UI for PDA application	Priority weight ( $w_2$ )
Weight vector	0.5000	0.5000	
$A_1$ Web-based UI	0.3070	0.0683	0.1877
$A_2$ GUI	0.8947	0.9953	0.9450

Table H.28 Priority weights of alternatives with respect to other non-functional requirements  $C_{12}$

	$C_{31}$ Sufficient processing and memorial power	$C_{32}$ Effective location tracking	Priority weight ( $w_3$ )
Weight vector	0.4660	0.6811	
$A_1$ Web-based UI	0.3070	0.6811	0.6070
$A_2$ GUI	0.8947	0.4660	0.7343

Table H.29 Priority weights of alternatives with respect to goal

	$C_{11}$ User friendliness	$C_{12}$ Other non-functional requirements	Priority weight ( $w_1$ )
Weight vector	0.8947	0.3070	
$A_1$ Web-based UI	0.1877	0.6070	0.3543
$A_2$ GUI	0.9450	0.7343	1.0709

Table H.30 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_2$ GUI	1.0709
2	$A_1$ Web-based UI	0.3543

## 6. GIS technology

### 6.1 Step 4.1 results

#### Process 4.1.2

$M_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$	$C_{15}$
$C_{11}$	1	1/5	1/3	1/3	3
$C_{12}$	5	1	3	3	5
$C_{13}$	3	1/3	1	1	3
$C_{14}$	3	1/3	1	1	3
$C_{15}$	1/3	1/5	1/3	1/3	1

$C_{11}$ : user friendliness

$C_{12}$ : cost

$C_{13}$ : data synchronization

$C_{14}$ : other non-functional requirements

$C_{15}$ : data management

$M_2 =$

	$C_{21}$	$C_{22}$
$C_{21}$	1	5
$C_{22}$	1/5	1

$C_{21}$ : user friendly vehicle tracking functionalities for public user

$C_{22}$ : effective data presentation

$M_3 =$

	$C_{31}$	$C_{32}$
$C_{31}$	1	1/7
$C_{32}$	7	1

$C_{31}$ : fixed cost

$C_{32}$ : variable cost

$M_4 =$

	$C_{41}$
$C_{41}$	1

$C_{41}$ : effective data integration to legacy system

$M_5 =$



	$C_{51}$	$C_{52}$	$C_{53}$
$C_{51}$	1	1/5	1/5
$C_{52}$	5	1	1
$C_{53}$	5	1	1

$C_{51}$ : maintainability

$C_{52}$ : availability

$C_{53}$ : sufficient processing and memorial power

$M_6 =$

	$C_{61}$
$C_{61}$	1

$C_{61}$ : secured data transaction

### ***Process 4.1.3***

$M_2, M_3, M_4$  and  $M_6$  involve less than 3 objectives and consistency test is not needed.

$$CR_1 = 0.0580,$$

$$CR_5 = 0.000$$

$M_1$  and  $M_5$  are considered consistent for their consistency ratio valued less than 0.100.

### ***Process 4.1.4***

$M'_1 =$

	$C_{11}$	$C_{12}$	$C_{13}$	$C_{14}$	$C_{15}$
$C_{11}$	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	1/(1, 3, 5)	(1, 3, 5)
$C_{12}$	(3, 5, 7)	(1, 1, 3)	(1, 3, 5)	(1, 3, 5)	(3, 5, 7)
$C_{13}$	(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)	(1, 1, 3)	(1, 3, 5)
$C_{14}$	(1, 3, 5)	1/(1, 3, 5)	1/(1, 1, 3)	(1, 1, 3)	(1, 3, 5)
$C_{15}$	1/(1, 3, 5)	1/(3, 5, 7)	1/(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)

$M'_2 =$

	$C_{21}$	$C_{22}$
$C_{21}$	(1, 1, 3)	(3, 5, 7)
$C_{22}$	1/(3, 5, 7)	(1, 1, 3)

$$M'_3 =$$

$C_{31}$	$C_{32}$
$(1, 1, 3)$	$1/(5, 7, 9)$
$(5, 7, 9)$	$(1, 1, 3)$

$$M'_5 =$$

$C_{51}$	$C_{52}$	$C_{53}$
$(1, 1, 3)$	$1/(3, 5, 7)$	$1/(3, 5, 7)$
$(3, 5, 7)$	$(1, 1, 3)$	$(1, 1, 3)$
$(3, 5, 7)$	$1/(1, 1, 3)$	$(1, 1, 3)$

**Process 4.1.5**

$S^1_1 = (0.034, 0.119, 0.492),$	$S^1_2 = (0.119, 0.417, 1.285),$
$S^1_3 = (0.056, 0.205, 0.809),$	$S^1_4 = (0.047, 0.205, 0.714),$
$S^1_5 = (0.023, 0.054, 0.301),$	
$S^2_1 = (0.300, 0.833, 1.944),$	$S^2_2 = (0.086, 0.167, 0.648),$
$S^3_1 = (0.073, 0.125, 0.450),$	$S^3_2 = (0.395, 0.875, 1.688),$
$S^5_1 = (0.046, 0.091, 0.345),$	$S^5_2 = (0.181, 0.455, 1.224),$
$S^5_3 = (0.157, 0.455, 1.036),$	

**Process 4.1.6**

$W'_1 = (0.5558, 1.0000, 0.7643, 0.7365, 0.3342)^T,$	$W'_2 = (1.0000, 0.3431)^T,$
$W'_3 = (0.0686, 1.0000)^T,$	$W'_5 = (0.3116, 1.0000, 1.0000)^T$
$W_1 = (0.2182, 0.3926, 0.3001, 0.2891, 0.1312)^T,$	$W_2 = (0.8947, 0.3070)^T,$
$W_3 = (0.0683, 0.9953)^T,$	$W_5 = (0.1486, 0.4769, 0.4769).$

**Table H.31 Ranking for fundamental-objectives**

Ranking	Fundamental-objective	Weight vector
1	$C_{12}$ Cost	0.3001
2	$C_{13}$ Data synchronization	0.3001
	$C_{14}$ Other non-functional requirements	0.2891
4	$C_{11}$ User friendliness	0.2182
5	$C_{15}$ Data management	0.1312



Ranking	Fundamental-objective	Weight vector
1	C <sub>21</sub> User friendly vehicle tracking functionalities for public user	0.8947
2	C <sub>22</sub> Effective data presentation	0.3070
Ranking	Fundamental-objective	Weight vector
1	C <sub>32</sub> Variable cost	0.9953
2	C <sub>31</sub> Fixed cost	0.0683
Ranking	Fundamental-objective	Weight vector
1	C <sub>52</sub> Availability	0.4769
	C <sub>53</sub> Sufficient processing and memorial power	0.4769
3	C <sub>51</sub> Maintainability	0.1486

## 6.2 Step 4.2 results

### Process 4.2.2

$$M_{21} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1 \\ A_2 & 1 & 1 \end{array}$$

$$M_{22} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1/5 \\ A_2 & 5 & 1 \end{array}$$

$$M_{31} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 5 \\ A_2 & 1/5 & 1 \end{array}$$

$$M_{32} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1/3 \\ A_2 & 3 & 1 \end{array}$$

$$M_{41} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 1/3 \\ A_2 & 3 & 1 \end{array}$$

$$M_{51} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 5 \\ A_2 & 1/5 & 1 \end{array}$$

$$M_{52} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 3 \\ A_2 & 1/3 & 1 \end{array}$$

$$M_{53} = \begin{array}{c} \\ A_1 & A_2 \\ A_1 & 1 & 5 \\ A_2 & 1/5 & 1 \end{array}$$

$$M_{61} =$$

	$A_1$	$A_2$
$A_1$	1	5
$A_2$	1/5	1

$A_1$ : MS MapPoint

$A_2$ : ARC GIS

### ***Process 4.2.3***

As there are only two alternatives, the PCMs are regarded always consistent.

### ***Process 4.2.4***

$$M'_{21} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 1, 3)
$A_2$	1/(1, 1, 3)	(1, 1, 3)

$$M'_{22} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(3, 5, 7)
$A_2$	(3, 5, 7)	(1, 1, 3)

$$M'_{31} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

$$M'_{32} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(1, 3, 5)
$A_2$	(1, 3, 5)	(1, 1, 3)

$$M'_{41} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	1/(1, 3, 5)
$A_2$	(1, 3, 5)	(1, 1, 3)



$$M'_{51} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

$$M'_{52} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(1, 3, 5)
$A_2$	1/(1, 3, 5)	(1, 1, 3)

$$M'_{53} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

$$M'_{61} =$$

	$A_1$	$A_2$
$A_1$	(1, 1, 3)	(3, 5, 7)
$A_2$	1/(3, 5, 7)	(1, 1, 3)

### Process 4.2.5

$S^{21}_1 = (0.2000, 0.5000, 1.8000),$	$S^{21}_2 = (0.1333, 0.5000, 1.2000),$
$S^{22}_1 = (0.0857, 0.1667, 0.6481),$	$S^{22}_2 = (0.3000, 0.8333, 1.9444),$
$S^{31}_1 = (0.3000, 0.8333, 1.9444),$	$S^{31}_2 = (0.0857, 0.1667, 0.6481),$
$S^{32}_1 = (0.1000, 0.2500, 1.2500),$	$S^{32}_2 = (0.1667, 0.7500, 2.5000),$
$S^{41}_1 = (0.1000, 0.2500, 1.2500),$	$S^{41}_2 = (0.1667, 0.7500, 2.5000),$
$S^{51}_1 = (0.3000, 0.8333, 1.9444),$	$S^{51}_2 = (0.0857, 0.1667, 0.6481),$
$S^{52}_1 = (0.1667, 0.7500, 2.5000),$	$S^{52}_2 = (0.1000, 0.2500, 1.2500),$
$S^{53}_1 = (0.3000, 0.8333, 1.9444),$	$S^{53}_2 = (0.0857, 0.1667, 0.6481)$
$S^{61}_1 = (0.3000, 0.8333, 1.9444),$	$S^{61}_2 = (0.0857, 0.1667, 0.6481).$

### Process 4.2.6

$W'_{21} = (1.0000, 1.0000)^T,$	$W'_{22} = (0.3431, 1.0000)^T,$
$W'_{31} = (1.0000, 0.3431)^T,$	$W'_{32} = (0.6842, 1.0000)^T,$

$$W'_{41} = (0.6842, 1.0000)^T,$$

$$W'_{52} = (1.000, 0.6842)^T,$$

$$W'_{61} = (1.000, 0.3431)^T.$$

$$W'_{51} = (1.000, 0.3431)^T,$$

$$W'_{53} = (1.000, 0.3431)^T,$$

$$W_{21} = (0.5000, 0.5000)^T,$$

$$W_{31} = (0.8947, 0.3070)^T,$$

$$W_{41} = (0.4660, 0.6811)^T,$$

$$W_{52} = (0.6811, 0.4660)^T,$$

$$W_{61} = (0.8947, 0.3070)^T.$$

$$W_{22} = (0.3070, 0.8947)^T,$$

$$W_{32} = (0.4660, 0.6811)^T,$$

$$W_{51} = (0.8947, 0.3070)^T,$$

$$W_{53} = (0.8947, 0.3070)^T$$

Table H.32 Priority weights of alternatives with respect to user friendliness  $C_{11}$

	$C_{21}$ User friendly vehicle tracking functionalities for public user	$C_{22}$ Effective data presentation	Priority weight ( $w_2$ )
Weight vector	0.8947	0.3070	
$A_1$ MS MapPoint	0.5000	0.3070	0.541
$A_2$ ARC GIS	0.5000	0.8947	0.7220

Table H.33 Priority weights of alternatives with respect to cost  $C_{12}$

	$C_{31}$ Fixed cost	$C_{32}$ Variable cost	Priority weight ( $w_3$ )
Weight vector	0.8947	0.3070	
$A_1$ MS MapPoint	0.8947	0.4660	0.5416
$A_2$ ARC GIS	0.3070	0.6811	0.7220

Table H.34 Priority weights of alternatives with respect to data synchronization  $C_{13}$

	$C_{41}$ Effective data integration to legacy system	Priority weight ( $w_4$ )
Weight vector	1	
$A_1$ MS MapPoint	0.4660	0.4660
$A_2$ ARC GIS	0.6811	0.6811



Table H.35 Priority weights of alternatives with respect to other non-functional requirements  $C_{14}$

	$C_{51}$ Maintainability	$C_{52}$ Availability	$C_{53}$ Sufficient processing and memorial power	Priority weight ( $w_5$ )
Weight vector	0.4769	0.4769	0.1486	
$A_1$ MS MapPoint	0.8947	0.6811	0.8947	0.8845
$A_2$ ARC GIS	0.3070	0.4660	0.3070	0.4143

Table H.36 Priority weights of alternatives with respect to data management  $C_{15}$

	$C_{61}$ Secured data transaction	Priority weight ( $w_6$ )
Weight vector	1	
$A_1$ MS MapPoint	0.8947	0.8947
$A_2$ ARC GIS	0.3070	0.3070

Table H.37 Priority weights of alternatives with respect to goal

	$C_{11}$ User friendliness	$C_{12}$ Cost	$C_{13}$ Data synchronization
Weight vector	0.2182	0.3001	0.3001
$A_1$ MS MapPoint	0.541	0.5416	0.4660
$A_2$ ARC GIS	0.7220	0.7220	0.6811
	$C_{14}$ Other non-functional requirements	$C_{15}$ Data management	Priority weight ( $w_1$ )
Weight vector	0.2891	0.1312	
$A_1$ MS MapPoint	0.8845	0.8947	0.7935
$A_2$ ARC GIS	0.4143	0.3070	0.7387

Table H.38 Ranking of alternatives

Ranking	Alternative	Priority weight ( $w_1$ )
1	$A_1$ MS MapPoint	0.7935
2	$A_2$ ARC GIS	0.7387

## APPENDIX I – QUESTIONNAIRE DESIGN FOR CASE STUDY IV

This appendix includes 13 unfilled questionnaires designed for carrying out the TSS methodology in case study IV. The questionnaires 1-x were designed for surveying the relative importance of fundamental-objectives in *process 4.1.1*; the questionnaires 2-x were designed for surveying relative effectiveness of alternatives in *process 4.2.1*; the questionnaire 3 was designed for surveying the relative importance of solution components in *process 5.1.1*.



## Questionnaire 1-1

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study IV.)

### Solution component: Tracking technology

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_ End time: \_\_\_\_\_

Number of questions: 7 Duration: \_\_\_\_\_

### Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data synchronization
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
Data synchronization	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements

### Section II – Level 2 Cost Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
<b>Fixed cost</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Variable cost</b>

**Section III – Level 2 *Other non-functional requirements* Factors Comparison**

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
<b>Effective location tracking</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Availability</b>
<b>Effective location tracking</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Maintainability</b>
<b>Availability</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Maintainability</b>



## Questionnaire 1-2

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study IV.)

### Solution component: PDA software platform

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 11

Duration: \_\_\_\_\_

### Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Cost
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data synchronization
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data synchronization

Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
Data synchronization	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements

### Section II – Level 2 Cost Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Fixed cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Variable cost

### Section III – Level 2 Data synchronization Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Effective live tracking data update to DB	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Effective live job data update to DB

### Section IV – Level 2 Other non-functional requirements Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Maintainability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Availability
Maintainability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Sufficient processing & memorial power
Availability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Sufficient processing &





## Questionnaire 1-3

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study IV.)

### Solution component: database management system

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 14

Duration: \_\_\_\_\_

### Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data synchronization
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data management
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
Data synchronization	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data management
Data synchronization	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements



Data management	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
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### Section II – Level 2 Cost Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Fixed cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Variable cost

### Section III – Level 2 Data synchronization Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Effective live tracking data update to DB	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Effective live job data update to DB
Effective live tracking data update to DB	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Effective data integration to legacy system
Effective live data update to DB	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Effective data integration to legacy system

### Section IV – Level 2 Data Management Comparison

Sufficient data storage & data transaction capabilities	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Secured data transaction
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### Section V – Level 2 Other non-functional requirements Comparison

Maintainability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Availability
Maintainability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Sufficient processing & memorial power
Availability	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Sufficient processing & memorial power



## Questionnaire 1-4

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study IV.)

### Solution component: user interface (portal application)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 3

Duration: \_\_\_\_\_

### Section I – Level 1 *Goal* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
User friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements

### Section II – Level 2 *User friendliness* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important	

User friendly vehicle tracking functionalities	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	Effective data presentation
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

**Section III – Level 2 *Other non-functional requirements* Factors Comparison**

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Sufficient processing & memorial power	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Effective location tracking



## Questionnaire 1-5

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study IV.)

### Solution component: user interface (PDA applications)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 3

Duration: \_\_\_\_\_

### Section I – Level 1 *Goal* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements

### Section II – Level 2 *User friendliness* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important		

<b>User friendly UI for PDA applications</b>	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	<b>Effective data presentation</b>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

**Section III – Level 2 *Other non-functional requirements* Factors Comparison**

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
<b>Sufficient Processing &amp; memorial power</b>	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	<b>Effective location tracking</b>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	



## Questionnaire 1-6

(This questionnaire is designed for *process 4.1.1* of the TSS methodology for case study IV.)

### Solution component: GIS technology

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 15

Duration: \_\_\_\_\_

### Section I – Level 1 Goal Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Cost
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data synchronization
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
User Friendliness	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data management

Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data synchronization
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
Cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data management
Data synchronization	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Other non-functional requirements
Data synchronization	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data management
Other non-functional requirements	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Data management

### Section II – Level 2 *User friendliness* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
User friendly vehicle tracking functionalities	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Effective data presentation

### Section III – Level 2 *Cost* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Fixed cost	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Variable cost



## Section IV – Level 2 *Other non-functional requirements* Factors Comparison

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
<b>Maintainability</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Availability</b>
<b>Maintainability</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Sufficient processing and memorial power</b>
<b>Availability</b>	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	<b>Sufficient processing and memorial power</b>

## Questionnaire 2-1

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study IV.)

### Solution component: Tracking technology

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after “Remarks” must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option “Equally Effective / (1)” means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_ End time: \_\_\_\_\_

Number of questions: 6 Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Fixed cost*

Means-objectives: Hardware purchase cost, setup cost, software development cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	
GPS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	RFID

### Section II – Comparison against criteria *Variable cost*



Means-objectives: Vehicle-based purchase cost (e.g. cost for data carrier), maintenance cost, labour cost for manual operations

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
GPS	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID

**Section III – Comparison against criteria *Effective live tracking data update to database***

Means-objectives: Connectivity from tracking device to data modem, connectivity from data modem to remote server

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
GPS	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID

**Section IV – Comparison against criteria *Effective location tracking***

Means-objectives: Location tracking accuracy, low data error rate

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
GPS	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID

## Section V – Comparison against criteria *Maintainability*

Means-objectives: Less need for collection of mobile devices during maintenance, low breakdown/operational failure rate

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
GPS	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID

## Section VI – Comparison against criteria *Availability*

Means-objectives: Influence by environmental factors (e.g. weather), geographical tracking coverage, low breakdown/operational failure rate

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
GPS	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	RFID



## Questionnaire 2-2

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study IV.)

### Solution component: PDA software platform

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 8

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Effective data presentation*

Means-objectives: Rich graphical interface, quick screen refresh rate, short loading time

Remarks: \_\_\_\_\_  
\_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS Windows Mobile	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS

**Section II – Comparison against criteria *Fixed cost***

Means-objectives: PDA purchase cost, software development cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS Windows Mobile	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS

**Section III – Comparison against criteria *Variable cost***

Means-objectives: Maintenance cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS Windows Mobile	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS

**Section IV – Comparison against criteria *Effective live tracking data update to database***

Means-objectives: Connectivity to tracking devices, connectivity to remote server

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS Windows	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS



Mobile	
--------	--

**Section V – Comparison against criteria *Effective live job data update to database***

Means-objectives: Connectivity to remote server

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS Windows Mobile	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS

**Section VI – Comparison against criteria *Maintainability***

Means-objectives: Quality of support from provider

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS Windows Mobile	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS

**Section VII – Comparison against criteria *Availability***

Means-objectives: Operational stability

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
7-1	MS Windows Mobile	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS

**Section VIII – Comparison against criteria *Sufficient processing and memorial power***

Means-objectives: High processing and memorial performance

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1	MS Windows Mobile	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Palm OS



## Questionnaire 2-3

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study IV.)

### Solution component: database management system

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_ End time: \_\_\_\_\_

Number of questions: 10 Duration: \_\_\_\_\_

### Section I – Comparison against criteria *Fixed cost*

Means-objectives: Software purchasing cost, setup cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	
Oracle 10g	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	MS SQL 2000

### Section II – Comparison against criteria *Variable cost*

Means-objectives: Administration cost, maintenance cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section III – Comparison against criteria *Effective live tracking data update to database***

Means-objectives: Effective data interface to applications

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section IV – Comparison against criteria *Effective live job data update to database***

Means-objectives: Effective data interface to applications

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section V – Comparison against criteria *Effective data integration to***



**legacy system**

Means-objectives: Capability in handling continuous frequent data import

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1 Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section VI – Comparison against criteria *Maintainability***

Means-objectives: Low breakdown rate, easy-to-upgrade

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
1 Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section VII – Comparison against criteria *Availability***

Means-objectives: Operational stability

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
2.1 Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section VIII – Comparison against criteria *Sufficient processing and memorial power***

Means-objectives: Being efficient with huge amount of data transaction and data storage

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section IX – Comparison against criteria *Sufficient data storage and data transaction capabilities***

Means-objectives: Capability in handling huge amount of historical data, capability to handling continuous frequent accesses

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000

**Section X – Comparison against criteria *Secured data transaction***

Means-objectives: Data security

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Oracle 10g	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	MS SQL 2000



## Questionnaire 2-4

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study IV.)

### Solution component: user interface (portal applications)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 4

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *User friendly vehicle tracking functionalities for public user*

Means-objectives: OS independent for access of application, avoid additional software installation, conventional reading format

Remarks: \_\_\_\_\_  
\_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

## Section II – Comparison against criteria *Effective data presentation*

Means-objectives: Rich content presentation, quick screen refresh rate, short loading time

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

## Section III – Comparison against criteria *Sufficient processing and memorial power*

Means-objectives: Low resources requirements to server

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

## Section IV – Comparison against criteria *Effective location tracking*

Means-objectives: Rich content presentation, tracking automatical information refreshing

Remarks: \_\_\_\_\_  
 \_\_\_\_\_



		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
4.1	Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

## Questionnaire 2-5

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study IV.)

### Solution component: user interface (PDA applications)

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 4

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *User friendly user interface for PDA applicaitons*

Means-objectives: Efficient use of screen space, avoid horizontal scroll bar

Remarks: \_\_\_\_\_  
\_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
4.1 Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI



## Section II – Comparison against criteria *Effective data presentation*

Means-objectives: Rich content presentation, quick screen refresh rate, short loading time

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

## Section III – Comparison against criteria *Sufficient processing and memorial power*

Means-objectives: Low resources requirement to server

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI

## Section IV – Comparison against criteria *Effective location tracking*

Means-objectives: Capability to manage tracking device and remote server connectivity status on screen

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	

4.1	Web-based user interface	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GUI
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## Questionnaire 2-6

(This questionnaire is designed for *process 4.2.1* of the TSS methodology for case study IV.)

### Solution component: GIS technology

Please answer every question in all sections. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria according to their effectiveness towards the criteria they against. The provided space after "Remarks" must be filled with reason(s) for answers considering the provided means-objectives.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Effective / (1)" means that the two criteria are considered equally effective; the answer options on the right side of it mean that the criterion on the right side is considered more effective with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more effective with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 9

Duration: \_\_\_\_\_

### Section I – Comparison against criteria *User friendly vehicle tracking functionalities for public user*

Means-objectives: Map readability, ETA (Estimated Time of Arrival), distance calculation

Remarks: \_\_\_\_\_  
\_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS

**Section II – Comparison against criteria *Effective data presentation***

Means-objectives: Map zooming, fast screen refresh

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
2.1	MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS

**Section III – Comparison against criteria *Fixed cost***

Means-objectives: Software purchase cost (include geographical data purchase cost if any), software integration cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
3.1	MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS

**Section IV – Comparison against criteria *Variable cost***

Means-objectives: Service subscription cost, maintenance cost

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
4.1	MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS



**Section V – Comparison against criteria *Effective data integration to legacy system***

Means-objectives: Geocoding and reverse geocoding for address data integration

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
5.1	MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS

**Section VI – Comparison against criteria *Maintainability***

Means-objectives: Quality of support from provider

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
5.1	MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS

**Section VII – Comparison against criteria *Availability***

Means-objectives: Operational stability

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

		Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
7.1	MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS

**Section VIII – Comparison against criteria *Sufficient processing and***

**memorial power**

Means-objectives: Low resource requirement to server

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS

**Section IX – Comparison against criteria *Secured data transaction***

Means-objectives: Managed geographical data protection

Remarks: \_\_\_\_\_  
 \_\_\_\_\_

	Extremely Effective	Very Effective	Effective	Moderately Effective	Equally Effective	Moderately Effective	Effective	Very Effective	Extremely Effective	
MS MapPoint	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	ARC GIS



### Questionnaire 3

(This questionnaire is designed for *process 5.1.1* of the TSS methodology for case study IV.)

Please answer all questions. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 10

Duration: \_\_\_\_\_

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	PDA software platform
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Database management system
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (portal app.)
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (PDA app.)
PDA software platform	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	Database management system
PDA software platform	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	User interface (portal app.)

PDA software platform	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	User interface (PDA app.)
Database management system	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	User interface (portal app.)
Database management system	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	User interface (PDA app.)
User interface (portal app.)	(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)	User interface (PDA app.)



## Questionnaire 4

(This questionnaire is designed for *process 5.1.1 (round 2)* of the TSS methodology for case study IV.)

Please answer all questions. Please select one and only one answer by ticking the box below it. \*The answer should indicate the comparison between two criteria in terms of their importance for achieving the goal.

\* Hints: The number in the bracket of every answer option indicates the amount of importance. The answer option "Equally Important / (1)" means that the two criteria are considered equally important; the answer options on the right side of it mean that the criterion on the right side is considered more important with the amount indicated by the selected answer; similarly, the answer options on the left side of it mean that the criterion on the left side is considered more important with the amount indicated by the selected answer.

Please mark the time (up to minute) that you started and finished the questionnaire:

Start time: \_\_\_\_\_

End time: \_\_\_\_\_

Number of questions: 5

Duration: \_\_\_\_\_

	Extremely Important	Very Important	Moderately Important	Equally Important	Moderately Important	Very Important	Extremely Important			
Tracking technology	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GIS technology
PDA software platform	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GIS technology
Database management system	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GIS technology
User interface (portal app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GIS technology
User interface (PDA app.)	(9) <input type="checkbox"/>	(7) <input type="checkbox"/>	(5) <input type="checkbox"/>	(3) <input type="checkbox"/>	(1) <input type="checkbox"/>	(3) <input type="checkbox"/>	(5) <input type="checkbox"/>	(7) <input type="checkbox"/>	(9) <input type="checkbox"/>	GIS technology

## APPENDIX J - PHASE 5 RESULTS FOR CASE STUDY III

*Appendix J* documents the *phase 5* results for the case study III. With ranking of alternatives for each solution components obtained in *phase 4*, *phase 5* attempts to obtain the ranking of relative importance between the solution components, and consequently identify potential solutions and finally obtain the ranking of potential solutions.

This document is divided into two sections for outlining the results of *step 5.1* and *step 5.2* respectively.

The first section contains the PCMs resulted from *process 5.1.1* and *process 5.1.2*, the consistency ratios as the consistency test results in *process 5.1.3*, the fuzzified PCMs resulted from *process 5.1.4*, the synthetic extents as the results of *process 5.1.5*, the weight vectors and thereby rankings of relative importance of solution components resulted from *process 4.1.6*.

The second section lists the potential solutions with its solution component contents, and outlines the mathematical process for obtaining the final integrated result – the ranking of potential solutions.

### 1. Step 5.1

#### *Process 5.1.2*

M =

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>
C <sub>1</sub>	1	5	9	3	7	7
C <sub>2</sub>	1/5	1	3	1/3	5	3
C <sub>3</sub>	1/9	1/3	1	1/5	1/3	1/3
C <sub>4</sub>	1/3	3	5	1	5	5
C <sub>5</sub>	1/7	1/5	3	1/5	1	1
C <sub>5</sub>	1/7	1/3	3	1/5	1	1

C<sub>1</sub>: tracking technology

C<sub>2</sub>: software platform (intranet application)

C<sub>3</sub>: software platform (internet application)

C<sub>4</sub>: data management



$C_5$ : user interface (customer reporting)

$C_6$ : user interface (other intranet application)

*Process 5.1.3*

M is considered consistent for the consistency ratio (CR) valued 0.0874, less than 0.100.

*Process 5.1.4*

$M' =$

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$
$C_1$	(1, 1, 3)	(3, 5, 7)	(7, 9, 9)	(1, 3, 5)	(5, 7, 9)	(5, 7, 9)
$C_2$	1/(3, 5, 7)	(1, 1, 3)	(1, 3, 5)	1/(1, 3, 5)	(3, 5, 7)	(1, 3, 5)
$C_3$	1/(7, 9, 9)	1/(1, 3, 5)	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	1/(1, 3, 5)
$C_4$	1/(1, 3, 5)	(1, 3, 5)	(3, 5, 7)	(1, 1, 3)	(3, 5, 7)	(3, 5, 7)
$C_5$	1/(5, 7, 9)	1/(3, 5, 7)	(1, 3, 5)	1/(3, 5, 7)	(1, 1, 3)	(1, 3, 5)
$C_6$	1/(5, 7, 9)	1/(1, 3, 5)	(1, 3, 5)	1/(3, 5, 7)	1/(1, 3, 5)	(1, 1, 3)

*Process 5.1.5*

$S_1 = (0.1344, 0.3351, 0.8639),$        $S_2 = (0.0538, 0.1769, 0.5280),$   
 $S_3 = (0.0158, 0.0335, 0.1600),$        $S_4 = (0.0952, 0.2793, 0.7199),$   
 $S_5 = (0.0285, 0.1053, 0.3328),$        $S_6 = (0.0223, 0.0699, 0.2528).$

*Process 5.1.6*

$W' = (1.0000, 0.7132, 0.0783, 0.9129, 0.4633, 0.3087)^T.$

$W = (0.3762, 0.2683, 0.0295, 0.3434, 0.1743, 0.1161)^T.$

Table J.1 Ranking for solution components

Ranking	Solution components ( $C_i$ )	Weight vector ( $v_i$ )
1	$C_1$ Tracking technology	0.3762
2	$C_4$ Data management	0.3434
3	$C_2$ Software platform (intranet application)	0.2683
4	$C_5$ User interface (customer reporting)	0.1743
5	$C_6$ User interface (other intranet)	0.1161

	application)	
6	C <sub>3</sub> Software platform (internet application)	0.0295

## 2. Step 5.2

Alternatives for solution components are denoted as below.

Table J.2 Solution component and alternative summary

Solution components ( $C_i$ )	Alternatives ( $A_{ij}$ )
C <sub>1</sub> Tracking technology	A <sub>11</sub> Barcode, A <sub>12</sub> RFID, A <sub>13</sub> GPS.
C <sub>2</sub> Software platform (intranet application)	A <sub>21</sub> Adobe AIR, A <sub>22</sub> MS .Net, A <sub>23</sub> Java.
C <sub>3</sub> Software platform (internet application)	A <sub>31</sub> Adobe AIR, A <sub>32</sub> MS .Net, A <sub>33</sub> Java.
C <sub>4</sub> Data management	A <sub>41</sub> Oracle 10g, A <sub>42</sub> MS SQL 2000.
C <sub>5</sub> User interface (customer reporting)	A <sub>51</sub> Web-based UI, A <sub>52</sub> GUI.
C <sub>6</sub> User interface (other intranet application)	A <sub>51</sub> Web-based UI, A <sub>52</sub> GUI.

Potential solutions are denoted by  $PS_k$  which contains a set of solution components ( $A_{k,1}, A_{k,2}, A_{k,3}, A_{k,4}, A_{k,5}, A_{k,6}$ ). As indicated by compatibility analysis, all alternatives shown in above table are compatible with all alternatives of other solution components. There are 216 potential solutions exist. They are listed below.

Table J.3 Potential solution summary

Potential solutions ( $PS_k$ )	Contents ( $A_{k,1}, A_{k,2}, A_{k,3}, A_{k,4}, A_{k,5}, A_{k,6}$ )	Potential solutions ( $PS_k$ )	Contents ( $A_{k,1}, A_{k,2}, A_{k,3}, A_{k,4}, A_{k,5}, A_{k,6}$ )
$PS_1$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{51}, A_{61}$ .	$PS_2$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{51}, A_{62}$ .
$PS_3$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{52}, A_{61}$ .	$PS_4$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{52}, A_{62}$ .
$PS_5$	$A_{11}, A_{21}, A_{31}, A_{42}, A_{51}, A_{61}$ .	$PS_6$	$A_{11}, A_{21}, A_{31}, A_{42}, A_{51}, A_{62}$ .











<i>PS</i> <sub>155</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>156</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>157</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>158</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>159</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>160</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>161</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>162</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>163</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>164</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>165</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>166</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>167</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>168</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>169</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>170</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>171</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>172</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>173</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>174</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>175</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>176</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>177</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>178</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>179</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>180</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>181</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>182</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>183</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>184</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>185</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>186</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>187</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>188</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>189</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>190</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>191</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>192</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>193</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>194</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>195</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>196</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>197</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>198</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>199</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>200</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>201</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>202</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>203</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>204</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>205</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>206</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>207</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>208</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>209</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>210</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>211</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>212</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>213</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>214</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>215</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>216</sub>	<i>A</i> <sub>13</sub> , <i>A</i> <sub>23</sub> , <i>A</i> <sub>33</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .

Ranking of the relative importance of the potential solutions can be achieved by integrating the relative effectiveness of the containing alternatives. Two steps are involved in this: 1) transform the priority weight of the alternatives into comparison score; 2) find the priority weight of potential solutions with the comparison scores of alternatives and the weight vectors of solution component.

The following equation can be used to transform the priority weights ( $w_{ij}$ ) into comparison score ( $w_{ij}'$ ).

$$w_{ij}' = w_{ij} / \sum_j w_{ij} \quad (J.1)$$

Table J.4 shows the normalized priority weight of alternatives.

Table J.4 Comparison scores of alternatives

Solution components ( $C_i$ )	Alternatives ( $A_{ij}$ )	Priority weight ( $w_{ij}$ )	Comparison score ( $w_{ij}'$ )
$C_1$	$A_{11}$ Barcode	0.6484	0.4115
	$A_{12}$ RFID	0.5196	0.3298
	$A_{13}$ GPS	0.4077	0.2587
$C_2$	$A_{21}$ Adobe AIR	0.2255	0.1580
	$A_{22}$ MS .Net	0.7211	0.5054
	$A_{23}$ Java	0.4802	0.3366
$C_3$	$A_{31}$ Adobe AIR	0.4733	0.2937
	$A_{32}$ MS .Net	0.6328	0.3926
	$A_{33}$ Java	0.5056	0.3137
$C_4$	$A_{41}$ Oracle 10g	0.8102	0.5860
	$A_{42}$ MS SQL 2000	0.5725	0.4140
$C_5$	$A_{51}$ Web-based UI	0.6926	0.4785
	$A_{52}$ GUI	0.7548	0.5215
$C_6$	$A_{61}$ Web-based UI	1.1659	0.8207
	$A_{62}$ GUI	0.2548	0.1793

Therefore, ranking of the relative importance of the potential solution can be obtained by finding their priority weight ( $w_k$ ). The priority weight is simply the sum of the priority weights multiplies with the respective weight vector of the containing alternatives. It can be expressed with formula below.

$$w_k = \sum_i (w'_{k,i} * v_i) \quad (J.2)$$

For example, priority weight of  $PS_1$  can be found as below:

$$\begin{aligned} w_1 &= (w'_{11} * v_1) + (w'_{21} * v_2) + (w'_{31} * v_3) + (w'_{41} * v_4) + (w'_{51} * v_5) + (w'_{61} * v_6) \\ &= (0.4115 * 0.3762) + (0.1580 * 0.2683) + (0.2937 * 0.0295) + (0.5860 * 0.3434) \\ &\quad + (0.4785 * 0.1743) + (0.8207 * 0.1161) \end{aligned}$$



= 0.5858

Table J.5 shows the priority weights of the potential solutions.

Table J.5 Priority weight of potential solutions

Potential solutions ( $PS_k$ )	Priority weight ( $w_k$ )	Potential solutions ( $PS_k$ )	Priority weight ( $w_k$ )
$PS_1$	0.5858	$PS_2$	0.5113
$PS_3$	0.5933	$PS_4$	0.5188
$PS_5$	0.5267	$PS_6$	0.4522
$PS_7$	0.5342	$PS_8$	0.4597
$PS_9$	0.5887	$PS_{10}$	0.5142
$PS_{11}$	0.5962	$PS_{12}$	0.5217
$PS_{13}$	0.5296	$PS_{14}$	0.4552
$PS_{15}$	0.5342	$PS_{16}$	0.4627
$PS_{17}$	0.5864	$PS_{18}$	0.5119
$PS_{19}$	0.5939	$PS_{20}$	0.5194
$PS_{21}$	0.5273	$PS_{22}$	0.4528
$PS_{23}$	0.5348	$PS_{24}$	0.4603
$PS_{25}$	0.6790	$PS_{26}$	0.6045
$PS_{27}$	0.6865	$PS_{28}$	0.6120
$PS_{29}$	0.6199	$PS_{30}$	0.5455
$PS_{31}$	0.6274	$PS_{32}$	0.5530
$PS_{33}$	0.6819	$PS_{34}$	0.6074
$PS_{35}$	0.6894	$PS_{36}$	0.6149
$PS_{37}$	0.6228	$PS_{38}$	0.5484
$PS_{39}$	0.6274	$PS_{40}$	0.5559
$PS_{41}$	0.6796	$PS_{42}$	0.6051
$PS_{43}$	0.6871	$PS_{44}$	0.6126
$PS_{45}$	0.6205	$PS_{46}$	0.5460
$PS_{47}$	0.6280	$PS_{48}$	0.5535
$PS_{49}$	0.6337	$PS_{50}$	0.5592
$PS_{51}$	0.6412	$PS_{52}$	0.5667
$PS_{53}$	0.5746	$PS_{54}$	0.5002
$PS_{55}$	0.5821	$PS_{56}$	0.5077
$PS_{57}$	0.6366	$PS_{58}$	0.5621
$PS_{59}$	0.6441	$PS_{60}$	0.5696

<i>PS</i> <sub>61</sub>	0.5776	<i>PS</i> <sub>62</sub>	0.5031
<i>PS</i> <sub>63</sub>	0.5821	<i>PS</i> <sub>64</sub>	0.5106
<i>PS</i> <sub>65</sub>	0.6343	<i>PS</i> <sub>66</sub>	0.5598
<i>PS</i> <sub>67</sub>	0.6418	<i>PS</i> <sub>68</sub>	0.5673
<i>PS</i> <sub>69</sub>	0.5752	<i>PS</i> <sub>70</sub>	0.5008
<i>PS</i> <sub>71</sub>	0.5827	<i>PS</i> <sub>72</sub>	0.5083
<i>PS</i> <sub>73</sub>	0.5550	<i>PS</i> <sub>74</sub>	0.4806
<i>PS</i> <sub>75</sub>	0.5625	<i>PS</i> <sub>76</sub>	0.4881
<i>PS</i> <sub>77</sub>	0.4960	<i>PS</i> <sub>78</sub>	0.4215
<i>PS</i> <sub>79</sub>	0.5035	<i>PS</i> <sub>80</sub>	0.4290
<i>PS</i> <sub>81</sub>	0.5580	<i>PS</i> <sub>82</sub>	0.4835
<i>PS</i> <sub>83</sub>	0.5655	<i>PS</i> <sub>84</sub>	0.4910
<i>PS</i> <sub>85</sub>	0.4989	<i>PS</i> <sub>86</sub>	0.4244
<i>PS</i> <sub>87</sub>	0.5035	<i>PS</i> <sub>88</sub>	0.4319
<i>PS</i> <sub>89</sub>	0.5556	<i>PS</i> <sub>90</sub>	0.4812
<i>PS</i> <sub>91</sub>	0.5631	<i>PS</i> <sub>92</sub>	0.4887
<i>PS</i> <sub>93</sub>	0.4966	<i>PS</i> <sub>94</sub>	0.4221
<i>PS</i> <sub>95</sub>	0.5041	<i>PS</i> <sub>96</sub>	0.4296
<i>PS</i> <sub>97</sub>	0.6483	<i>PS</i> <sub>98</sub>	0.5738
<i>PS</i> <sub>99</sub>	0.6557	<i>PS</i> <sub>100</sub>	0.5813
<i>PS</i> <sub>101</sub>	0.5892	<i>PS</i> <sub>102</sub>	0.5147
<i>PS</i> <sub>103</sub>	0.5967	<i>PS</i> <sub>104</sub>	0.5222
<i>PS</i> <sub>105</sub>	0.6512	<i>PS</i> <sub>106</sub>	0.5767
<i>PS</i> <sub>107</sub>	0.6587	<i>PS</i> <sub>108</sub>	0.5842
<i>PS</i> <sub>109</sub>	0.5921	<i>PS</i> <sub>110</sub>	0.5176
<i>PS</i> <sub>111</sub>	0.5967	<i>PS</i> <sub>112</sub>	0.5251
<i>PS</i> <sub>113</sub>	0.6488	<i>PS</i> <sub>114</sub>	0.5744
<i>PS</i> <sub>115</sub>	0.6563	<i>PS</i> <sub>116</sub>	0.5819
<i>PS</i> <sub>117</sub>	0.5898	<i>PS</i> <sub>118</sub>	0.5153
<i>PS</i> <sub>119</sub>	0.5973	<i>PS</i> <sub>120</sub>	0.5228
<i>PS</i> <sub>121</sub>	0.6030	<i>PS</i> <sub>122</sub>	0.5285
<i>PS</i> <sub>123</sub>	0.6105	<i>PS</i> <sub>124</sub>	0.5360
<i>PS</i> <sub>125</sub>	0.5439	<i>PS</i> <sub>126</sub>	0.4694
<i>PS</i> <sub>127</sub>	0.5514	<i>PS</i> <sub>128</sub>	0.4769
<i>PS</i> <sub>129</sub>	0.6059	<i>PS</i> <sub>130</sub>	0.5314
<i>PS</i> <sub>131</sub>	0.6134	<i>PS</i> <sub>132</sub>	0.5389
<i>PS</i> <sub>133</sub>	0.5468	<i>PS</i> <sub>134</sub>	0.4723



<i>PS</i> <sub>135</sub>	0.5514	<i>PS</i> <sub>136</sub>	0.4798
<i>PS</i> <sub>137</sub>	0.6036	<i>PS</i> <sub>138</sub>	0.5291
<i>PS</i> <sub>139</sub>	0.6110	<i>PS</i> <sub>140</sub>	0.5366
<i>PS</i> <sub>141</sub>	0.5445	<i>PS</i> <sub>142</sub>	0.4700
<i>PS</i> <sub>143</sub>	0.5520	<i>PS</i> <sub>144</sub>	0.4775
<i>PS</i> <sub>145</sub>	0.5283	<i>PS</i> <sub>146</sub>	0.4538
<i>PS</i> <sub>147</sub>	0.5358	<i>PS</i> <sub>148</sub>	0.4613
<i>PS</i> <sub>149</sub>	0.4692	<i>PS</i> <sub>150</sub>	0.3948
<i>PS</i> <sub>151</sub>	0.4767	<i>PS</i> <sub>152</sub>	0.4023
<i>PS</i> <sub>153</sub>	0.5312	<i>PS</i> <sub>154</sub>	0.4567
<i>PS</i> <sub>155</sub>	0.5387	<i>PS</i> <sub>156</sub>	0.4910
<i>PS</i> <sub>157</sub>	0.4721	<i>PS</i> <sub>158</sub>	0.3977
<i>PS</i> <sub>159</sub>	0.4767	<i>PS</i> <sub>160</sub>	0.4052
<i>PS</i> <sub>161</sub>	0.5289	<i>PS</i> <sub>162</sub>	0.4544
<i>PS</i> <sub>163</sub>	0.5364	<i>PS</i> <sub>164</sub>	0.4619
<i>PS</i> <sub>165</sub>	0.4698	<i>PS</i> <sub>166</sub>	0.3954
<i>PS</i> <sub>167</sub>	0.4773	<i>PS</i> <sub>168</sub>	0.4029
<i>PS</i> <sub>169</sub>	0.6215	<i>PS</i> <sub>170</sub>	0.5470
<i>PS</i> <sub>171</sub>	0.6290	<i>PS</i> <sub>172</sub>	0.5545
<i>PS</i> <sub>173</sub>	0.5624	<i>PS</i> <sub>174</sub>	0.4880
<i>PS</i> <sub>175</sub>	0.5699	<i>PS</i> <sub>176</sub>	0.4955
<i>PS</i> <sub>177</sub>	0.6244	<i>PS</i> <sub>178</sub>	0.5500
<i>PS</i> <sub>179</sub>	0.6319	<i>PS</i> <sub>180</sub>	0.5575
<i>PS</i> <sub>181</sub>	0.5654	<i>PS</i> <sub>182</sub>	0.4909
<i>PS</i> <sub>183</sub>	0.5699	<i>PS</i> <sub>184</sub>	0.4984
<i>PS</i> <sub>185</sub>	0.6221	<i>PS</i> <sub>186</sub>	0.5476
<i>PS</i> <sub>187</sub>	0.6296	<i>PS</i> <sub>188</sub>	0.5551
<i>PS</i> <sub>189</sub>	0.5630	<i>PS</i> <sub>190</sub>	0.4886
<i>PS</i> <sub>191</sub>	0.5705	<i>PS</i> <sub>192</sub>	0.4961
<i>PS</i> <sub>193</sub>	0.5762	<i>PS</i> <sub>194</sub>	0.5017
<i>PS</i> <sub>195</sub>	0.5837	<i>PS</i> <sub>196</sub>	0.5092
<i>PS</i> <sub>197</sub>	0.5172	<i>PS</i> <sub>198</sub>	0.4427
<i>PS</i> <sub>199</sub>	0.5246	<i>PS</i> <sub>200</sub>	0.4502
<i>PS</i> <sub>201</sub>	0.5791	<i>PS</i> <sub>202</sub>	0.5047
<i>PS</i> <sub>203</sub>	0.5866	<i>PS</i> <sub>204</sub>	0.5122
<i>PS</i> <sub>205</sub>	0.5201	<i>PS</i> <sub>206</sub>	0.4456
<i>PS</i> <sub>207</sub>	0.5246	<i>PS</i> <sub>208</sub>	0.4531

$PS_{209}$	0.5768	$PS_{210}$	0.5023
$PS_{211}$	0.5843	$PS_{212}$	0.5098
$PS_{213}$	0.5177	$PS_{214}$	0.4433
$PS_{215}$	0.5252	$PS_{216}$	0.4508

Therefore, below is the top ten ranked potential solutions according to table below.

Table J.6 Top ten ranked potential solutions

Ranking	Potential solutions ( $PS_k$ )	Priority weight ( $w_k$ )	Alternatives ( $A_{ij}$ )
1	$PS_{35}$	0.6894	$A_{11}$ Barcode, $A_{22}$ MS .Net, $A_{32}$ MS .Net, $A_{41}$ Oracle 10g, $A_{52}$ GUI, $A_{61}$ Web-based UI.
2	$PS_{43}$	0.6871	$A_{11}$ Barcode, $A_{22}$ MS .Net, $A_{33}$ Java, $A_{41}$ Oracle 10g, $A_{52}$ GUI, $A_{61}$ Web-based UI.
3	$PS_{27}$	0.6865	$A_{11}$ Barcode, $A_{22}$ MS .Net, $A_{31}$ Adobe AIR, $A_{41}$ Oracle 10g, $A_{52}$ GUI, $A_{61}$ Web-based UI.
4	$PS_{33}$	0.6819	$A_{11}$ Barcode, $A_{22}$ MS .Net, $A_{32}$ MS .Net, $A_{41}$ Oracle 10g, $A_{51}$ Web-based UI, $A_{61}$ Web-based UI.
5	$PS_{41}$	0.6796	$A_{11}$ Barcode, $A_{22}$ MS .Net, $A_{33}$ Java,



			<i>A<sub>41</sub></i> Oracle 10g, <i>A<sub>51</sub></i> Web-based UI, <i>A<sub>61</sub></i> Web-based UI.
6	<i>PS<sub>25</sub></i>	0.6790	<i>A<sub>11</sub></i> Barcode, <i>A<sub>22</sub></i> MS .Net, <i>A<sub>31</sub></i> Adobe AIR, <i>A<sub>41</sub></i> Oracle 10g, <i>A<sub>51</sub></i> Web-based UI, <i>A<sub>61</sub></i> Web-based UI.
7	<i>PS<sub>107</sub></i>	0.6587	<i>A<sub>12</sub></i> RFID, <i>A<sub>22</sub></i> MS .Net, <i>A<sub>32</sub></i> MS .Net, <i>A<sub>41</sub></i> Oracle 10g, <i>A<sub>52</sub></i> GUI, <i>A<sub>61</sub></i> Web-based UI.
8	<i>PS<sub>115</sub></i>	0.6563	<i>A<sub>12</sub></i> RFID, <i>A<sub>22</sub></i> MS .Net, <i>A<sub>33</sub></i> Java, <i>A<sub>41</sub></i> Oracle 10g, <i>A<sub>52</sub></i> GUI, <i>A<sub>61</sub></i> Web-based UI.
9	<i>PS<sub>99</sub></i>	0.6557	<i>A<sub>12</sub></i> RFID, <i>A<sub>22</sub></i> MS .Net, <i>A<sub>31</sub></i> Adobe AIR, <i>A<sub>41</sub></i> Oracle 10g, <i>A<sub>52</sub></i> GUI, <i>A<sub>61</sub></i> Web-based UI.
10	<i>PS<sub>105</sub></i>	0.6512	<i>A<sub>12</sub></i> RFID, <i>A<sub>22</sub></i> MS .Net, <i>A<sub>32</sub></i> MS .Net, <i>A<sub>41</sub></i> Oracle 10g, <i>A<sub>51</sub></i> Web-based UI, <i>A<sub>61</sub></i> Web-based UI.

## APPENDIX K - PHASE 5 RESULTS FOR CASE STUDY IV

*Appendix K* documents the *phase 5* results for the case study IV. With ranking of alternatives for each solution components obtained in *phase 4*, *phase 5* attempts to obtain the ranking of relative importance between the solution components, and consequently identify potential solutions and finally obtain the ranking of potential solutions.

This document is divided into two sections for outlining the results of *step 5.1* and *step 5.2* respectively.

The first section contains the PCMs resulted from *process 5.1.1* and *process 5.1.2*, the consistency ratios as the consistency test results in *process 5.1.3*, the fuzzified PCMs resulted from *process 5.1.4*, the synthetic extents as the results of *process 5.1.5*, the weight vectors and thereby rankings of relative importance of solution components resulted from *process 4.1.6*.

The second section lists the potential solutions with its solution component contents, and outlines the mathematical process for obtaining the final integrated result – the ranking of potential solutions.

### 1. Step 5.1

#### *Process 5.1.2*

M =

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>
C <sub>1</sub>	1	3	1	3	3	3
C <sub>2</sub>	1/3	1	1/5	1/3	1/3	5
C <sub>3</sub>	1	5	1	3	3	9
C <sub>4</sub>	1/3	3	1/3	1	1	5
C <sub>5</sub>	1/3	3	1/3	1	1	5
C <sub>5</sub>	1/3	1/5	1/9	1/5	1/5	1

C<sub>1</sub>: tracking technology

C<sub>2</sub>: PDA software platform

C<sub>3</sub>: database management system

C<sub>4</sub>: user interface (portal application)



$C_5$ : user interface (PDA application)

$C_6$ : GIS technology

*Process 5.1.3*

M is considered consistent for the consistency ratio (CR) valued 0.091, less than 0.100.

*Process 5.1.4*

$M' =$

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$
$C_1$	(1, 1, 3)	(1, 3, 5)	(1, 1, 3)	(1, 3, 5)	(1, 3, 5)	(1, 3, 5)
$C_2$	1/(1, 3, 5)	(1, 1, 3)	1/(3, 5, 7)	1/(1, 3, 5)	1/(1, 3, 5)	(3, 5, 7)
$C_3$	1/(1, 1, 3)	(3, 5, 7)	(1, 1, 3)	(1, 3, 5)	(1, 3, 5)	(7, 9, 9)
$C_4$	1/(1, 3, 5)	(1, 3, 5)	1/(1, 3, 5)	(1, 1, 3)	(1, 1, 3)	(3, 5, 7)
$C_5$	1/(1, 3, 5)	(1, 3, 5)	1/(1, 3, 5)	1/(1, 1, 3)	(1, 1, 3)	(3, 5, 7)
$C_6$	1/(1, 3, 5)	1/(3, 5, 7)	1/(7, 9, 9)	1/(3, 5, 7)	1/(3, 5, 7)	(1, 1, 3)

*Process 5.1.5*

$$S_1 = (0.0533, 0.2103, 0.6851), \quad S_2 = (0.0422, 0.1081, 0.3513),$$

$$S_3 = (0.1185, 0.3304, 0.7905), \quad S_4 = (0.0569, 0.1602, 0.5270),$$

$$S_5 = (0.0510, 0.1602, 0.4743), \quad S_6 = (0.0155, 0.0307, 0.1355).$$

*Process 5.1.6*

$$W' = (0.8250, 0.5115, 1.0000, 0.7058, 0.6764, 0.0536)^T.$$

$$W = (0.2844, 0.1763, 0.3447, 0.2433, 0.2332, 0.0185)^T.$$

Table K.1 Ranking for solution components

Ranking	Solution components ( $C_i$ )	Weight vector ( $v_i$ )
1	$C_3$ Database management system	0.3447
2	$C_1$ Tracking technology	0.2844
3	$C_4$ User interface (portal application)	0.2433
	$C_5$ User interface (PDA application)	0.2332
5	$C_2$ PDA software platform	0.1763

6	C <sub>6</sub> GIS technology	0.0185
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## 2. Step 5.2

Alternatives for solution components are denoted as below.

Table K.2 Solution component and alternative summary

Solution components ( $C_i$ )	Alternatives ( $A_{ij}$ )
$C_1$ Tracking technology	$A_{11}$ GPS, $A_{12}$ RFID.
$C_2$ PDA software platform	$A_{21}$ MS Windows Mobile, $A_{22}$ Palm OS.
$C_3$ Database management system	$A_{31}$ Oracle 10g, $A_{32}$ MS SQL 2000.
$C_4$ User interface (portal application)	$A_{41}$ Web-based UI, $A_{42}$ GUI.
$C_5$ User interface (PDA application)	$A_{51}$ Web-based UI, $A_{52}$ GUI.
$C_6$ GIS technology	$A_{61}$ MS MapPoint, $A_{62}$ ARC GIS.

Potential solutions are denoted by  $PS_k$  containing a set of solution components ( $A_{k,1}$ ,  $A_{k,2}$ ,  $A_{k,3}$ ,  $A_{k,4}$ ,  $A_{k,5}$ ,  $A_{k,6}$ ). As indicated by compatibility analysis, all alternatives shown in above table are compatible with all alternatives of other solution components. There are 64 potential solutions exist. They are listed below.

Table K.3 Potential solution summary

Potential solutions ( $PS_k$ )	Contents ( $A_{k,1}$ , $A_{k,2}$ , $A_{k,3}$ , $A_{k,4}$ , $A_{k,5}$ , $A_{k,6}$ )	Potential solutions ( $PS_k$ )	Contents ( $A_{k,1}$ , $A_{k,2}$ , $A_{k,3}$ , $A_{k,4}$ , $A_{k,5}$ , $A_{k,6}$ )
$PS_1$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{51}, A_{61}$ .	$PS_2$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{51}, A_{62}$ .
$PS_3$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{52}, A_{61}$ .	$PS_4$	$A_{11}, A_{21}, A_{31}, A_{41}, A_{52}, A_{62}$ .
$PS_5$	$A_{11}, A_{21}, A_{31}, A_{42}, A_{51}, A_{61}$ .	$PS_6$	$A_{11}, A_{21}, A_{31}, A_{42}, A_{51}, A_{62}$ .
$PS_7$	$A_{11}, A_{21}, A_{31}, A_{42}, A_{52}, A_{61}$ .	$PS_8$	$A_{11}, A_{21}, A_{31}, A_{42}, A_{52}, A_{62}$ .
$PS_9$	$A_{11}, A_{21}, A_{32}, A_{41}, A_{51}, A_{61}$ .	$PS_{10}$	$A_{11}, A_{21}, A_{32}, A_{41}, A_{51}, A_{62}$ .
$PS_{11}$	$A_{11}, A_{21}, A_{32}, A_{41}, A_{52}, A_{61}$ .	$PS_{12}$	$A_{11}, A_{21}, A_{32}, A_{41}, A_{52}, A_{62}$ .
$PS_{13}$	$A_{11}, A_{21}, A_{32}, A_{42}, A_{51}, A_{61}$ .	$PS_{14}$	$A_{11}, A_{21}, A_{32}, A_{42}, A_{51}, A_{62}$ .
$PS_{15}$	$A_{11}, A_{21}, A_{32}, A_{42}, A_{52}, A_{61}$ .	$PS_{16}$	$A_{11}, A_{21}, A_{32}, A_{42}, A_{52}, A_{62}$ .



<i>PS</i> <sub>17</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>18</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>19</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>20</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>21</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>22</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>23</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>24</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>25</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>26</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>27</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>28</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>29</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>30</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>31</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>32</sub>	<i>A</i> <sub>11</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>33</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>34</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>35</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>36</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>37</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>38</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>39</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>40</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>41</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>42</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>43</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>44</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>45</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>46</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>47</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>48</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>21</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>49</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>50</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>51</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>52</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>53</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>54</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>55</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>56</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>31</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>57</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>58</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>59</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>60</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>41</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>61</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>62</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>51</sub> , <i>A</i> <sub>62</sub> .
<i>PS</i> <sub>63</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>61</sub> .	<i>PS</i> <sub>64</sub>	<i>A</i> <sub>12</sub> , <i>A</i> <sub>22</sub> , <i>A</i> <sub>32</sub> , <i>A</i> <sub>42</sub> , <i>A</i> <sub>52</sub> , <i>A</i> <sub>62</sub> .

Ranking of the relative importance of the potential solutions can be achieved by integrating the relative effectiveness of the containing alternatives. Two steps are involved in this: 1) normalize the priority weight of the alternatives; 2) find the priority weight of potential solutions with the normalized priority weight of alternatives and the weight vector of solution component.

The following equation can be used to transform the priority weights ( $w_{ij}$ ) into normalized priority weights ( $w_{ij}'$ ).

$$w_{ij}' = w_{ij} / \sum_j w_{ij} \quad (\text{K.1})$$

Table K.4 shows the normalized priority weight of alternatives.

Table K.4 Normalized priority weights

Solution components ( $C_i$ )	Alternatives ( $A_{ij}$ )	Priority weight ( $w_{ij}$ )	Normalized priority weight ( $w'_{ij}$ or $w'_{k,i}$ )
$C_1$	$A_{11}$ GPS	0.9502	0.6533
	$A_{12}$ RFID	0.5042	0.3467
$C_2$	$A_{21}$ MS Windows Mobile	0.8490	0.5236
	$A_{22}$ Palm OS	0.7726	0.4764
$C_3$	$A_{31}$ Oracle 10g	1.0112	0.7707
	$A_{32}$ MS SQL 2000	0.3008	0.2293
$C_4$	$A_{41}$ Web-based UI	0.8873	0.6353
	$A_{42}$ GUI	0.5094	0.3647
$C_5$	$A_{51}$ Web-based UI	0.3543	0.2486
	$A_{52}$ GUI	1.0709	0.7514
$C_6$	$A_{61}$ MS MapPoint	0.7935	0.5179
	$A_{62}$ ARC GIS	0.7387	0.4821

Therefore, ranking of the relative importance of the potential solution can be obtained by finding their priority weight ( $w_k$ ). The priority weight is simply the sum of the priority weights multiplies with the respective weight vector of the containing alternatives. It can be expressed with forumula below.

$$w_k = \sum_i (w'_{k,i} * v_i) \tag{K.2}$$

For example, priority weight of  $PS_1$  can be found as below:

$$\begin{aligned} w_1 &= (w'_{11} * v_1) + (w'_{21} * v_2) + (w'_{31} * v_3) + (w'_{41} * v_4) + (w'_{51} * v_5) + (w'_{61} * v_6) \\ &= (0.6533 * 0.2844) + (0.5236 * 0.1763) + (0.7707 * 0.3447) + (0.6353 * 0.2433) \\ &\quad + (0.2486 * 0.2332) + (0.5179 * 0.0185) \\ &= 0.7659 \end{aligned}$$

Table K.5 shows the priority weights of the potential solutions.

Table K.5 Priority weight of potential solutions

Potential solutions ( $PS_k$ )	Priority weight ( $w_k$ )	Potential solutions ( $PS_k$ )	Priority weight ( $w_k$ )
$PS_1$	0.7659	$PS_2$	0.7652
$PS_3$	0.8831	$PS_4$	0.8825



<i>PS</i> <sub>5</sub>	0.7001	<i>PS</i> <sub>6</sub>	0.6994
<i>PS</i> <sub>7</sub>	0.8173	<i>PS</i> <sub>8</sub>	0.8166
<i>PS</i> <sub>9</sub>	0.5793	<i>PS</i> <sub>10</sub>	0.5786
<i>PS</i> <sub>11</sub>	0.6965	<i>PS</i> <sub>12</sub>	0.6959
<i>PS</i> <sub>13</sub>	0.5134	<i>PS</i> <sub>14</sub>	0.5128
<i>PS</i> <sub>15</sub>	0.6307	<i>PS</i> <sub>16</sub>	0.6300
<i>PS</i> <sub>17</sub>	0.7576	<i>PS</i> <sub>18</sub>	0.7569
<i>PS</i> <sub>19</sub>	0.8748	<i>PS</i> <sub>20</sub>	0.8742
<i>PS</i> <sub>21</sub>	0.6917	<i>PS</i> <sub>22</sub>	0.6911
<i>PS</i> <sub>23</sub>	0.8090	<i>PS</i> <sub>24</sub>	0.8083
<i>PS</i> <sub>25</sub>	0.5710	<i>PS</i> <sub>26</sub>	0.5703
<i>PS</i> <sub>27</sub>	0.6882	<i>PS</i> <sub>28</sub>	0.6875
<i>PS</i> <sub>29</sub>	0.5051	<i>PS</i> <sub>30</sub>	0.5045
<i>PS</i> <sub>31</sub>	0.6224	<i>PS</i> <sub>32</sub>	0.6217
<i>PS</i> <sub>33</sub>	0.6787	<i>PS</i> <sub>34</sub>	0.6780
<i>PS</i> <sub>35</sub>	0.7959	<i>PS</i> <sub>36</sub>	0.7953
<i>PS</i> <sub>37</sub>	0.6129	<i>PS</i> <sub>38</sub>	0.6122
<i>PS</i> <sub>39</sub>	0.7301	<i>PS</i> <sub>40</sub>	0.7294
<i>PS</i> <sub>41</sub>	0.4921	<i>PS</i> <sub>42</sub>	0.4914
<i>PS</i> <sub>43</sub>	0.6093	<i>PS</i> <sub>44</sub>	0.6087
<i>PS</i> <sub>45</sub>	0.4262	<i>PS</i> <sub>46</sub>	0.4256
<i>PS</i> <sub>47</sub>	0.5435	<i>PS</i> <sub>48</sub>	0.5428
<i>PS</i> <sub>49</sub>	0.6704	<i>PS</i> <sub>50</sub>	0.6697
<i>PS</i> <sub>51</sub>	0.7876	<i>PS</i> <sub>52</sub>	0.7870
<i>PS</i> <sub>53</sub>	0.6045	<i>PS</i> <sub>54</sub>	0.6039
<i>PS</i> <sub>55</sub>	0.7218	<i>PS</i> <sub>56</sub>	0.7211
<i>PS</i> <sub>57</sub>	0.4838	<i>PS</i> <sub>58</sub>	0.4831
<i>PS</i> <sub>59</sub>	0.6010	<i>PS</i> <sub>60</sub>	0.6003
<i>PS</i> <sub>61</sub>	0.4179	<i>PS</i> <sub>62</sub>	0.4173
<i>PS</i> <sub>63</sub>	0.5352	<i>PS</i> <sub>64</sub>	0.5345

Therefore, below are the top ten ranked potential solutions according to table below.

Table K.6 Ranking of potential solutions

Ranking	Potential solutions ( $PS_k$ )	Priority weight ( $w_k$ )	Alternatives ( $A_{ij}$ )
1	$PS_3$	0.8831	$A_{11}$ GPS, $A_{21}$ MS Windows Mobile, $A_{31}$ Oracle 10g, $A_{41}$ Web-based UI, $A_{52}$ GUI, $A_{61}$ MS MapPoint.
2	$PS_4$	0.8825	$A_{11}$ GPS, $A_{21}$ MS Windows Mobile, $A_{31}$ Oracle 10g, $A_{41}$ Web-based UI, $A_{52}$ GUI, $A_{62}$ ARC GIS.
3	$PS_{19}$	0.8748	$A_{11}$ GPS, $A_{22}$ Palm OS, $A_{31}$ Oracle 10g, $A_{41}$ Web-based UI, $A_{52}$ GUI, $A_{61}$ MS MapPoint.
4	$PS_{20}$	0.8742	$A_{11}$ GPS, $A_{22}$ Palm OS, $A_{31}$ Oracle 10g, $A_{41}$ Web-based UI, $A_{52}$ GUI, $A_{62}$ ARC GIS.
5	$PS_7$	0.8173	$A_{11}$ GPS, $A_{21}$ MS Windows Mobile, $A_{31}$ Oracle 10g, $A_{42}$ GUI, $A_{52}$ GUI, $A_{61}$ MS MapPoint.
6	$PS_8$	0.8166	$A_{11}$ GPS, $A_{21}$ MS Windows Mobile, $A_{31}$ Oracle 10g, $A_{42}$ GUI, $A_{52}$ GUI,



			<i>A</i> <sub>62</sub> ARC GIS.
7	<i>PS</i> <sub>23</sub>	0.8090	<i>A</i> <sub>11</sub> GPS, <i>A</i> <sub>22</sub> Palm OS, <i>A</i> <sub>31</sub> Oracle 10g, <i>A</i> <sub>42</sub> GUI, <i>A</i> <sub>52</sub> GUI, <i>A</i> <sub>61</sub> MS MapPoint.
8	<i>PS</i> <sub>24</sub>	0.8083	<i>A</i> <sub>11</sub> GPS, <i>A</i> <sub>22</sub> Palm OS, <i>A</i> <sub>31</sub> Oracle 10g, <i>A</i> <sub>42</sub> GUI, <i>A</i> <sub>52</sub> GUI, <i>A</i> <sub>62</sub> ARC GIS.
9	<i>PS</i> <sub>35</sub>	0.7959	<i>A</i> <sub>12</sub> RFID, <i>A</i> <sub>21</sub> MS Windows Mobile, <i>A</i> <sub>31</sub> Oracle 10g, <i>A</i> <sub>41</sub> Web-based UI, <i>A</i> <sub>52</sub> GUI, <i>A</i> <sub>61</sub> MS MapPoint.
10	<i>PS</i> <sub>36</sub>	0.7953	<i>A</i> <sub>12</sub> RFID, <i>A</i> <sub>21</sub> MS Windows Mobile, <i>A</i> <sub>31</sub> Oracle 10g, <i>A</i> <sub>41</sub> Web-based UI, <i>A</i> <sub>52</sub> GUI, <i>A</i> <sub>62</sub> ARC GIS.

## **APPENDIX L – PUBLISHED PAPER: A FAHP-BASED TECHNOLOGY SELECTION AND SPECIFICATION METHODOLOGY**

This appendix archives the paper entitled “A FAHP-based Technology selection and Specification Methodology” that was published by Proceedings of the 10th International Conference on Enterprise Information Systems (ICEIS). The paper was the early version of the proposed TSS methodology.



# A FAHP-BASED TECHNOLOGY SELECTION AND SPECIFICATION METHODOLOGY

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**Keywords:** fuzzy analytic hierarchy process (FAHP), system design, technology selection, system specification

**Abstract:** Selection of technology in IT projects is recognized as a multi-criteria decision-making (MDCM) problem because it is important to incorporate multiple opinions from people and consider the interdependence among criteria (Lee and Kim, 2000). Various techniques were proposed to address the technology selection problems and some of them, such as analytic hierarchy process (AHP) (e.g. Bard, 1986), were proved effective in literatures. However, technology selection problem in a system development project can be viewed as a system design activity and there is lack of literatures view technology selection from system design perspective and integrate it with other system design activity. The research argues that AHP can be applied to generate technology specification and other useful information for system design purpose, in additions of technology selection. A high-level system design framework and the FAHP-based technology specification methodology are presented in this paper.

## 1 INTRODUCTION

Assessment and selection of technology in IT projects are required when more than one alternative are available and commit to a right technology can lead to optimal benefits to the business. Literatures (e.g. Chou et al., 2004) suggested that the technology selection can be viewed as a MDCM problem. It is because it involves activities that intakes multiple opinions from different parties and considers the interdependence among criteria (Lee and Kim, 2000). Analytic hierarchy process (AHP) has been studied extensively and been used in almost all the applications related with MCDM in the last 20 years (Ho, 2007). Literatures (e.g. Bard, 1986; Nelson and Kastenber, 1986) indicate that AHP is an effective technique in the field of technology selection.

Technology assessment and selection happens in two stages of an IT project: project justification (Gunasekaran et al., 2006) and system design. The former activity may influence the later process by providing partial technology selection decisions to system designer in order to bind the developing system to certain technology strategically.

From a system development perspective, technologies that compose the developing system

must be well-defined in the system design process. However, there is lack of literature associates technology selection with system design activity. Also, the research proposes that the characteristics of AHP provide opportunities for system designer to collect useful information from people for purposes not limited to technology assessment.

The research proposes a generic high-level system design framework and an FAHP-based technology specification methodology as a member of the framework.

## 2 A HIGH-LEVEL SYSTEM DESIGN (HLS) FRAMEWORK

According to Sommerville (2002), system design generally encompasses six activities include architecture design, abstract specification, interface design, component design, data structure design and algorithm design. Each of the activity takes design product input from previous activity and generate design product for the next activity (see figure 1).



In particular, the architecture design activity aims to identify sub-systems and relationships of the system while the abstract specification aims to specify the sub-system. These two activities aim to describe a complete picture of system with system architecture and specification of the architectural components. On the other hand, the other four activities specify the details of the architectural components. Therefore, these six activities can be separated into two groups according to the level of detail they concern, namely *high-level design* activities and *detailed design* activities.

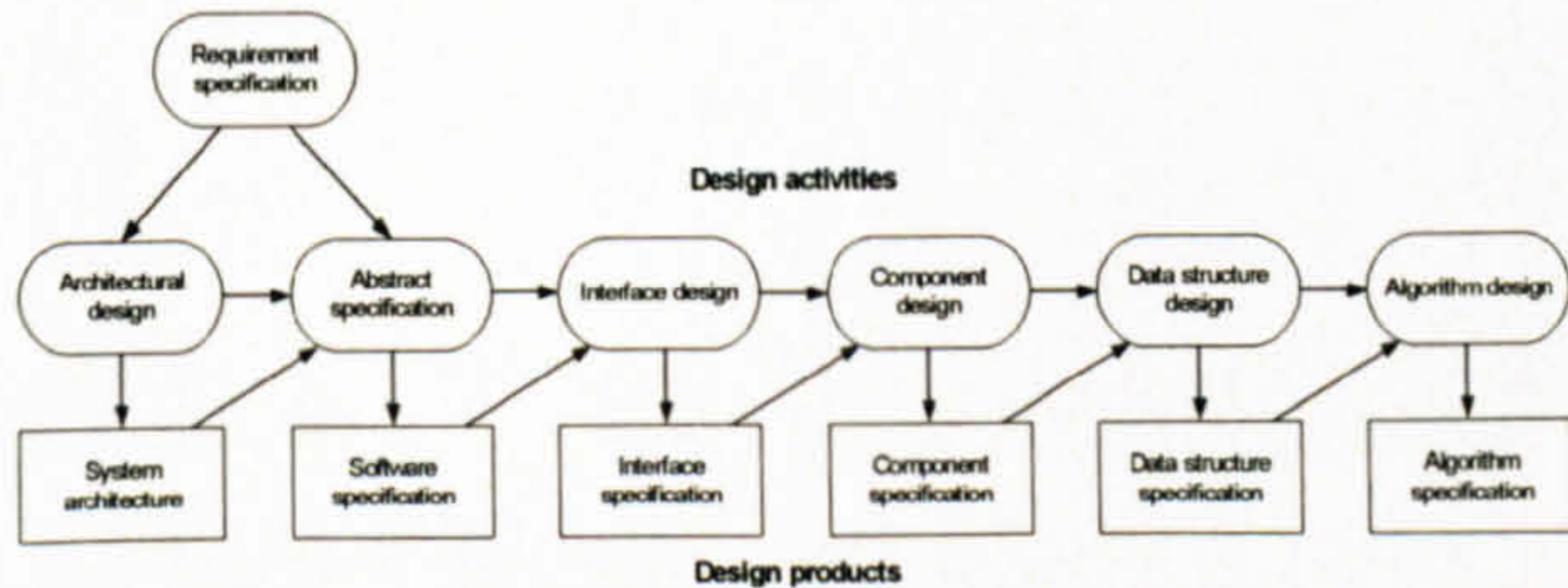


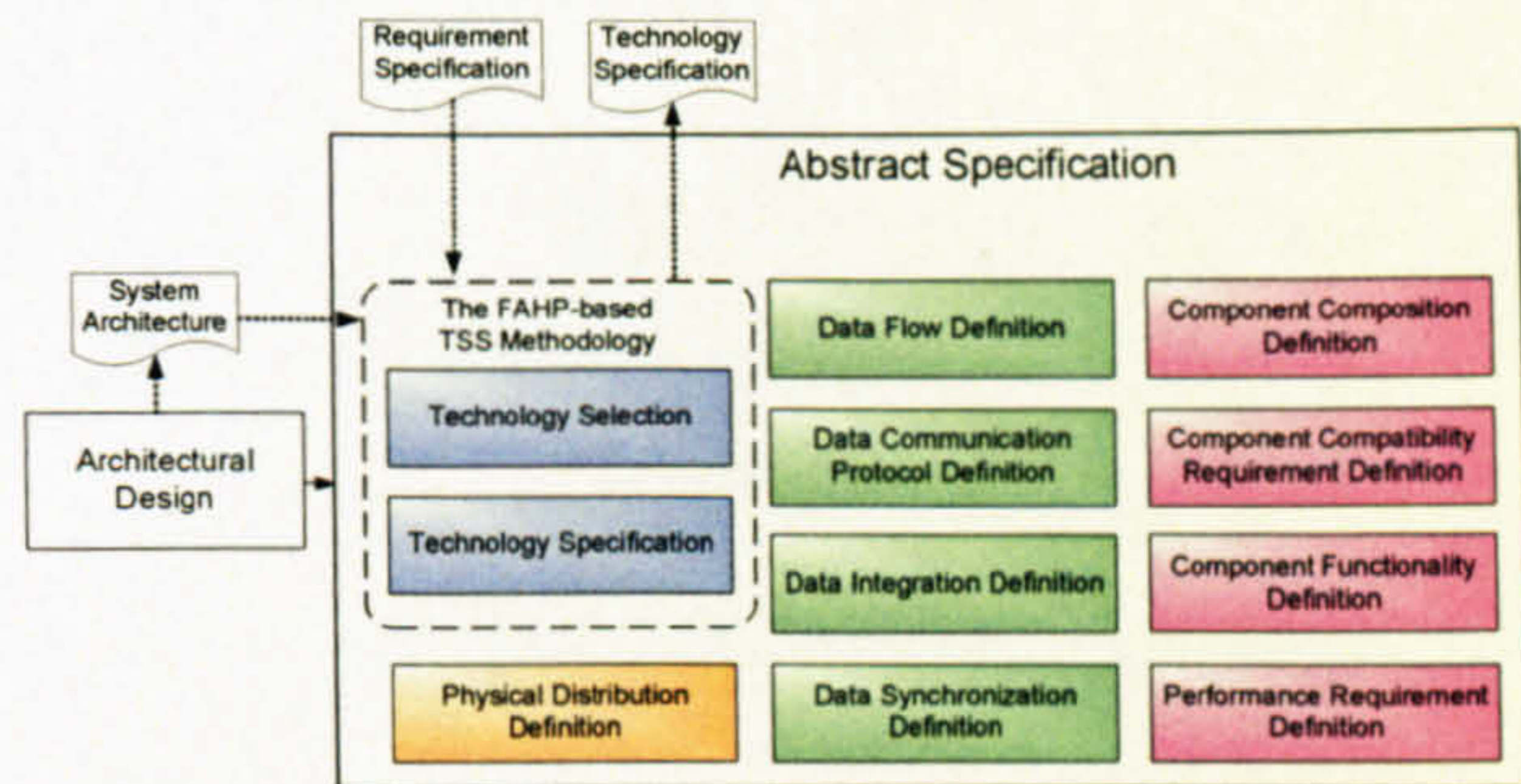
Figure 1: A general model of the system design process (source: Sommerville, 2002)

According to above, there are two general high-level design activities and they aim to produce the system architecture and system specification for the use of detailed design. Technology may be decided strategically before the high-level design. Despite the technology decisions made in project justification before system design, the need for technologies must be identified after the relevant details of the related architectural components are defined. This indicates that the technology selection is a part of the abstract specification activity. In fact, the activity aims to generate a system specification which includes the technology definitions.

The research proposes a high-level system design (HLSD) framework based on Sommerville's generic model and results from case studies. Based on case studies, eleven functional areas of abstract specification including technology selection and specification are identified. The framework covers the scope of the two activities mentioned above and proposes that the second activity is composed by the eleven identified functional areas. The eleven functional areas are divided into four groups, indicated by four different colours, according to the subject they concern. The framework aims to identify the role of technology selection within a general system design process. Figure 2 illustrates the proposed high-level system design (HLSD) framework.

A FAHP-based technology selection and specification (TSS) methodology is proposed in section 4 that supports technology selection and technology specification indicated by figure 2. The function of the methodology is to provide a mean for

decision-makers to assess technologies and then select technologies among alternatives. Furthermore, it utilizes the AHP process to collect useful information from people and thereby generate technology specification of the developing system



which serves as the part of the content of system specification.

### 3 FUZZY-AHP (FAHP)

#### 3.1 Introduction to FAHP

AHP was developed by Saaty in 1971 (Saaty, 1980) and is recognized as an effective technique for handling unstructured or semi-structured decision-making problem with involvements of multiple persons and multiple criteria inputs simultaneously (Durán and Aguilo, 2007; Saaty and Kearns, 1985). It has been proved to be effective tool for decision supporting in MCDM problems such as ranking, selection, evaluation, optimization, and prediction (Lee et al., 2001; Ho, 2007). In particular, AHP has been extensively applied to various technology selection problems and is proved to be an effective approach (e.g. Bard, 1986; Lai et al., 1999).

According to Saaty (1980) and other literatures (e.g. Liu et al., 2007; Lee et al., 2006; Chang, 1996), the conventional AHP encompasses two phases: decomposition and synthesis. The first phase is to decompose the complexity of problem by building a hierarchy model in order to discover and structure the relations. The second phase is to obtain useful results with the hierarchy model through pairwise comparisons and other techniques.

However, AHP has weakness in treating fuzziness and vagueness data which commonly exist in many decision-making problems (Levary and Wan, 1998; Ribeiro, 1996). Integrate the fuzzy set theory to the pairwise comparison of the AHP is believed an effective solution (Karsak and



Kuzgunkaya, 2002; Mon et al., 1994). The integration of the fuzzy set theory and the conventional AHP is named fuzzy-AHP (FAHP) which was first introduced by Van Laarhoven and Pedrycz (1983).

The FAHP approaches presented by literatures (e.g. Lee et al., 2006; Liu et al., 2007; Chang, 1996) are variable in steps and use of techniques. According to literatures (Lee et al., 2006; Liu et al., 2007; Sadiqa and Husain, 2005; Zeng et al., 2007; Durán and Aguilo, 2007), FAHP has modified the conventional AHP with the following steps generally:

- Fuzzification: judgments are transformed into fuzzy values and pairwise comparisons are based on fuzzy judgment matrices.
- Synthesis: instead of dealing with crisp judgment values conventionally using techniques such as eigenvalue and eigenvector, FAHP approach handles synthesis in a fuzzy environment. Methods such as fuzzy extent analysis (Chang, 1992, 1996) were proposed by literatures.
- Defuzzification: in order to obtain an overall ranking of alternatives, the score of alternatives in fuzzy number must either be transformed into crisp number or be compared.

### 3.2 FAHP as a Technology Selection and Specification Approach

FAHP is adopted in the proposed TSS methodology not only for technology selection purpose but also for generation of information. FAHP is adopted for the reason of its characteristics and the advantages it brings:

- AHP is "excellent for clarifying a problem and displaying the decision process" (Nelson and Kastenber, 1986). Useful information such as end users' and decision makers' concerns and preferences, performance measurement of alternatives, and reasons of selection result can be identified through the AHP process. In the proposed methodology, AHP process contributes in the production of technologies specification.
- AHP is a powerful tool for communication (Roper-Lowe and Sharp, 1990). Outcome from AHP is a conclusion of selected participants' judgments. This meets the need in an IT project that people from different parties can be involved in selection of technology. This also shares the responsibility

among different people as well as have useful data input from appropriate people.

- Use of FAHP instead of conventional AHP means a significant benefit in a technology selection problem since failed to deal with the data fuzziness can lead to inaccurate performance measurement of alternatives.

## 4 THE FAHP-BASED TECHNOLOGY SELECTION AND SPECIFICATION (TSS) METHODOLOGY

### 4.1 Objectives

The proposed FAHP-based TSS methodology aims to facilitate the high-level design process mainly by 1) provides a mean for decision makers to assess alternatives and make decision on selection of technologies; 2) specify technologies and generate respective technology specifications.

### 4.2 Multi-level Solution Structuring

As a matter of previous literatures, technology is to be evaluated and decided separately from other parts of the system. The proposed methodology considers technology selection as a part of system design activity which aims to achieve a technology solution instead of only part of it.

To do that, the selection and specification needs of the developing system must be identified and structured into multiple hierarchical levels. Terminologically, the top level is the technology *solution* that includes *solution components* at lower levels. A solution component means a particular architectural component which requires the technology selection and specification process. For instance, design of an enterprise system requires selection and specification of a database management system which can be viewed as a solution component. A solution means a set of solution components indicated by system architecture.

The proposed methodology aims to evaluate alternatives of different solution components efficiently and thereby propose the best-performed solution considering compatibility issues.

### 4.3 The Six Phases

The TSS methodology is illustrated by figure 5. It includes six phases: Preparation, Decomposition,



Solution Component Decomposition, Solution Component Assessment, Solution Assessment, and Conclusions. Each phase contains one or more steps and each step is composed by one or more process. Process may require external data input such as the requirement specification document and survey results.

The methodology begins with the **Preparation** phase in which a project team must be constituted (*process 1.1.1*) and the team will act as an important source of data in the later stages.

The second and the third phases are **Solution Decomposition** and **Solution Component Decomposition** respectively. The term "decomposition" was adapted from the first of the two basic phases of conventional AHP according to Saaty (1980). Decomposition is a process that decomposes the complexity of problem by building a hierarchy model in order to discover and structure the relations (Saaty, 1980).

In the second phase, the goal (*process 2.1.1*) and objectives (*process 2.1.2*), solution components (*process 2.2.1*) and the alternatives (*process 2.2.2*) of them are identified and arranged into a solution-level hierarchical model. Example of the goal can be "Evaluate and specify the most suitable technology solution". *Process 2.1.2* is a generalization process that translates the requirements into objectives for technology. The objectives must be created based on requirement specification in order to ensure the selection and specification results are responsible to it. The solution components can be defined with system architecture created previously in system design process.

As the outcome of the phase, the hierarchical model is based on a well-defined fundamental-objective hierarchy (*process 2.1.3*) that graphically illustrates the relations between the hierarchy elements (see figure 3 for example). In particular, compatibilities of alternatives of each solution component to alternatives of each other solution component are considered. The alternatives that are considered completely incompatible or poorly compatible to alternatives of other solution component should be eliminated (*process 2.2.3*).

In the third phase, solution-component-level hierarchy models are created. While the solution-level hierarchy model reflects the solution-level elements, a solution-component-level hierarchy model is defined with a solution components perspective in regard to the solution-level goal and objectives.

Each solution component will have a hierarchy model created as the output of the third phase. The third phase is composed by two steps (*step 3.1 and 3.2*) and they are in iteration where each round will create a solution-component-level hierarchy model

for one solution component. A solution-component-level hierarchy model is created by define the means to the solution-level objectives by a particular solution component (*process 3.1.1*) and thereby to build the respective means-objective network for the solution component (*process 3.1.3*). As the means-to-objectives of different solution component can be different, some solution-level objectives may be found irrelevant to certain solution component and they must be eliminated from the solution-component-level hierarchy (*process 3.1.2*). On the other side, goal for the hierarchy must be defined according to the solution-level goal (*process 3.2.1*). With the goal and objective structured, the fundamental-objective hierarchy can be defined (*process 3.2.2*). A means-objective network and a fundamental-objective hierarchy together form a solution-component-level hierarchy model (see figure 4 for example).

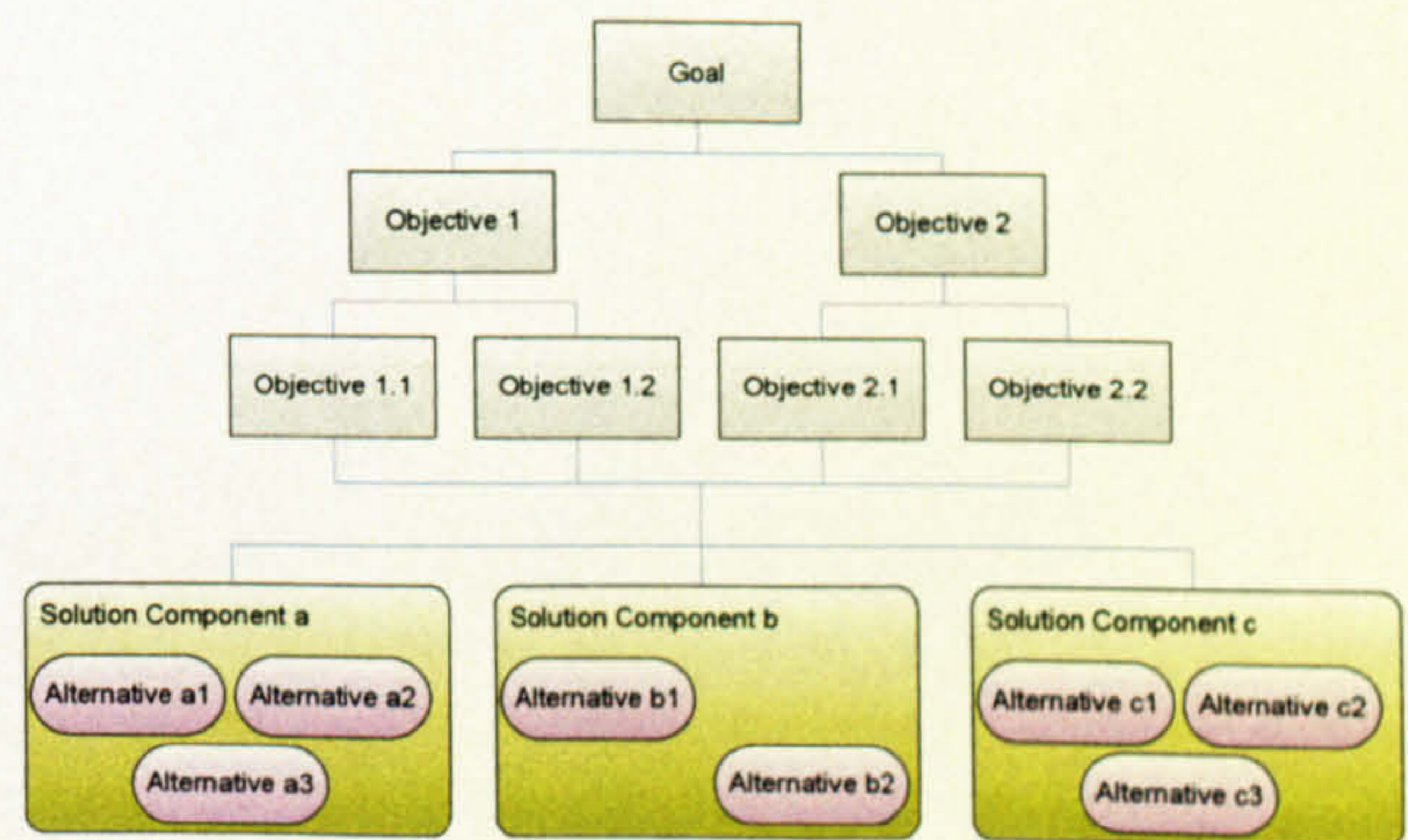


Figure 3: An illustrative example of a solution-level hierarchy model

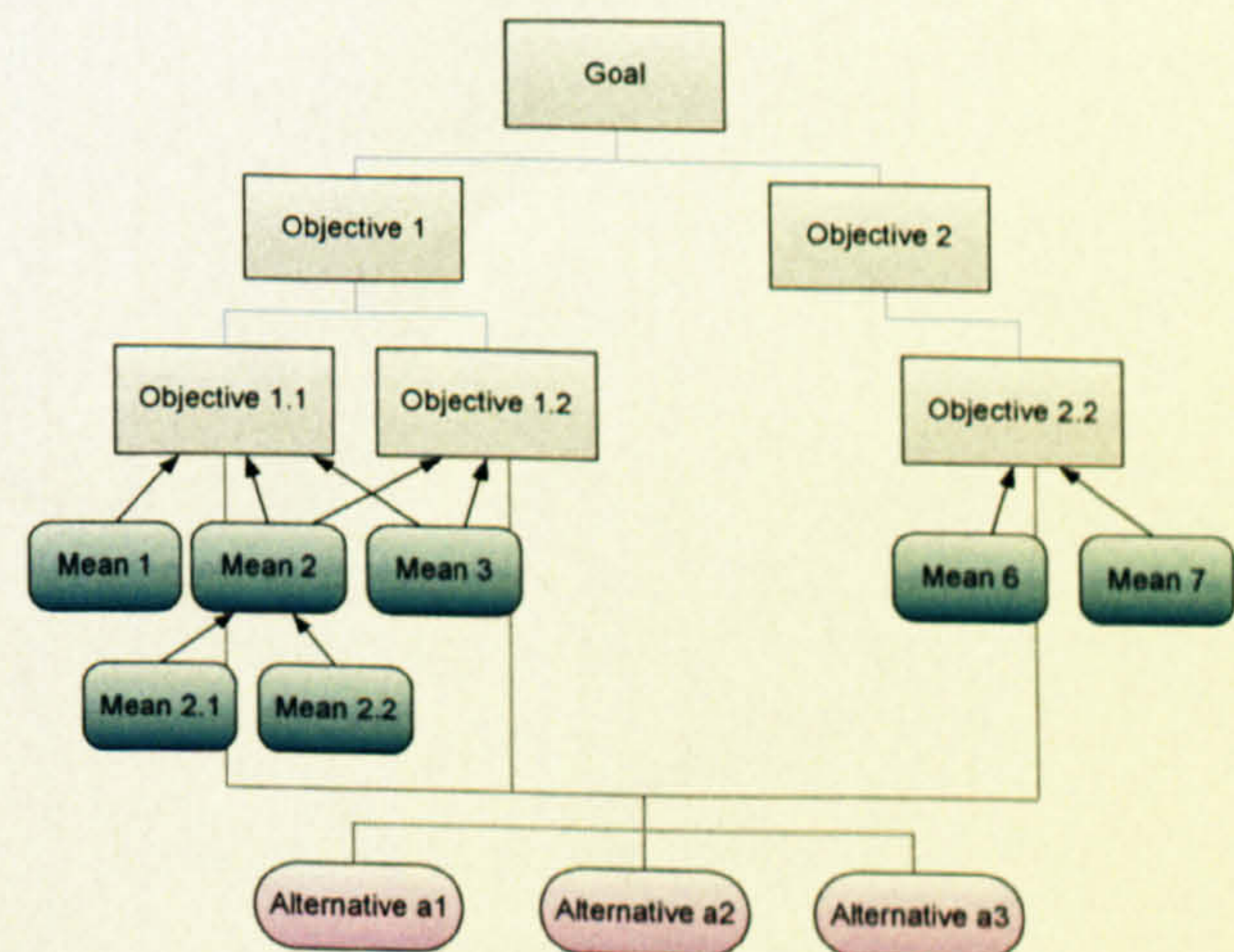


Figure 4: An illustrative example of a solution-component-level AHP hierarchy model



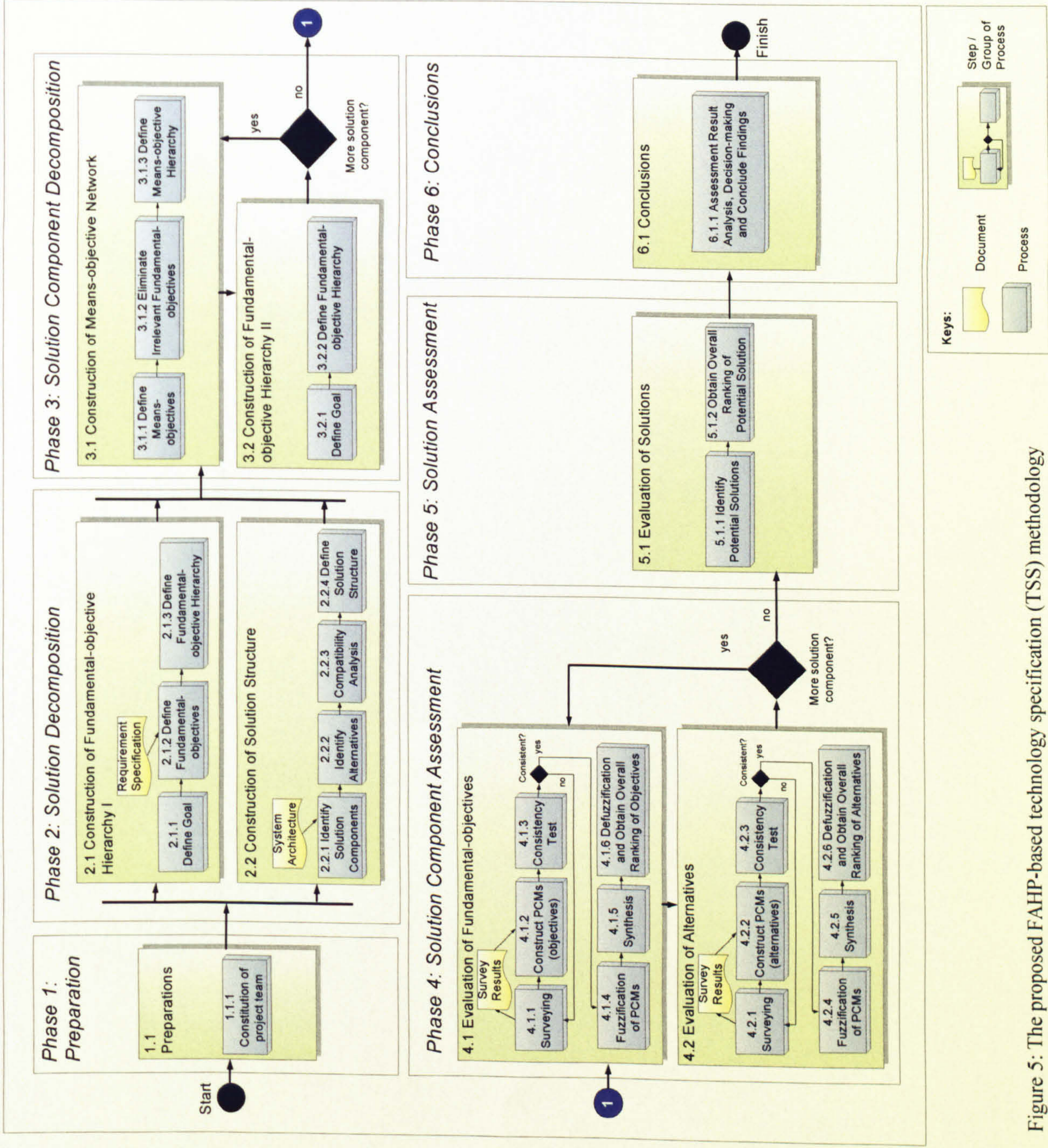


Figure 5: The proposed FAHP-based technology specification (TSS) methodology



Technology selection and specification were important in the system design stage of the system development process. The proposed TSS methodology can be applied in order to demonstrate the use of the proposed methodology.

## 5.2 Demonstration of the TSS Methodology

This section briefly outlines the key activities of the six phases of the TSS methodology with the case study.

In the first phase, a project team is formed with project manager and technology experts from the IT consultant (the Aimes Centre), personnel from management level of clients and end user.

In the second phase, solution components, alternatives of them, and solution-level fundamental-objective hierarchy are defined with goal "*select and specify the best technology solution*". Table 1 shows the 4 identified solution components and their alternatives.

Table 1: Solution component and alternatives

Solution Component	Alternatives
Database management system	Oracle database, SQL database
Vehicle tracking technology	Long-range RFID (Radio Frequency Identification), short-range RFID, GPS system
Software platform	Microsoft .Net Platform, Java-based platform
Presentation	GUI, Web page
Network Connection	Web standards, private network standards

Therefore, the third phase had the four AHP hierarchy models created with means-objective network and the fundamental-objective hierarchy included. Each of the models was created for assessment of one of the solution components in the next phase.

The FAHP processing in the fourth phase has suggested the best alternatives of the solution component as shown in table 2.

Table 2: Solution component assessment results

Solution Component	Best Performed Alternative
Database management system	Oracle database
Vehicle tracking technology	GPS system
Software platform	Microsoft .Net Platform
Presentation	GUI
Network Connection	Web standards

Through the assessment process, information about judgment reason was collected from experts and they explain the reason for assessment result as well as providing specification data of the technologies. For instance, GPS was believed more preferable for the lower implementation cost as well as its satisfying capabilities. Before researched above opinion, capability and implementation cost of GPS and other alternatives were given, evaluated and compared. The information was documented for technology specification purpose.

Although GUI (Graphical User Interface) was recognized as the best-performed presentation technology for its capable of provide more powerful functionalities than Web portal, the fifth phase had proposed the best-performed solution without it. The main reason was that GUI was recognized relatively less compatible than that of web portal in the fifth phase: it requires installation of extra application on user's computer, local security settings may disallow database connection, and GUI-based application is usually software platform dependent. Accessing Web portal through Web browser will not meet above problems and thereby work better with other technologies shown in table 2. The proposed solution includes Oracle database, GPS system, .Net Platform, Web portal and web standard network.



The best-performed solution above is currently applied by the live system. As there has no issue indicates any need in change of technology after the system has gone live for approximately a year, I can conclude that the methodology provides satisfying selection result to the goal.

## 6 CONCLUSIONS

A HLSD framework was proposed to indicate the role of technology selection process within a generic system design process. It suggests that the technology specification and specification can be a separate activity apart from other functional areas of abstract specification.

A FAHP-based TSS approach was proposed to support technology selection and specification activities of the HLSD framework. As a part of the framework, it takes input from the previous system design step and aims to generate specification information for later system design activities. By taking the advantages of AHP (see section 3.2), the proposed methodology attempts to generate useful information such as technology specifications for system design and project management purposes. The proposed methodology applies the means-objective network technique for strengthen the linkages between requirement specification and decision-makers' judgments. It ensures that both technology selection and specification results are responsible to the requirement definitions. The proposed methodology also introduced the multiple-hierarchical-level solution structure technique in order to address the system design needs.

Beside the general advantages of FAHP that was mentioned in section 3.2, some advantages of the proposed FAHP-based TSS methodology are outlined below.

- Complete picture of technology solution is considered by the proposed methodology with compatibility issues between solution components.
- Instead of assess all of the potential solution using pairwise comparison according to conventional AHP approach, the proposed methodology divides the assessment of solution into two parts – *phase 4* and *phase 5*. This greatly reduces the number of comparison judgment necessarily to be made and thereby has improved the efficiency. It implies reduction in risk of creating inconsistent datasets.
- As the proposed HLSD framework is developed based on a general design process model (see section 2), it's highly adaptable by various software process model such as waterfall model.

Nevertheless, there are limitations of the proposed methodology that indicates space of improvement in the future. For example, although the TSS methodology considers the compatibility of solution component alternatives in assessment of potential solutions, it can be more specific in handling different levels of compatibility since it may influence the ranking of potential solutions effectively.

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## APPENDIX M – EXPERIMENT LOG FILES

This appendix archives two log files generated by a software programme.

The first log file (log file 1) archives calculation results based on equation below:

$$K = \{c * [c - 1 + (\prod_i b_i)^2 - \prod_i b_i] - \sum_i [c_i * (c_i - 1 - b_i^2 + b_i)] - a(a - 1)\}$$

for  $2 \leq a \leq a_{max}$ ,  $2 \leq b_i \leq b_{max}$ ,  $1 \leq c \leq c_{max}$ ,  $1 \leq c_i \leq c$ .

Under above given range of variables, there is huge number of calculation results (i.e. total number of calculated  $K$  is  $2.38E+88$ ). In order to avoid unnecessarily huge log file, the log file in this appendix only shows a subset of the results using condition:  $2 \leq a \leq 30$ ,  $b_i = 2$ ,  $1 \leq c \leq 30$ ,  $c_i = c$ ,  $i = 1$  to  $a$ . However, the final conclusion at the end of the first log file taken all calculations into account.

It is noted that base on equations suggested in *chapter 5*,

$$(t_1 - t_2) = K * (d / 2)$$

with  $d/2$  as positive number,  $K$  is useful to indicate  $(t_1 - t_2)$  proportionally.

Furthermore, the second log file (log file 2) stores value of variables for all the results with negative  $K$ .

Following the decomposition phases, the created hierarchy models will be used in the fourth phase *Solution Component Assessment*: It is a FAHP-based process for assessment of each solution component. It consists of two steps (*step 4.1 and 4.2*) and they are in iteration where each round will have created assessment result for one solution component. General FAHP steps are proposed in this phase: surveying (*process 4.1.1 and 4.2.1*), building of pairwise matrices (*process 4.1.2 and 4.2.2*), consistency test (*process 4.1.3 and 4.2.3*), fuzzification (*process 4.1.4 and 4.2.4*), defuzzification and obtain overall ranking as the assessment result (*process 4.1.6 and 4.2.6*).

The key differences of the use of FAHP in the proposed methodology from other FAHP/AHP-based approaches in literatures can be summarized as below:

- The proposed methodology is not for project justification purpose but for the system design benefit. Instead of involving people from different background, *Step 4.1* of the proposed methodology requires the involvement of experts to the fields of relevant technology. It helps to improve the data quality and the accuracy of assessment results.
- Assessment of alternatives in *step 4.2* requires judges to make judgment based on the means-to-objectives and the objectives are the generalization results of requirement specification. Therefore, the means-objective network acts as a linkage between the requirement specification and participants' judgments. This ensures the assessment results be responsible to requirement definitions.
- Judges must provide evidence for the judgment based on the means-to-objectives. The evidence can be qualitative knowledge relate to the alternatives or quantitative measurement of their capabilities. These information explain how and how well a technology alternative satisfies the objectives. In additions, the information can be used for generate specification information about the assessed alternatives (*process 6.1.1*).

Alternatives of each solution component are ranked at the end of assessment (*process 4.2.6*). The rankings of solution component alternatives can be used to derive a score with crisp value through defuzzification methods, for example. The scores are useful for the assessment of the potential solutions in the fifth phase *Solution Assessment*. With the result from the compatibility analysis (*process 2.2.3*), the potential solutions to be assessed must first be defined (*process 5.1.1*) and thereby to be assessed (*process 5.1.2*). The assessment aims to rank the potential solutions by assign an overall score to each of them. An overall score is obtained through calculation with the scores of included solution component alternatives. The calculation should consider the relative importance of solution component and other necessary criteria. The final scores reflect how relatively well the solutions satisfy the solution-level objectives for the solution-level goal in regard to the requirement specification.

Finally, the sixth phase *Conclusions* provides a space for decision makers to make use of the information generated through the previous phases. The best performed solution(s) suggested by *phase 5* will be proposed to decision makers and thereby decision makers may make decision on technology selection. On the other hand, the specification information of technologies can be identified qualitatively and/or quantitatively in *phase 4*. The *process 6.1.1* concludes these findings and documents relevant information to form the technology specification for the detail design and for other project management purpose. Furthermore, other useful information such as relative importance weight of objectives obtained in *step 4.1*, ranking of alternatives obtained in *step 4.2*, and score of potential solutions in *step 5.1* can be documented for various project management purposes as well.

## 5 CASE STUDY

### 5.1 Background

This section outlines the use of the key steps of the application of the TSS methodology to a transportation management system development project.

ContainerPort ([www.containerport.co.uk](http://www.containerport.co.uk)) is a commercial project conducted by the Aimes Centre ([www.aim.es.net](http://www.aim.es.net)), the University of Liverpool. The project has developed an UK-based transportation management system with GPS (Global Positioning System), Oracle database, Microsoft .net Platform, and Web portal technologies.



# Log file 1

Conditions:  $a_{max} = 30$ ,  $b_{max} = 30$ ,  $c_{max} = 30$ ,  $i_{max} = 30$

Log:

K	a	b1	c	c1					
					474	3	2	20	20
					456	3	2	21	21
					434	3	2	22	22
					408	3	2	23	23
					378	3	2	24	24
					344	3	2	25	25
					306	3	2	26	26
					264	3	2	27	27
					218	3	2	28	28
					168	3	2	29	29
					114	3	2	30	30
					236	4	2	1	1
					478	4	2	2	2
					714	4	2	3	3
					944	4	2	4	4
					1168	4	2	5	5
					1386	4	2	6	6
					1598	4	2	7	7
					1804	4	2	8	8
					2004	4	2	9	9
					2198	4	2	10	10
					2386	4	2	11	11
					2568	4	2	12	12
					2744	4	2	13	13
					2914	4	2	14	14
					3078	4	2	15	15
					3236	4	2	16	16
					3388	4	2	17	17
					3534	4	2	18	18
					3674	4	2	19	19
					3808	4	2	20	20
					3936	4	2	21	21
					4058	4	2	22	22
					4174	4	2	23	23
					4284	4	2	24	24
					4388	4	2	25	25
					4486	4	2	26	26
					4578	4	2	27	27
					4664	4	2	28	28
					4744	4	2	29	29
					4818	4	2	30	30
					982	5	2	1	1
					1976	5	2	2	2
					2962	5	2	3	3
					3940	5	2	4	4
					4910	5	2	5	5
					5872	5	2	6	6
					6826	5	2	7	7
					7772	5	2	8	8
					8710	5	2	9	9
					9640	5	2	10	10

10562	5	2	11	11	162118	7	2	10	10
11476	5	2	12	12	178268	7	2	11	11
12382	5	2	13	13	194406	7	2	12	12
13280	5	2	14	14	210532	7	2	13	13
14170	5	2	15	15	226646	7	2	14	14
15052	5	2	16	16	242748	7	2	15	15
15926	5	2	17	17	258838	7	2	16	16
16792	5	2	18	18	274916	7	2	17	17
17650	5	2	19	19	290982	7	2	18	18
18500	5	2	20	20	307036	7	2	19	19
19342	5	2	21	21	323078	7	2	20	20
20176	5	2	22	22	339108	7	2	21	21
21002	5	2	23	23	355126	7	2	22	22
21820	5	2	24	24	371132	7	2	23	23
22630	5	2	25	25	387126	7	2	24	24
23432	5	2	26	26	403108	7	2	25	25
24226	5	2	27	27	419078	7	2	26	26
25012	5	2	28	28	435036	7	2	27	27
25790	5	2	29	29	450982	7	2	28	28
26560	5	2	30	30	466916	7	2	29	29
4014	6	2	1	1	482838	7	2	30	30
8048	6	2	2	2	65240	8	2	1	1
12072	6	2	3	3	130522	8	2	2	2
16086	6	2	4	4	195790	8	2	3	3
20090	6	2	5	5	261044	8	2	4	4
24084	6	2	6	6	326284	8	2	5	5
28068	6	2	7	7	391510	8	2	6	6
32042	6	2	8	8	456722	8	2	7	7
36006	6	2	9	9	521920	8	2	8	8
39960	6	2	10	10	587104	8	2	9	9
43904	6	2	11	11	652274	8	2	10	10
47838	6	2	12	12	717430	8	2	11	11
51762	6	2	13	13	782572	8	2	12	12
55676	6	2	14	14	847700	8	2	13	13
59580	6	2	15	15	912814	8	2	14	14
63474	6	2	16	16	977914	8	2	15	15
67358	6	2	17	17	1043000	8	2	16	16
71232	6	2	18	18	1108072	8	2	17	17
75096	6	2	19	19	1173130	8	2	18	18
78950	6	2	20	20	1238174	8	2	19	19
82794	6	2	21	21	1303204	8	2	20	20
86628	6	2	22	22	1368220	8	2	21	21
90452	6	2	23	23	1433222	8	2	22	22
94266	6	2	24	24	1498210	8	2	23	23
98070	6	2	25	25	1563184	8	2	24	24
101864	6	2	26	26	1628144	8	2	25	25
105648	6	2	27	27	1693090	8	2	26	26
109422	6	2	28	28	1758022	8	2	27	27
113186	6	2	29	29	1822940	8	2	28	28
116940	6	2	30	30	1887844	8	2	29	29
16228	7	2	1	1	1952734	8	2	30	30
32486	7	2	2	2	261578	9	2	1	1
48732	7	2	3	3	523212	9	2	2	2
64966	7	2	4	4	784830	9	2	3	3
81188	7	2	5	5	1046432	9	2	4	4
97398	7	2	6	6	1308018	9	2	5	5
113596	7	2	7	7	1569588	9	2	6	6
129782	7	2	8	8	1831142	9	2	7	7
145956	7	2	9	9	2092680	9	2	8	8



2354202	9	2	9	9	33537554	11	2	8	8
2615708	9	2	10	10	37729672	11	2	9	9
2877198	9	2	11	11	41921770	11	2	10	10
3138672	9	2	12	12	46113848	11	2	11	11
3400130	9	2	13	13	50305906	11	2	12	12
3661572	9	2	14	14	54497944	11	2	13	13
3922998	9	2	15	15	58689962	11	2	14	14
4184408	9	2	16	16	62881960	11	2	15	15
4445802	9	2	17	17	67073938	11	2	16	16
4707180	9	2	18	18	71265896	11	2	17	17
4968542	9	2	19	19	75457834	11	2	18	18
5229888	9	2	20	20	79649752	11	2	19	19
5491218	9	2	21	21	83841650	11	2	20	20
5752532	9	2	22	22	88033528	11	2	21	21
6013830	9	2	23	23	92225386	11	2	22	22
6275112	9	2	24	24	96417224	11	2	23	23
6536378	9	2	25	25	100609042	11	2	24	24
6797628	9	2	26	26	104800840	11	2	25	25
7058862	9	2	27	27	108992618	11	2	26	26
7320080	9	2	28	28	113184376	11	2	27	27
7581282	9	2	29	29	117376114	11	2	28	28
7842468	9	2	30	30	121567832	11	2	29	29
1047482	10	2	1	1	125759530	11	2	30	30
2095036	10	2	2	2	16773012	12	2	1	1
3142572	10	2	3	3	33546134	12	2	2	2
4190090	10	2	4	4	50319234	12	2	3	3
5237590	10	2	5	5	67092312	12	2	4	4
6285072	10	2	6	6	83865368	12	2	5	5
7332536	10	2	7	7	100638402	12	2	6	6
8379982	10	2	8	8	117411414	12	2	7	7
9427410	10	2	9	9	134184404	12	2	8	8
10474820	10	2	10	10	150957372	12	2	9	9
11522212	10	2	11	11	167730318	12	2	10	10
12569586	10	2	12	12	184503242	12	2	11	11
13616942	10	2	13	13	201276144	12	2	12	12
14664280	10	2	14	14	218049024	12	2	13	13
15711600	10	2	15	15	234821882	12	2	14	14
16758902	10	2	16	16	251594718	12	2	15	15
17806186	10	2	17	17	268367532	12	2	16	16
18853452	10	2	18	18	285140324	12	2	17	17
19900700	10	2	19	19	301913094	12	2	18	18
20947930	10	2	20	20	318685842	12	2	19	19
21995142	10	2	21	21	335458568	12	2	20	20
23042336	10	2	22	22	352231272	12	2	21	21
24089512	10	2	23	23	369003954	12	2	22	22
25136670	10	2	24	24	385776614	12	2	23	23
26183810	10	2	25	25	402549252	12	2	24	24
27230932	10	2	26	26	419321868	12	2	25	25
28278036	10	2	27	27	436094462	12	2	26	26
29325122	10	2	28	28	452867034	12	2	27	27
30372190	10	2	29	29	469639584	12	2	28	28
31419240	10	2	30	30	486412112	12	2	29	29
4192168	11	2	1	1	503184618	12	2	30	30
8384426	11	2	2	2	67100542	13	2	1	1
12576664	11	2	3	3	134201216	13	2	2	2
16768882	11	2	4	4	201301866	13	2	3	3
20961080	11	2	5	5	268402492	13	2	4	4
25153258	11	2	6	6	335503094	13	2	5	5
29345416	11	2	7	7	402603672	13	2	6	6

469704226	13	2	7	7	6442253886	15	2	6	6
536804756	13	2	8	8	7515962804	15	2	7	7
603905262	13	2	9	9	8589671694	15	2	8	8
671005744	13	2	10	10	9663380556	15	2	9	9
738106202	13	2	11	11	10737089390	15	2	10	10
805206636	13	2	12	12	11810798196	15	2	11	11
872307046	13	2	13	13	12884506974	15	2	12	12
939407432	13	2	14	14	13958215724	15	2	13	13
1006507794	13	2	15	15	15031924446	15	2	14	14
1073608132	13	2	16	16	16105633140	15	2	15	15
1140708446	13	2	17	17	17179341806	15	2	16	16
1207808736	13	2	18	18	18253050444	15	2	17	17
1274909002	13	2	19	19	19326759054	15	2	18	18
1342009244	13	2	20	20	20400467636	15	2	19	19
1409109462	13	2	21	21	21474176190	15	2	20	20
1476209656	13	2	22	22	22547884716	15	2	21	21
1543309826	13	2	23	23	23621593214	15	2	22	22
1610409972	13	2	24	24	24695301684	15	2	23	23
1677510094	13	2	25	25	25769010126	15	2	24	24
1744610192	13	2	26	26	26842718540	15	2	25	25
1811710266	13	2	27	27	27916426926	15	2	26	26
1878810316	13	2	28	28	28990135284	15	2	27	27
1945910342	13	2	29	29	30063843614	15	2	28	28
2013010344	13	2	30	30	31137551916	15	2	29	29
268418918	14	2	1	1	32211260190	15	2	30	30
536837992	14	2	2	2	4294901552	16	2	1	1
805257040	14	2	3	3	8589803314	16	2	2	2
1073676062	14	2	4	4	12884705046	16	2	3	3
1342095058	14	2	5	5	17179606748	16	2	4	4
1610514028	14	2	6	6	21474508420	16	2	5	5
1878932972	14	2	7	7	25769410062	16	2	6	6
2147351890	14	2	8	8	30064311674	16	2	7	7
2415770782	14	2	9	9	34359213256	16	2	8	8
2684189648	14	2	10	10	38654114808	16	2	9	9
2952608488	14	2	11	11	42949016330	16	2	10	10
3221027302	14	2	12	12	47243917822	16	2	11	11
3489446090	14	2	13	13	51538819284	16	2	12	12
3757864852	14	2	14	14	55833720716	16	2	13	13
4026283588	14	2	15	15	60128622118	16	2	14	14
4294702298	14	2	16	16	64423523490	16	2	15	15
4563120982	14	2	17	17	68718424832	16	2	16	16
4831539640	14	2	18	18	73013326144	16	2	17	17
5099958272	14	2	19	19	77308227426	16	2	18	18
5368376878	14	2	20	20	81603128678	16	2	19	19
5636795458	14	2	21	21	85898029900	16	2	20	20
5905214012	14	2	22	22	90192931092	16	2	21	21
6173632540	14	2	23	23	94487832254	16	2	22	22
6442051042	14	2	24	24	98782733386	16	2	23	23
6710469518	14	2	25	25	1.03078E+11	16	2	24	24
6978887968	14	2	26	26	1.07373E+11	16	2	25	25
7247306392	14	2	27	27	1.11667E+11	16	2	26	26
7515724790	14	2	28	28	1.15962E+11	16	2	27	27
7784143162	14	2	29	29	1.20257E+11	16	2	28	28
8052561508	14	2	30	30	1.24552E+11	16	2	29	29
1073708876	15	2	1	1	1.28847E+11	16	2	30	30
2147417934	15	2	2	2	17179737874	17	2	1	1
3221126964	15	2	3	3	34359475988	17	2	2	2
4294835966	15	2	4	4	51539214070	17	2	3	3
5368544940	15	2	5	5	68718952120	17	2	4	4



85898690138	17	2	5	5	1.09951E+12	19	2	4	4
1.03078E+11	17	2	6	6	1.37439E+12	19	2	5	5
1.20258E+11	17	2	7	7	1.64926E+12	19	2	6	6
1.37438E+11	17	2	8	8	1.92414E+12	19	2	7	7
1.54618E+11	17	2	9	9	2.19902E+12	19	2	8	8
1.71797E+11	17	2	10	10	2.4739E+12	19	2	9	9
1.88977E+11	17	2	11	11	2.74877E+12	19	2	10	10
2.06157E+11	17	2	12	12	3.02365E+12	19	2	11	11
2.23337E+11	17	2	13	13	3.29853E+12	19	2	12	12
2.40516E+11	17	2	14	14	3.57341E+12	19	2	13	13
2.57696E+11	17	2	15	15	3.84828E+12	19	2	14	14
2.74876E+11	17	2	16	16	4.12316E+12	19	2	15	15
2.92056E+11	17	2	17	17	4.39804E+12	19	2	16	16
3.09235E+11	17	2	18	18	4.67292E+12	19	2	17	17
3.26415E+11	17	2	19	19	4.94779E+12	19	2	18	18
3.43595E+11	17	2	20	20	5.22267E+12	19	2	19	19
3.60774E+11	17	2	21	21	5.49755E+12	19	2	20	20
3.77954E+11	17	2	22	22	5.77243E+12	19	2	21	21
3.95134E+11	17	2	23	23	6.0473E+12	19	2	22	22
4.12314E+11	17	2	24	24	6.32218E+12	19	2	23	23
4.29493E+11	17	2	25	25	6.59706E+12	19	2	24	24
4.46673E+11	17	2	26	26	6.87193E+12	19	2	25	25
4.63853E+11	17	2	27	27	7.14681E+12	19	2	26	26
4.81033E+11	17	2	28	28	7.42169E+12	19	2	27	27
4.98212E+11	17	2	29	29	7.69657E+12	19	2	28	28
5.15392E+11	17	2	30	30	7.97144E+12	19	2	29	29
68719214322	18	2	1	1	8.24632E+12	19	2	30	30
1.37438E+11	18	2	2	2	1.09951E+12	20	2	1	1
2.06158E+11	18	2	3	3	2.19902E+12	20	2	2	2
2.74877E+11	18	2	4	4	3.29853E+12	20	2	3	3
3.43596E+11	18	2	5	5	4.39804E+12	20	2	4	4
4.12315E+11	18	2	6	6	5.49755E+12	20	2	5	5
4.81035E+11	18	2	7	7	6.59706E+12	20	2	6	6
5.49754E+11	18	2	8	8	7.69657E+12	20	2	7	7
6.18473E+11	18	2	9	9	8.79608E+12	20	2	8	8
6.87192E+11	18	2	10	10	9.8956E+12	20	2	9	9
7.55911E+11	18	2	11	11	1.09951E+13	20	2	10	10
8.24631E+11	18	2	12	12	1.20946E+13	20	2	11	11
8.9335E+11	18	2	13	13	1.31941E+13	20	2	12	12
9.62069E+11	18	2	14	14	1.42936E+13	20	2	13	13
1.03079E+12	18	2	15	15	1.53931E+13	20	2	14	14
1.09951E+12	18	2	16	16	1.64927E+13	20	2	15	15
1.16823E+12	18	2	17	17	1.75922E+13	20	2	16	16
1.23695E+12	18	2	18	18	1.86917E+13	20	2	17	17
1.30567E+12	18	2	19	19	1.97912E+13	20	2	18	18
1.37438E+12	18	2	20	20	2.08907E+13	20	2	19	19
1.4431E+12	18	2	21	21	2.19902E+13	20	2	20	20
1.51182E+12	18	2	22	22	2.30897E+13	20	2	21	21
1.58054E+12	18	2	23	23	2.41892E+13	20	2	22	22
1.64926E+12	18	2	24	24	2.52887E+13	20	2	23	23
1.71798E+12	18	2	25	25	2.63883E+13	20	2	24	24
1.7867E+12	18	2	26	26	2.74878E+13	20	2	25	25
1.85542E+12	18	2	27	27	2.85873E+13	20	2	26	26
1.92414E+12	18	2	28	28	2.96868E+13	20	2	27	27
1.99286E+12	18	2	29	29	3.07863E+13	20	2	28	28
2.06158E+12	18	2	30	30	3.18858E+13	20	2	29	29
2.74877E+11	19	2	1	1	3.29853E+13	20	2	30	30
5.49755E+11	19	2	2	2	4.39804E+12	21	2	1	1
8.24632E+11	19	2	3	3	8.79609E+12	21	2	2	2

1.31941E+13	21	2	3	3	1.40737E+14	23	2	2	2
1.75922E+13	21	2	4	4	2.11106E+14	23	2	3	3
2.19902E+13	21	2	5	5	2.81475E+14	23	2	4	4
2.63883E+13	21	2	6	6	3.51844E+14	23	2	5	5
3.07863E+13	21	2	7	7	4.22212E+14	23	2	6	6
3.51844E+13	21	2	8	8	4.92581E+14	23	2	7	7
3.95824E+13	21	2	9	9	5.6295E+14	23	2	8	8
4.39804E+13	21	2	10	10	6.33319E+14	23	2	9	9
4.83785E+13	21	2	11	11	7.03687E+14	23	2	10	10
5.27765E+13	21	2	12	12	7.74056E+14	23	2	11	11
5.71746E+13	21	2	13	13	8.44425E+14	23	2	12	12
6.15726E+13	21	2	14	14	9.14794E+14	23	2	13	13
6.59707E+13	21	2	15	15	9.85162E+14	23	2	14	14
7.03687E+13	21	2	16	16	1.05553E+15	23	2	15	15
7.47668E+13	21	2	17	17	1.1259E+15	23	2	16	16
7.91648E+13	21	2	18	18	1.19627E+15	23	2	17	17
8.35628E+13	21	2	19	19	1.26664E+15	23	2	18	18
8.79609E+13	21	2	20	20	1.33701E+15	23	2	19	19
9.23589E+13	21	2	21	21	1.40737E+15	23	2	20	20
9.6757E+13	21	2	22	22	1.47774E+15	23	2	21	21
1.01155E+14	21	2	23	23	1.54811E+15	23	2	22	22
1.05553E+14	21	2	24	24	1.61848E+15	23	2	23	23
1.09951E+14	21	2	25	25	1.68885E+15	23	2	24	24
1.14349E+14	21	2	26	26	1.75922E+15	23	2	25	25
1.18747E+14	21	2	27	27	1.82959E+15	23	2	26	26
1.23145E+14	21	2	28	28	1.89996E+15	23	2	27	27
1.27543E+14	21	2	29	29	1.97032E+15	23	2	28	28
1.31941E+14	21	2	30	30	2.04069E+15	23	2	29	29
1.75922E+13	22	2	1	1	2.11106E+15	23	2	30	30
3.51844E+13	22	2	2	2	2.81475E+14	24	2	1	1
5.27765E+13	22	2	3	3	5.6295E+14	24	2	2	2
7.03687E+13	22	2	4	4	8.44425E+14	24	2	3	3
8.79609E+13	22	2	5	5	1.1259E+15	24	2	4	4
1.05553E+14	22	2	6	6	1.40737E+15	24	2	5	5
1.23145E+14	22	2	7	7	1.68885E+15	24	2	6	6
1.40737E+14	22	2	8	8	1.97032E+15	24	2	7	7
1.5833E+14	22	2	9	9	2.2518E+15	24	2	8	8
1.75922E+14	22	2	10	10	2.53327E+15	24	2	9	9
1.93514E+14	22	2	11	11	2.81475E+15	24	2	10	10
2.11106E+14	22	2	12	12	3.09622E+15	24	2	11	11
2.28698E+14	22	2	13	13	3.3777E+15	24	2	12	12
2.46291E+14	22	2	14	14	3.65917E+15	24	2	13	13
2.63883E+14	22	2	15	15	3.94065E+15	24	2	14	14
2.81475E+14	22	2	16	16	4.22212E+15	24	2	15	15
2.99067E+14	22	2	17	17	4.5036E+15	24	2	16	16
3.16659E+14	22	2	18	18	4.78507E+15	24	2	17	17
3.34251E+14	22	2	19	19	5.06655E+15	24	2	18	18
3.51844E+14	22	2	20	20	5.34802E+15	24	2	19	19
3.69436E+14	22	2	21	21	5.6295E+15	24	2	20	20
3.87028E+14	22	2	22	22	5.91097E+15	24	2	21	21
4.0462E+14	22	2	23	23	6.19245E+15	24	2	22	22
4.22212E+14	22	2	24	24	6.47392E+15	24	2	23	23
4.39805E+14	22	2	25	25	6.7554E+15	24	2	24	24
4.57397E+14	22	2	26	26	7.03687E+15	24	2	25	25
4.74989E+14	22	2	27	27	7.31835E+15	24	2	26	26
4.92581E+14	22	2	28	28	7.59982E+15	24	2	27	27
5.10173E+14	22	2	29	29	7.8813E+15	24	2	28	28
5.27765E+14	22	2	30	30	8.16277E+15	24	2	29	29
7.03687E+13	23	2	1	1	8.44425E+15	24	2	30	30



1.1259E+15	25	2	1	1	1.35108E+17	26	2	30	30
2.2518E+15	25	2	2	2	1.80144E+16	27	2	1	1
3.3777E+15	25	2	3	3	3.60288E+16	27	2	2	2
4.5036E+15	25	2	4	4	5.40432E+16	27	2	3	3
5.6295E+15	25	2	5	5	7.20576E+16	27	2	4	4
6.7554E+15	25	2	6	6	9.0072E+16	27	2	5	5
7.8813E+15	25	2	7	7	1.08086E+17	27	2	6	6
9.0072E+15	25	2	8	8	1.26101E+17	27	2	7	7
1.01331E+16	25	2	9	9	1.44115E+17	27	2	8	8
1.1259E+16	25	2	10	10	1.6213E+17	27	2	9	9
1.23849E+16	25	2	11	11	1.80144E+17	27	2	10	10
1.35108E+16	25	2	12	12	1.98158E+17	27	2	11	11
1.46367E+16	25	2	13	13	2.16173E+17	27	2	12	12
1.57626E+16	25	2	14	14	2.34187E+17	27	2	13	13
1.68885E+16	25	2	15	15	2.52202E+17	27	2	14	14
1.80144E+16	25	2	16	16	2.70216E+17	27	2	15	15
1.91403E+16	25	2	17	17	2.8823E+17	27	2	16	16
2.02662E+16	25	2	18	18	3.06245E+17	27	2	17	17
2.13921E+16	25	2	19	19	3.24259E+17	27	2	18	18
2.2518E+16	25	2	20	20	3.42274E+17	27	2	19	19
2.36439E+16	25	2	21	21	3.60288E+17	27	2	20	20
2.47698E+16	25	2	22	22	3.78302E+17	27	2	21	21
2.58957E+16	25	2	23	23	3.96317E+17	27	2	22	22
2.70216E+16	25	2	24	24	4.14331E+17	27	2	23	23
2.81475E+16	25	2	25	25	4.32346E+17	27	2	24	24
2.92734E+16	25	2	26	26	4.5036E+17	27	2	25	25
3.03993E+16	25	2	27	27	4.68374E+17	27	2	26	26
3.15252E+16	25	2	28	28	4.86389E+17	27	2	27	27
3.26511E+16	25	2	29	29	5.04403E+17	27	2	28	28
3.3777E+16	25	2	30	30	5.22418E+17	27	2	29	29
4.5036E+15	26	2	1	1	5.40432E+17	27	2	30	30
9.0072E+15	26	2	2	2	7.20576E+16	28	2	1	1
1.35108E+16	26	2	3	3	1.44115E+17	28	2	2	2
1.80144E+16	26	2	4	4	2.16173E+17	28	2	3	3
2.2518E+16	26	2	5	5	2.8823E+17	28	2	4	4
2.70216E+16	26	2	6	6	3.60288E+17	28	2	5	5
3.15252E+16	26	2	7	7	4.32346E+17	28	2	6	6
3.60288E+16	26	2	8	8	5.04403E+17	28	2	7	7
4.05324E+16	26	2	9	9	5.76461E+17	28	2	8	8
4.5036E+16	26	2	10	10	6.48518E+17	28	2	9	9
4.95396E+16	26	2	11	11	7.20576E+17	28	2	10	10
5.40432E+16	26	2	12	12	7.92634E+17	28	2	11	11
5.85468E+16	26	2	13	13	8.64691E+17	28	2	12	12
6.30504E+16	26	2	14	14	9.36749E+17	28	2	13	13
6.7554E+16	26	2	15	15	1.00881E+18	28	2	14	14
7.20576E+16	26	2	16	16	1.08086E+18	28	2	15	15
7.65612E+16	26	2	17	17	1.15292E+18	28	2	16	16
8.10648E+16	26	2	18	18	1.22498E+18	28	2	17	17
8.55684E+16	26	2	19	19	1.29704E+18	28	2	18	18
9.0072E+16	26	2	20	20	1.36909E+18	28	2	19	19
9.45756E+16	26	2	21	21	1.44115E+18	28	2	20	20
9.90792E+16	26	2	22	22	1.51321E+18	28	2	21	21
1.03583E+17	26	2	23	23	1.58527E+18	28	2	22	22
1.08086E+17	26	2	24	24	1.65732E+18	28	2	23	23
1.1259E+17	26	2	25	25	1.72938E+18	28	2	24	24
1.17094E+17	26	2	26	26	1.80144E+18	28	2	25	25
1.21597E+17	26	2	27	27	1.8735E+18	28	2	26	26
1.26101E+17	26	2	28	28	1.94556E+18	28	2	27	27
1.30604E+17	26	2	29	29	2.01761E+18	28	2	28	28

2.08967E+18	28	2	29	29	8.64691E+18	29	2	30	30
2.16173E+18	28	2	30	30	1.15292E+18	30	2	1	1
2.8823E+17	29	2	1	1	2.30584E+18	30	2	2	2
5.76461E+17	29	2	2	2	3.45876E+18	30	2	3	3
8.64691E+17	29	2	3	3	4.61169E+18	30	2	4	4
1.15292E+18	29	2	4	4	5.76461E+18	30	2	5	5
1.44115E+18	29	2	5	5	6.91753E+18	30	2	6	6
1.72938E+18	29	2	6	6	8.07045E+18	30	2	7	7
2.01761E+18	29	2	7	7	9.22337E+18	30	2	8	8
2.30584E+18	29	2	8	8	1.03763E+19	30	2	9	9
2.59407E+18	29	2	9	9	1.15292E+19	30	2	10	10
2.8823E+18	29	2	10	10	1.26821E+19	30	2	11	11
3.17053E+18	29	2	11	11	1.38351E+19	30	2	12	12
3.45876E+18	29	2	12	12	1.4988E+19	30	2	13	13
3.74699E+18	29	2	13	13	1.61409E+19	30	2	14	14
4.03523E+18	29	2	14	14	1.72938E+19	30	2	15	15
4.32346E+18	29	2	15	15	1.84467E+19	30	2	16	16
4.61169E+18	29	2	16	16	1.95997E+19	30	2	17	17
4.89992E+18	29	2	17	17	2.07526E+19	30	2	18	18
5.18815E+18	29	2	18	18	2.19055E+19	30	2	19	19
5.47638E+18	29	2	19	19	2.30584E+19	30	2	20	20
5.76461E+18	29	2	20	20	2.42114E+19	30	2	21	21
6.05284E+18	29	2	21	21	2.53643E+19	30	2	22	22
6.34107E+18	29	2	22	22	2.65172E+19	30	2	23	23
6.6293E+18	29	2	23	23	2.76701E+19	30	2	24	24
6.91753E+18	29	2	24	24	2.8823E+19	30	2	25	25
7.20576E+18	29	2	25	25	2.9976E+19	30	2	26	26
7.49399E+18	29	2	26	26	3.11289E+19	30	2	27	27
7.78222E+18	29	2	27	27	3.22818E+19	30	2	28	28
8.07045E+18	29	2	28	28	3.34347E+19	30	2	29	29
8.35868E+18	29	2	29	29	3.45876E+19	30	2	30	30

Conclusions:

Total number of K  
= 2.38E+88

Number of K > 0  
= 2.38E+88

Number of K <= 0  
= 201

+ve rate (P)  
= 100%

This is the end of report.



## Log file 2

```

K = -2, a = 2, c = 17
  b[0] = 2, b[1] = 2.
  c[0] = 17, c[1] = 17.
K = -20, a = 2, c = 18
  b[0] = 2, b[1] = 2.
  c[0] = 18, c[1] = 18.
K = -6, a = 2, c = 19
  b[0] = 2, b[1] = 2.
  c[0] = 18, c[1] = 19.
K = -6, a = 2, c = 19
  b[0] = 2, b[1] = 2.
  c[0] = 19, c[1] = 18.
K = -40, a = 2, c = 19
  b[0] = 2, b[1] = 2.
  c[0] = 19, c[1] = 19.
K = -26, a = 2, c = 20
  b[0] = 2, b[1] = 2.
  c[0] = 19, c[1] = 20.
K = -26, a = 2, c = 20
  b[0] = 2, b[1] = 2.
  c[0] = 20, c[1] = 19.
K = -62, a = 2, c = 20
  b[0] = 2, b[1] = 2.
  c[0] = 20, c[1] = 20.
K = -12, a = 2, c = 21
  b[0] = 2, b[1] = 2.
  c[0] = 19, c[1] = 21.
K = -10, a = 2, c = 21
  b[0] = 2, b[1] = 2.
  c[0] = 20, c[1] = 20.
K = -48, a = 2, c = 21
  b[0] = 2, b[1] = 2.
  c[0] = 20, c[1] = 21.
K = -12, a = 2, c = 21
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 19.
K = -48, a = 2, c = 21
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 20.
K = -86, a = 2, c = 21
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 21.
K = -34, a = 2, c = 22
  b[0] = 2, b[1] = 2.
  c[0] = 20, c[1] = 22.
K = -32, a = 2, c = 22
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 21.
K = -72, a = 2, c = 22
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 22.
K = -34, a = 2, c = 22
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 20.
K = -72, a = 2, c = 22
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 21.
K = -112, a = 2, c = 22
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 22.
K = -20, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 20, c[1] = 23.
K = -16, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 22.
K = -58, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 23.
K = -16, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 21.
K = -56, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 22.
K = -98, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 23.
K = -20, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 20.
K = -58, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 21.
K = -98, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 22.
K = -140, a = 2, c = 23
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 23.
K = -6, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 20, c[1] = 24.
K = 0, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 23.
K = -44, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 21, c[1] = 24.
K = -40, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 23.
K = -84, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 22, c[1] = 24.
K = 0, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 21.
K = -40, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 22.
K = -82, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 23.
K = -126, a = 2, c = 24
  b[0] = 2, b[1] = 2.
  c[0] = 23, c[1] = 24.
K = -6, a = 2, c = 24

```

$b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 20.$   
 $K = -44, a = 2, c = 24$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 21.$   
 $K = -84, a = 2, c = 24$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 22.$   
 $K = -126, a = 2, c = 24$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 23.$   
 $K = -170, a = 2, c = 24$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 24.$   
 $K = -30, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 21, c[1] = 25.$   
 $K = -24, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 22, c[1] = 24.$   
 $K = -70, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 22, c[1] = 25.$   
 $K = -22, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 23.$   
 $K = -66, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 24.$   
 $K = -112, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 25.$   
 $K = -24, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 22.$   
 $K = -66, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 23.$   
 $K = -110, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 24.$   
 $K = -156, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 25.$   
 $K = -30, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 21.$   
 $K = -70, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 22.$   
 $K = -112, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 23.$   
 $K = -156, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 24.$   
 $K = -202, a = 2, c = 25$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 25.$   
 $K = -16, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$

$c[0] = 21, c[1] = 26.$   
 $K = -8, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 22, c[1] = 25.$   
 $K = -56, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 22, c[1] = 26.$   
 $K = -4, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 24.$   
 $K = -50, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 25.$   
 $K = -98, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 26.$   
 $K = -4, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 23.$   
 $K = -48, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 24.$   
 $K = -94, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 25.$   
 $K = -142, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 26.$   
 $K = -8, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 22.$   
 $K = -50, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 23.$   
 $K = -94, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 24.$   
 $K = -140, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 25.$   
 $K = -188, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 26.$   
 $K = -16, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 21.$   
 $K = -56, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 22.$   
 $K = -98, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 23.$   
 $K = -142, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 24.$   
 $K = -188, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 25.$   
 $K = -236, a = 2, c = 26$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 26.$



$K = -2, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 21, c[1] = 27.$

$K = -42, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 22, c[1] = 27.$

$K = -34, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 26.$

$K = -84, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 27.$

$K = -30, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 25.$

$K = -78, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 26.$

$K = -128, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 27.$

$K = -30, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 24.$

$K = -76, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 25.$

$K = -124, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 26.$

$K = -174, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 27.$

$K = -34, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 23.$

$K = -78, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 24.$

$K = -124, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 25.$

$K = -172, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 26.$

$K = -222, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 27.$

$K = -2, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 21.$

$K = -42, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 22.$

$K = -84, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 23.$

$K = -128, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 24.$

$K = -174, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 24.$

$b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 25.$

$K = -222, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 26.$

$K = -272, a = 2, c = 27$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 27.$

$K = -28, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 22, c[1] = 28.$

$K = -18, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 27.$

$K = -70, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 28.$

$K = -12, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 26.$

$K = -62, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 27.$

$K = -114, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 28.$

$K = -10, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 25.$

$K = -58, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 26.$

$K = -108, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 27.$

$K = -160, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 28.$

$K = -12, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 24.$

$K = -58, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 25.$

$K = -106, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 26.$

$K = -156, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 27.$

$K = -208, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 28.$

$K = -18, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 23.$

$K = -62, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 24.$

$K = -108, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$

$c[0] = 27, c[1] = 25.$   
 $K = -156, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 26.$   
 $K = -206, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 27.$   
 $K = -258, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 28.$   
 $K = -28, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 22.$   
 $K = -70, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 23.$   
 $K = -114, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 24.$   
 $K = -160, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 25.$   
 $K = -208, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 26.$   
 $K = -258, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 27.$   
 $K = -310, a = 2, c = 28$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 28.$   
 $K = -14, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 22, c[1] = 29.$   
 $K = -2, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 28.$   
 $K = -56, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 23, c[1] = 29.$   
 $K = -46, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 28.$   
 $K = -100, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 24, c[1] = 29.$   
 $K = -40, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 27.$   
 $K = -92, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 28.$   
 $K = -146, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 25, c[1] = 29.$   
 $K = -38, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 26.$   
 $K = -88, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 27.$

$K = -140, a = 2, c = 29$   
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 $c[0] = 26, c[1] = 28.$   
 $K = -194, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 26, c[1] = 29.$   
 $K = -40, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 25.$   
 $K = -88, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 26.$   
 $K = -138, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 27.$   
 $K = -190, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 28.$   
 $K = -244, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 27, c[1] = 29.$   
 $K = -2, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 23.$   
 $K = -46, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 24.$   
 $K = -92, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 25.$   
 $K = -140, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 26.$   
 $K = -190, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 27.$   
 $K = -242, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 28.$   
 $K = -296, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 28, c[1] = 29.$   
 $K = -14, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 29, c[1] = 22.$   
 $K = -56, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 29, c[1] = 23.$   
 $K = -100, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 29, c[1] = 24.$   
 $K = -146, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 29, c[1] = 25.$   
 $K = -194, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 29, c[1] = 26.$   
 $K = -244, a = 2, c = 29$   
 $b[0] = 2, b[1] = 2.$   
 $c[0] = 29, c[1] = 27.$



296, a = 2, c = 29  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 28.  
K = -350, a = 2, c = 29  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 29.  
K = 0, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 22, c[1] = 30.  
K = -42, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 23, c[1] = 30.  
K = -30, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 24, c[1] = 29.  
K = -86, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 24, c[1] = 30.  
K = -22, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 25, c[1] = 28.  
K = -76, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 25, c[1] = 29.  
K = -132, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 25, c[1] = 30.  
K = -18, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 26, c[1] = 27.  
K = -70, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 26, c[1] = 28.  
K = -124, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 26, c[1] = 29.  
K = -180, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 26, c[1] = 30.  
K = -18, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 27, c[1] = 26.  
K = -68, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 27, c[1] = 27.  
K = -120, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 27, c[1] = 28.  
K = -174, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 27, c[1] = 29.  
K = -230, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 27, c[1] = 30.  
K = -22, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 28, c[1] = 25.  
K = -70, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 28, c[1] = 26.

This is the end of report.

K = -120, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 28, c[1] = 27.  
K = -172, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 28, c[1] = 28.  
K = -226, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 28, c[1] = 29.  
K = -282, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 28, c[1] = 30.  
K = -30, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 24.  
K = -76, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 25.  
K = -124, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 26.  
K = -174, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 27.  
K = -226, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 28.  
K = -280, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 29.  
K = -336, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 29, c[1] = 30.  
K = 0, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 22.  
K = -42, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 23.  
K = -86, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 24.  
K = -132, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 25.  
K = -180, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 26.  
K = -230, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 27.  
K = -282, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 28.  
K = -336, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 29.  
K = -392, a = 2, c = 30  
b[0] = 2, b[1] = 2.  
c[0] = 30, c[1] = 30.