Sustainable Management of Community Buildings

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Outline

- Introduction
- Conceptual framework
- Building Hierarchy
- Deterioration Prediction
- Risk cost optimisation
- A glimpse of software CAMS
- Data collection applet
- Concluding remarks

Where we started

- **Project funded by the Australian Research Council - $300,000 over a three year period, $105,000 industry contribution**
  - **2 Ph.D students –three years – full time**
  - **Half time research fellow**
  - **Software development cost**
  - **Commenced on 1 July 2009**

RMIT Research Team

- **Professor Ron Wakefield**
- **Associate Professor Sujeeva Setunge**
- **Associate Professor Kevin Zhang**
- **Hessam Mohseni (Research Fellow)**
- **Pushpitha Kalutara (Doctoral Student)**
- **Dr. Daniel Kong (Research Fellow)**
- **Dr. Buddhi Jayatilleke**
- **Kanishka Atapattu (Research Assistant)**

Partners of the ARC funded project

- **RMIT University**
- **Municipal Association of Victoria**
- **Brimbank City Council**
- **Glen Eira City Council**
- **Monash City Council**
- **Greater Dandenong City Council**
- **Mornington Peninsula Shire Council**
- **Kingston City Council**
- **Integrate Australia Pty Ltd.**

Other interested organisations

- **City of Melbourne**
- **Port of Melbourne Corporation**
- **Metro Trains**
- **South Gippsland Shire Council**

CAMS PROJECT FLOWCHART DIAGRAM

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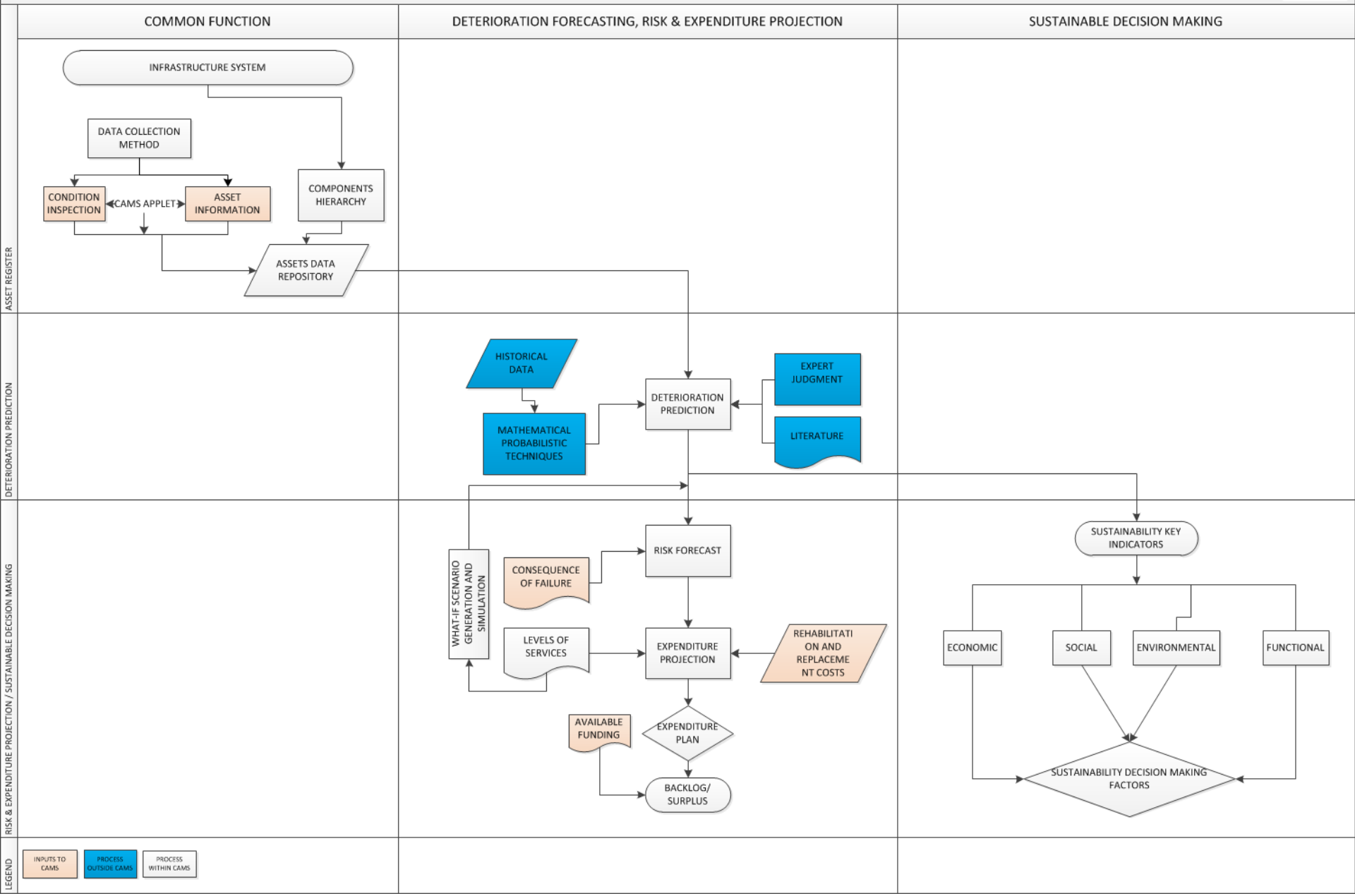


IPWEA -NAMS Hierarchy

1st LEVEL : Component Group
2nd LEVEL : Component Type
3rd LEVEL : Component

3rd — Component

1. Fire Extinguishers
2. Fire Hose Reels
3. Ventilating Fans

2nd — Component Type

I. Fire Alarm System	II. Fire Communications	III. Fire Services	IV. Fire Sprinkler System	V. Hydrant System

1st — Component Group

1. Electrical Services	2. Exterior Works	3. External Fabric	4. Fire Services	5. Interior Finishes	6. Lifts / Hoists Services	7. Mechanical Services	8. Plumbing	9. Security Services	10. Water Services

2nd — Component Type

I. Ceiling Finishes	II. Fixtures & Fittings	III. Floor Finishes	IV. Interior Doors	V. Interior Walls	VI. Interior Windows	VII. Wall Finishes

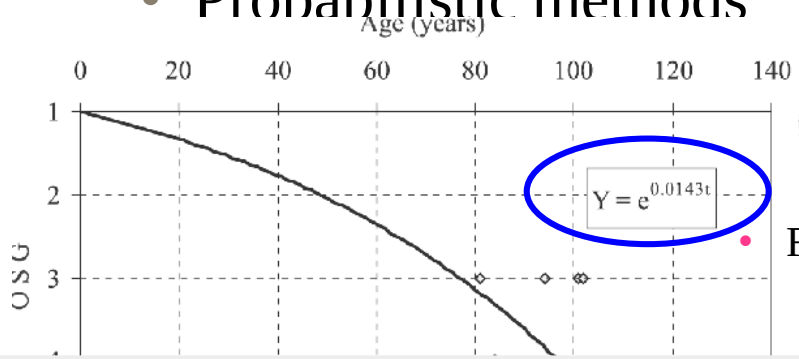
3rd — Component

1. Fibrolite	9. Plywood
2. Glass	10. Prefinished Metal
3. Gyprock Lining	11. Stainless steel
4. Hardboard	12. Tiles - Ceramic
5. Melteca / Seratone	13. Timber Lining
6. Paint Finish	14. Vinyl
7. Particle Board	15. Wallpaper Finish
8. Plaster Finish	

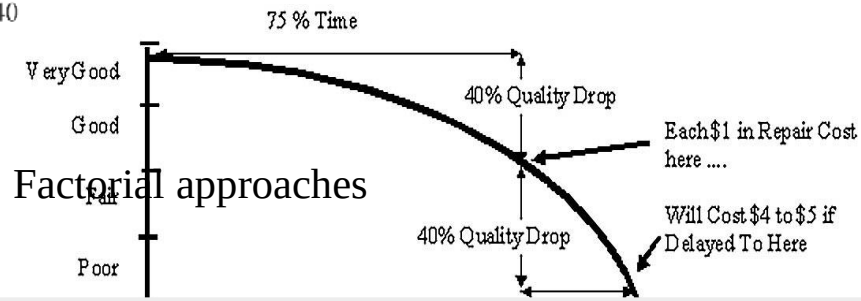
Deterioration prediction methods

- Discrete condition data collected using visual inspection

  - Deterministic vs. Probabilistic
    - Deterministic methods
    - Probabilistic methods

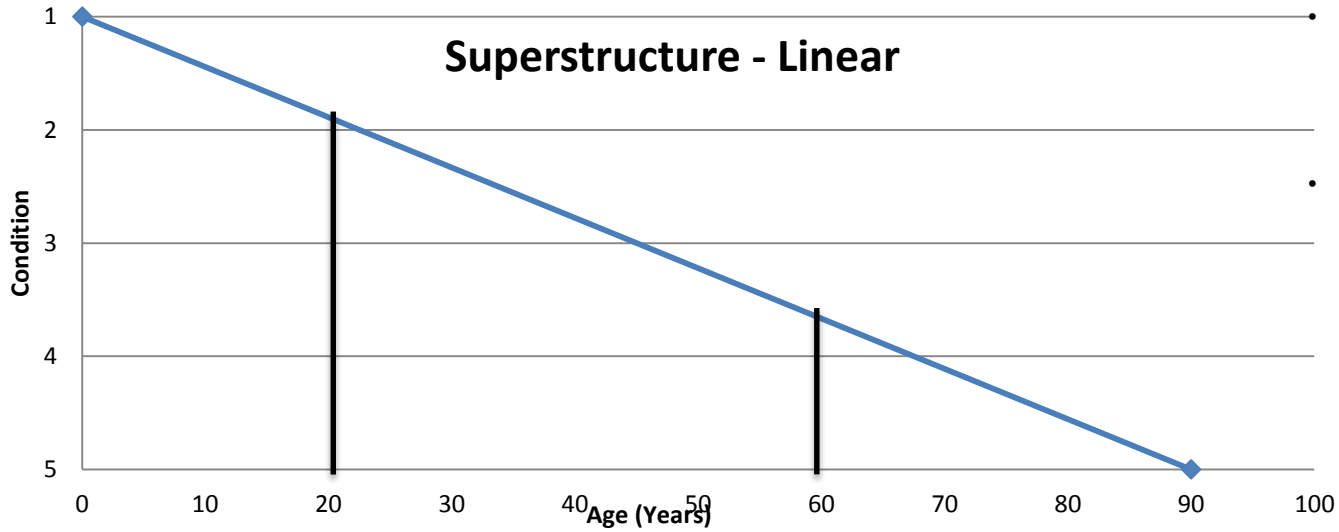


Factorial approaches

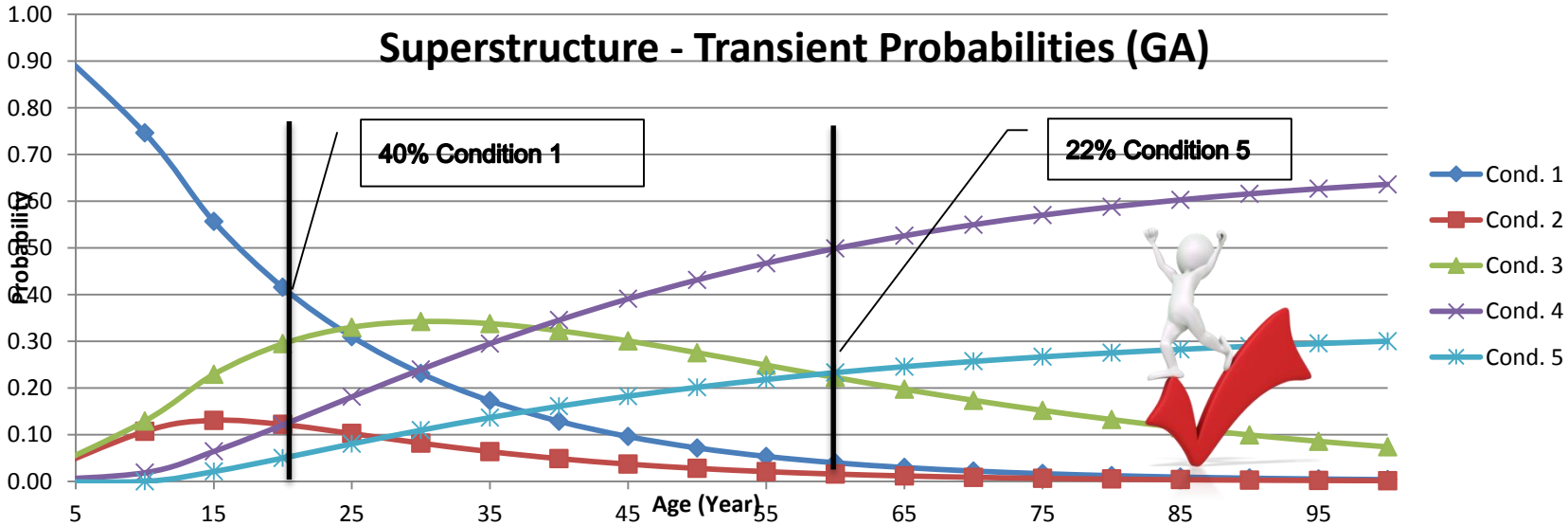


Estimated Service Life = Estimated Reference Service Life x
Quality x Design x Execution x
Indoor environment x Outdoor environment x
Conditions in use x Maintenance regime

Current Practice vs. Proposed Method

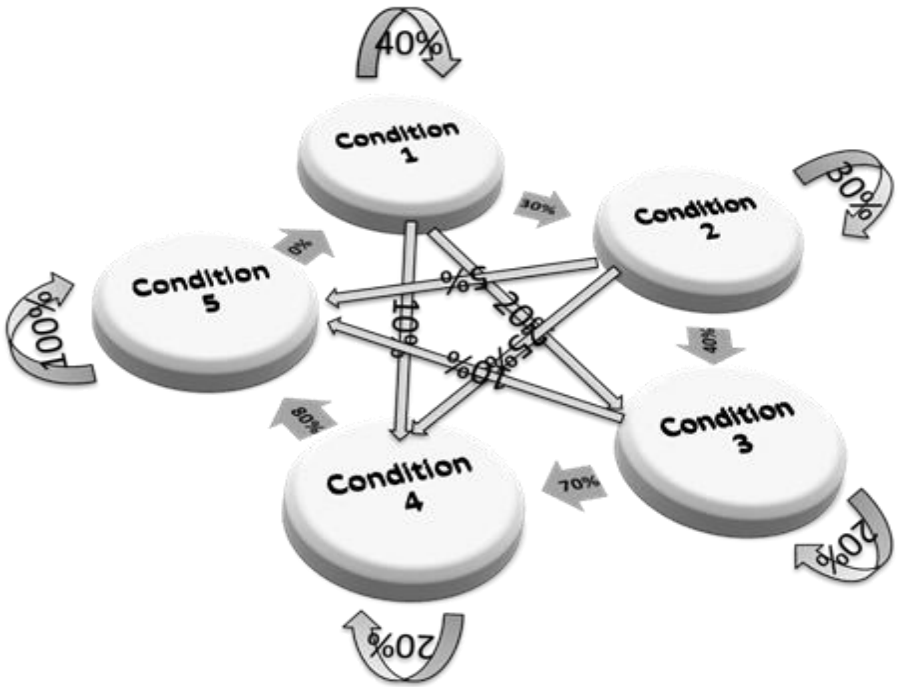


- Overestimating the deterioration trend
- Underestimating the deterioration trend



Deterioration Prediction
Markov Chain Application

p_{ij}	C.1	C.2	C.3	C.4	C.5
C.1	0.4	0.3	0.2	0.1	0
C.2	0	0.3	0.4	0.25	0.05
C.3	0	0	0.2	0.7	0.1
C.4	0	0	0	0.2	0.8
C.5	0	0	0	0	1



- Upper triangular matrix
- Reducible Markov Chain ; Unless Rehabilitation

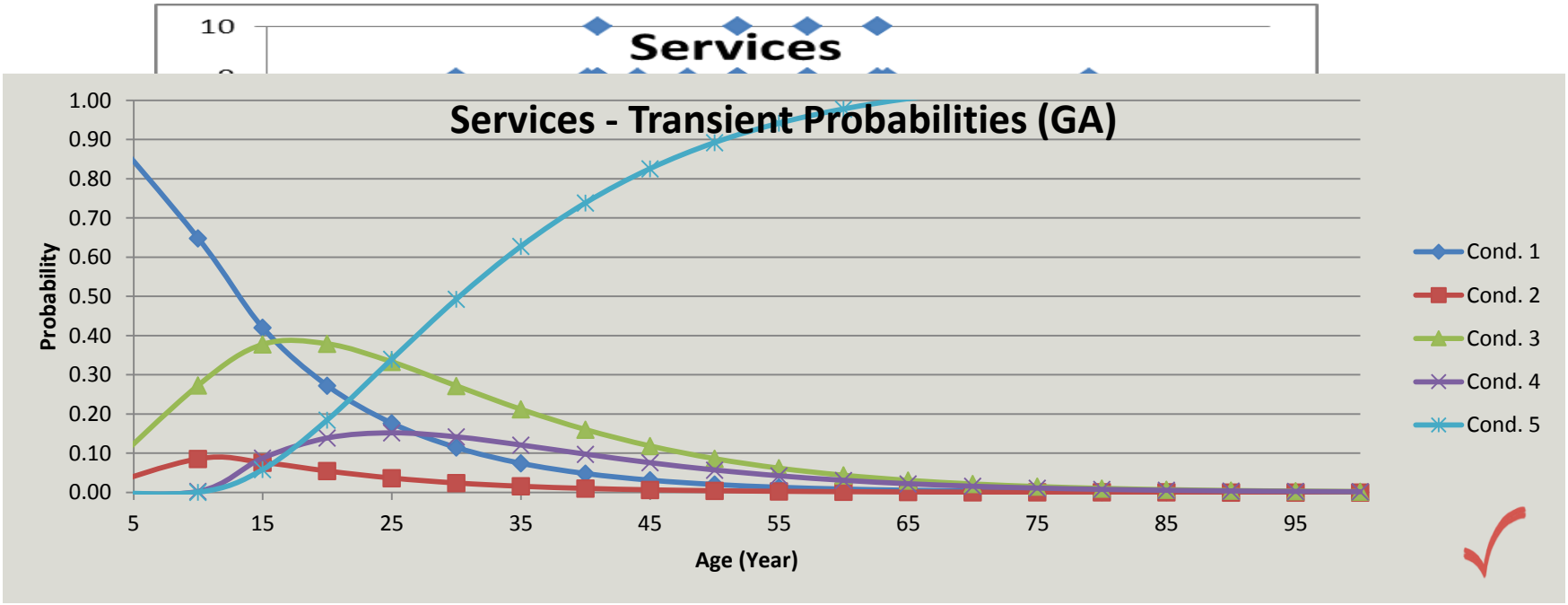
$$pii \geq 0$$

$$\sum_{j} pij = 1$$

Rating	Component Condition	Condition Description
1	Very Good Condition	The element is as new
2	Good Condition	The element is sound; Minor damage, Minor maintenance required
3	Moderate Condition	Moderate damage; Moderate maintenance required
4	Poor Condition	Major damage; Major maintenance required
5	Very Poor Condition	Serious damage; Element should be replaced

Deterioration prediction methods

- Deterioration prediction
  - Deterministic vs. Probabilistic
    - Deterministic methods



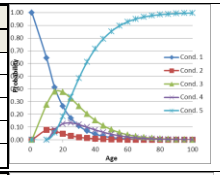
Calibrated & Validated Transition Matrices

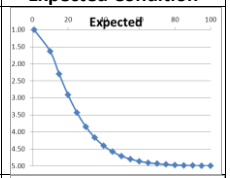
Element	Transition Matrix	Transient Probabilities	Expected Condition

Services

Services - Transition matrix

Cond.	1	2	3	4	5
1	0.64	0.08	0.28	0.00	0.00
2	0.00	0.24	0.31	0.46	0.00
3	0.00	0.00	0.63	0.16	0.20
4	0.00	0.00	0.00	0.39	0.61
5	0.00	0.00	0.00	0.00	1.00

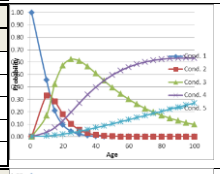


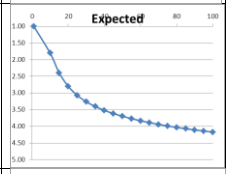


Finishes

Finishes - Transition matrix

Cond.	1	2	3	4	5
1	0.46	0.33	0.17	0.04	0.01
2	0.00	0.40	0.60	0.00	0.00
3	0.00	0.00	0.87	0.12	0.01
4	0.00	0.00	0.00	0.98	0.02
5	0.00	0.00	0.00	0.00	1.00

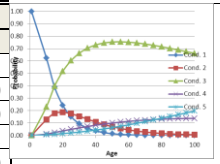


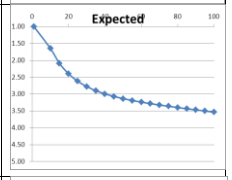


Essential Services

Essential Services - Transition matrix

Cond.	1	2	3	4	5
1	0.62	0.13	0.23	0.01	0.01
2	0.00	0.77	0.22	0.01	0.00
3	0.00	0.00	0.98	0.02	0.00
4	0.00	0.00	0.00	0.89	0.11
5	0.00	0.00	0.00	0.00	1.00

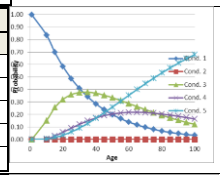


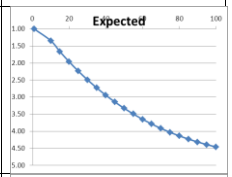


Superstructure

Superstructure - Transition matrix

Cond.	1	2	3	4	5
1	0.84	0.00	0.15	0.01	0.00
2	0.00	0.54	0.25	0.17	0.04
3	0.00	0.00	0.84	0.12	0.04
4	0.00	0.00	0.00	0.85	0.15
5	0.00	0.00	0.00	0.00	1.00

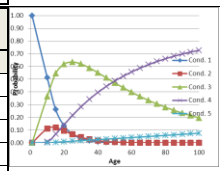


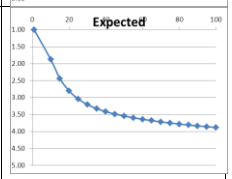


Internal Walls

Superstructure/Internal Walls - Transition matrix

Cond.	1	2	3	4	5
1	0.51	0.11	0.37	0.01	0.00
2	0.00	0.54	0.21	0.23	0.02
3	0.00	0.00	0.91	0.08	0.00
4	0.00	0.00	0.00	0.99	0.01
5	0.00	0.00	0.00	0.00	1.00

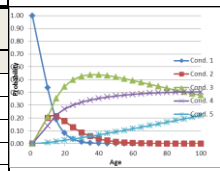


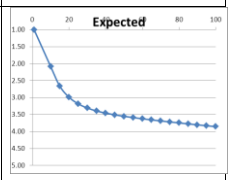


Ceiling

Superstructure/Ceiling - Transition matrix

Cond.	1	2	3	4	5
1	0.44	0.20	0.21	0.14	0.01
2	0.00	0.63	0.29	0.08	0.00
3	0.00	0.00	0.97	0.03	0.00
4	0.00	0.00	0.00	0.97	0.03
5	0.00	0.00	0.00	0.00	1.00

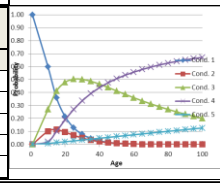


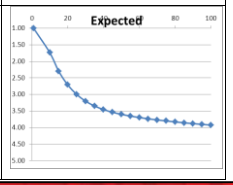


External Doors

Superstructure/External Doors - Transition matrix

Cond.	1	2	3	4	5
1	0.60	0.10	0.27	0.02	0.01
2	0.00	0.51	0.00	0.49	0.00
3	0.00	0.00	0.93	0.06	0.01
4	0.00	0.00	0.00	0.99	0.01
5	0.00	0.00	0.00	0.00	1.00

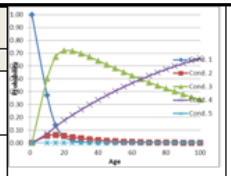


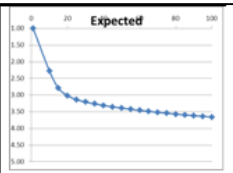


Veranda Post

Superstructure/Veranda Post - Transition matrix

Cond.	1	2	3	4	5
1	0.37	0.06	0.50	0.07	0.00
2	0.00	0.77	0.23	0.00	0.00
3	0.00	0.00	0.94	0.06	0.00
4	0.00	0.00	0.00	1.00	0.00
5	0.00	0.00	0.00	0.00	1.00

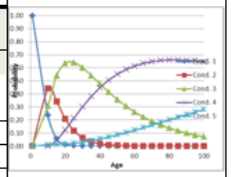


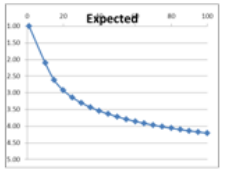


External Walls

Superstructure/External Walls - Transition matrix

Cond.	1	2	3	4	5
1	0.24	0.44	0.31	0.00	0.01
2	0.00	0.54	0.46	0.00	0.00
3	0.00	0.00	0.85	0.15	0.00
4	0.00	0.00	0.00	0.97	0.03
5	0.00	0.00	0.00	0.00	1.00

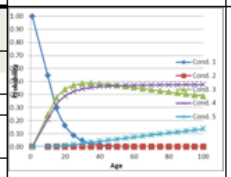


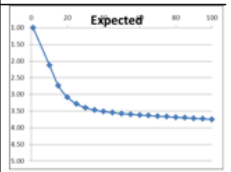


Stairs

Superstructure/Stairs - Transition matrix

Cond.	1	2	3	4	5
1	0.54	0.00	0.25	0.21	0.00
2	0.00	0.49	0.35	0.15	0.01
3	0.00	0.00	0.98	0.01	0.01
4	0.00	0.00	0.00	0.99	0.01
5	0.00	0.00	0.00	0.00	1.00

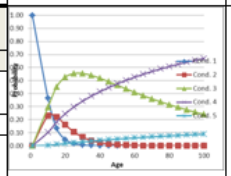


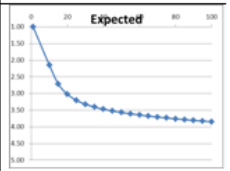


Windows

Superstructure/Windows - Transition matrix

Cond.	1	2	3	4	5
1	0.37	0.23	0.30	0.10	0.00
2	0.00	0.59	0.29	0.11	0.01
3	0.00	0.00	0.94	0.06	0.01
4	0.00	0.00	0.00	1.00	0.00
5	0.00	0.00	0.00	0.00	1.00

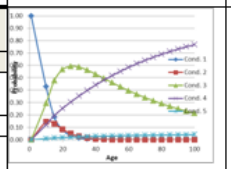


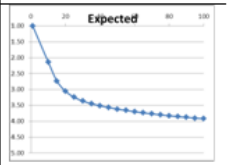


Roof

Superstructure/Roof - Transition matrix

Cond.	1	2	3	4	5
1	0.43	0.15	0.29	0.12	0.01
2	0.00	0.45	0.54	0.00	0.01
3	0.00	0.00	0.93	0.07	0.00
4	0.00	0.00	0.00	1.00	0.00
5	0.00	0.00	0.00	0.00	1.00

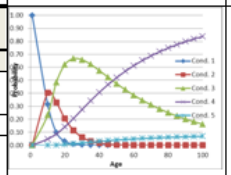


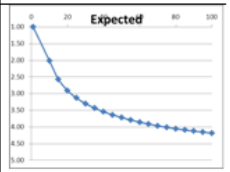


Internal Doors

Superstructure/Internal Doors - Transition matrix

Cond.	1	2	3	4	5
1	0.31	0.40	0.23	0.05	0.00
2	0.00	0.50	0.50	0.00	0.00
3	0.00	0.00	0.90	0.10	0.01
4	0.00	0.00	0.00	1.00	0.00
5	0.00	0.00	0.00	0.00	1.00

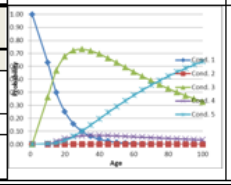


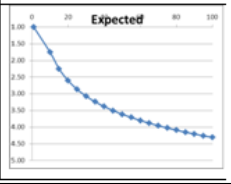


Upper Floors

Superstructure/Upper Floors - Transition matrix

Cond.	1	2	3	4	5
1	0.63	0.00	0.36	0.00	0.01
2	0.00	0.73	0.27	0.00	0.00
3	0.00	0.00	0.93	0.07	0.00
4	0.00	0.00	0.00	0.31	0.69
5	0.00	0.00	0.00	0.00	1.00



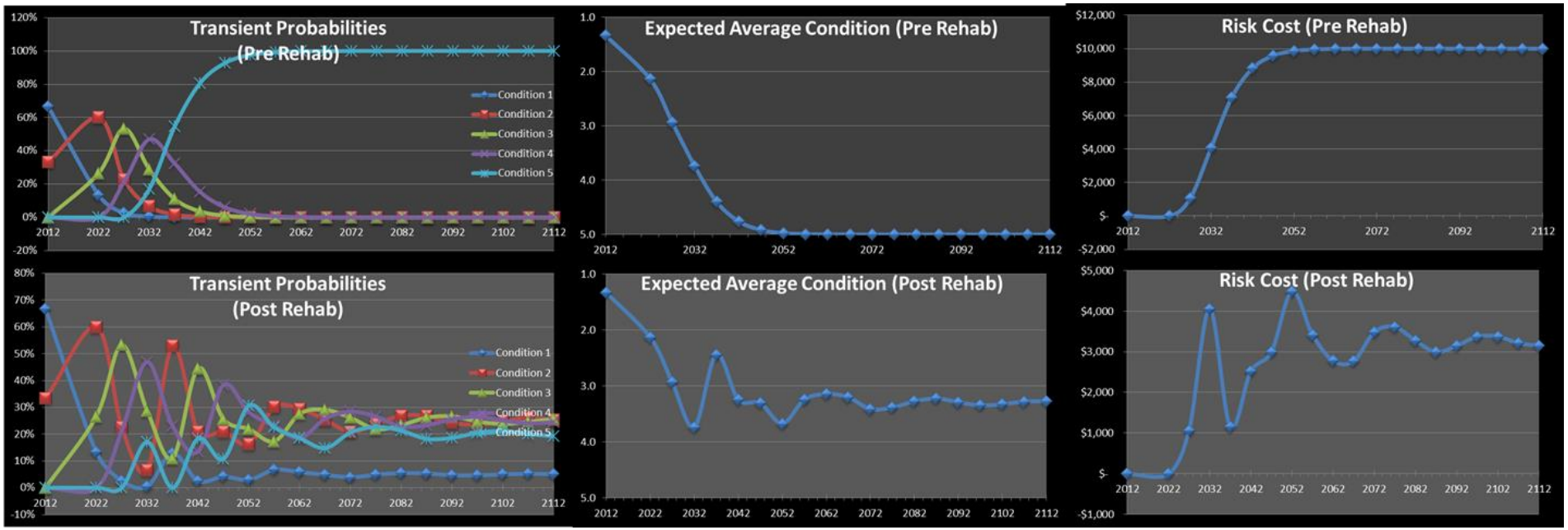


Risk and Expenditure Projections

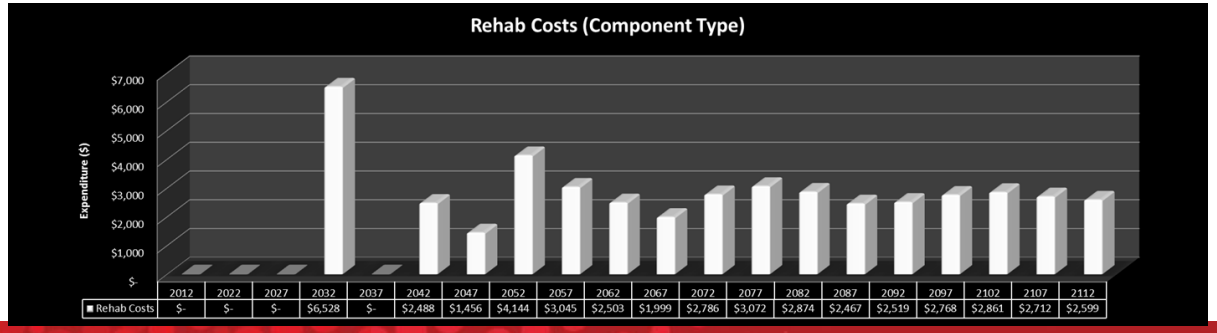
- **LoS, Rehabilitation Cost & Consequence:**

3	Unit	External Fabric			
			Intervention Criteria		
	Quantity of Element in Condition	Consequence Cost of Being in Condition	If Qty % Greater Than	Rehab to Cond	Cost/Unit ($)
Condition 1	80	$ -	100%	1	$ -
Condition 2	20	$ -	100%	2	$ -
Condition 3	20	$ 1,000	70%	2	$ 50
Condition 4	0	$ 3,000	40%	2	$ 100
Condition 5	10	$ 5,000	10%	1	$ 300

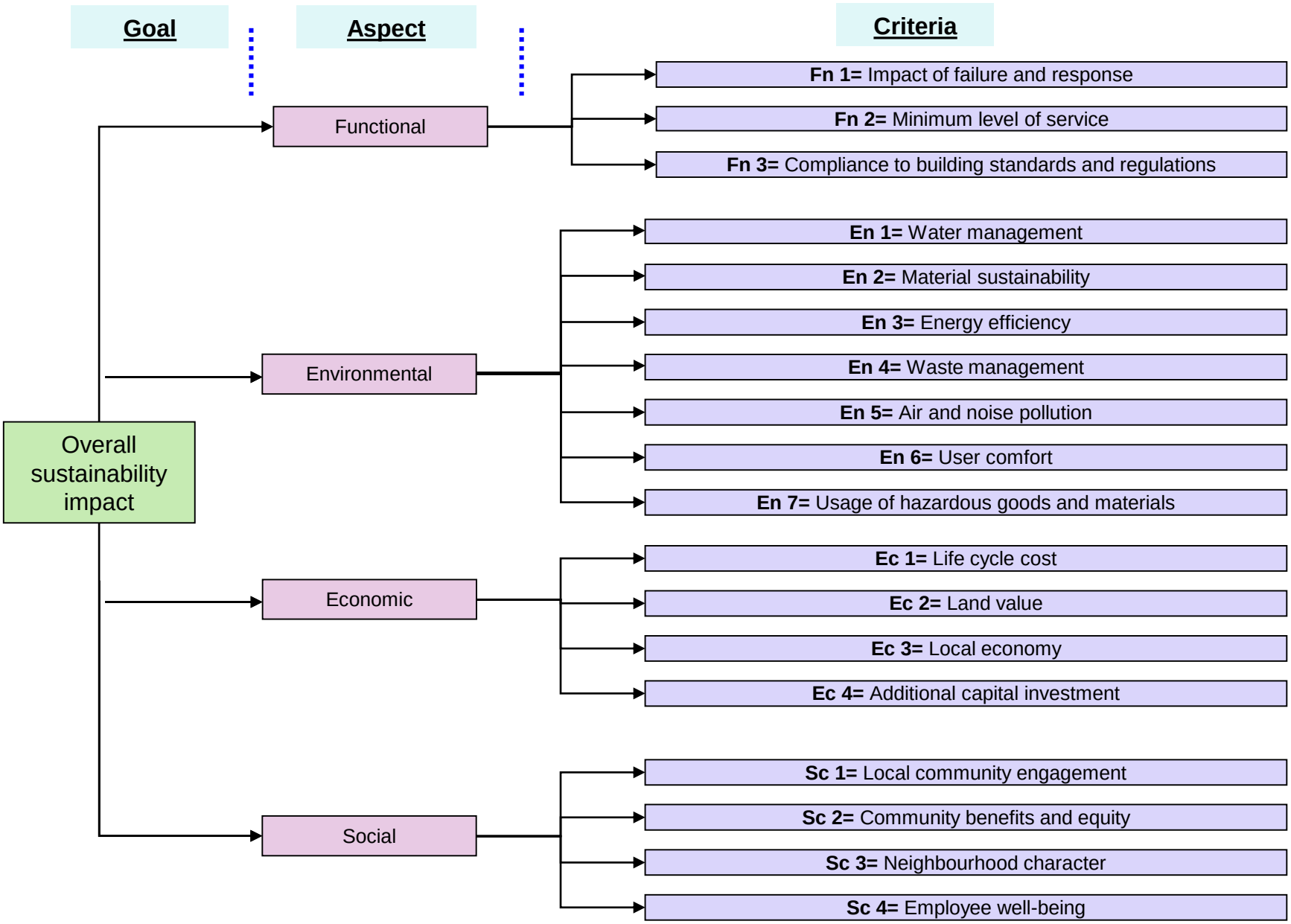
- **Projections (Pre-rehab & Post-rehab):**



- **Expenditure Projection (Individual & Network Level):**



Sustainable Decision-Making



Calculation of Sustainability Index Values

Component	Impact on **Environmental** Sustainability	Impact on **Economic** Sustainability	Impact on **Social** Sustainability	Impact on **Functional** Sustainability	Impact on **Overall** Sustainability
A	3.40	3.45	3.10	3.00	3.31
B	3.13	3.15	3.30	3.25	3.18
C	2.34	2.88	2.02	3.12	2.52
D	2.79	2.88	2.40	2.38	2.70
E	3.79	3.62	3.78	3.92	3.75
F	3.96	5.00	3.90	3.33	4.12
G	1.25	1.60	1.80	2.00	1.54
H	2.54	2.32	2.45	2.04	2.41
I	3.07	3.25	3.10	3.25	3.15
J	3.76	3.98	3.88	4.21	3.87

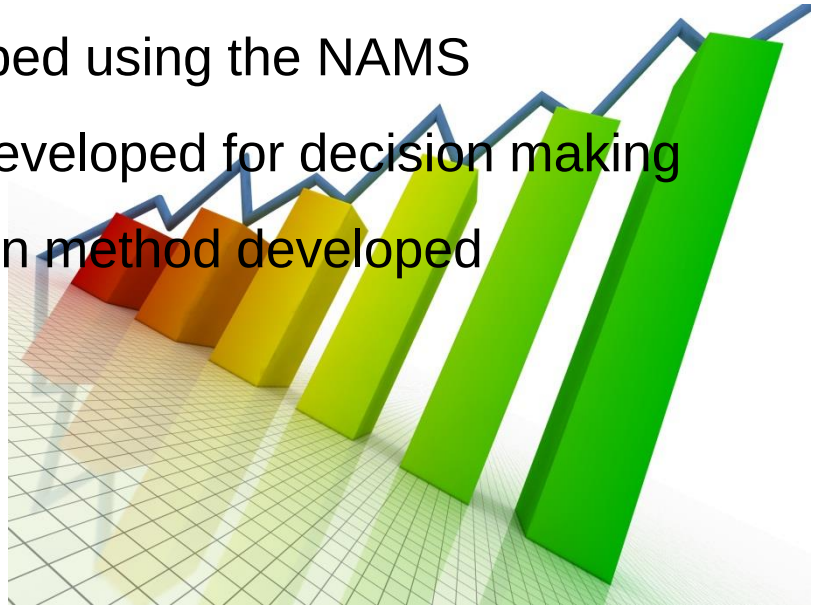
Council Asset Management System

RMIT UNIVERSITY

Features

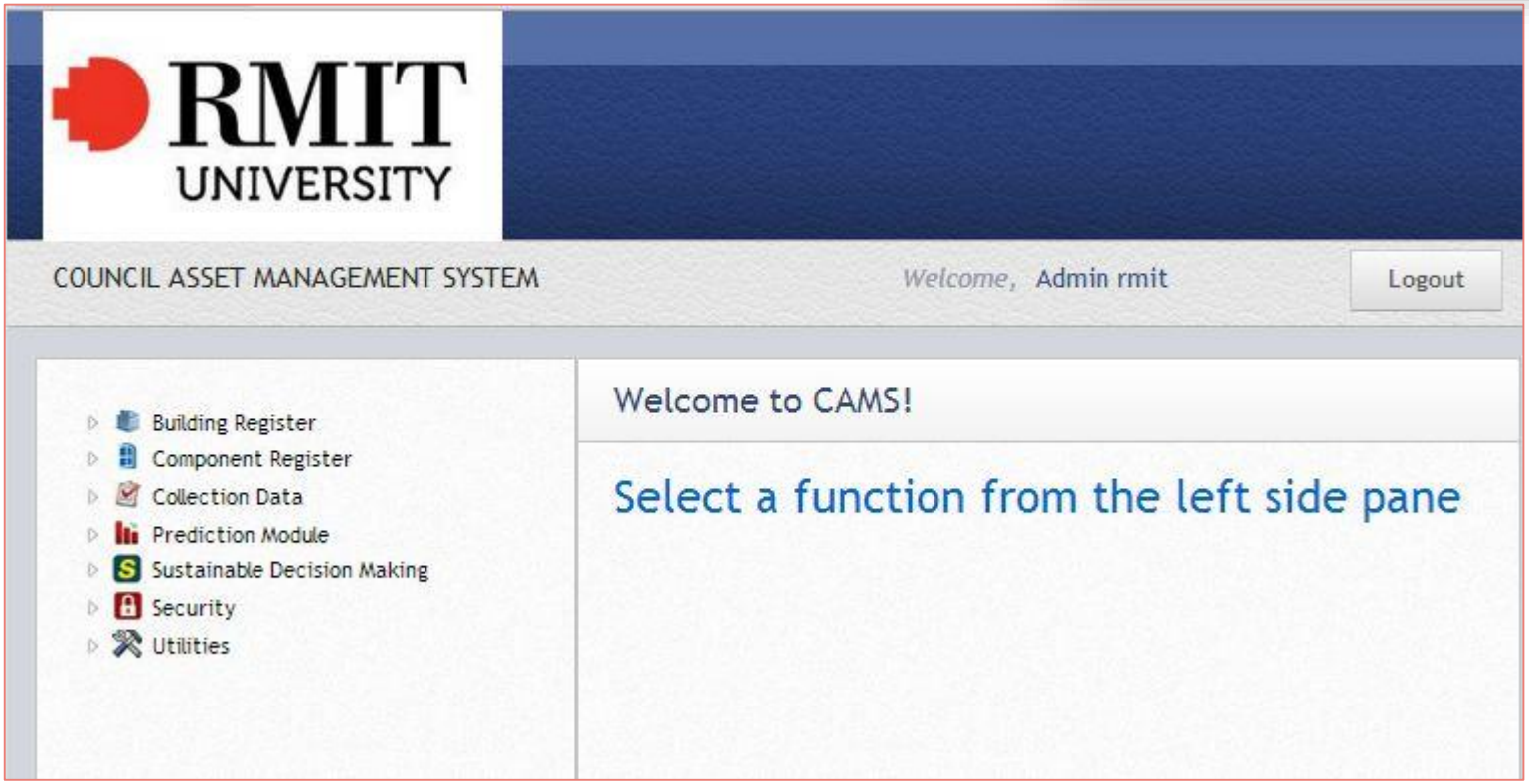
www.assethub.com.au

- A flexible asset registry developed
  - Identify buildings – child care centre, sports pavilion etc.
  - Component types, groups and components
  - Functional areas within a building
- Deterioration curves for key building components developed using condition data
- 320 component level curves developed using the NAMS
- Probabilistic risk-cost optimisation developed for decision making
- A sustainability focussed prioritisation method developed
- Hosted in Amazon server Sydney



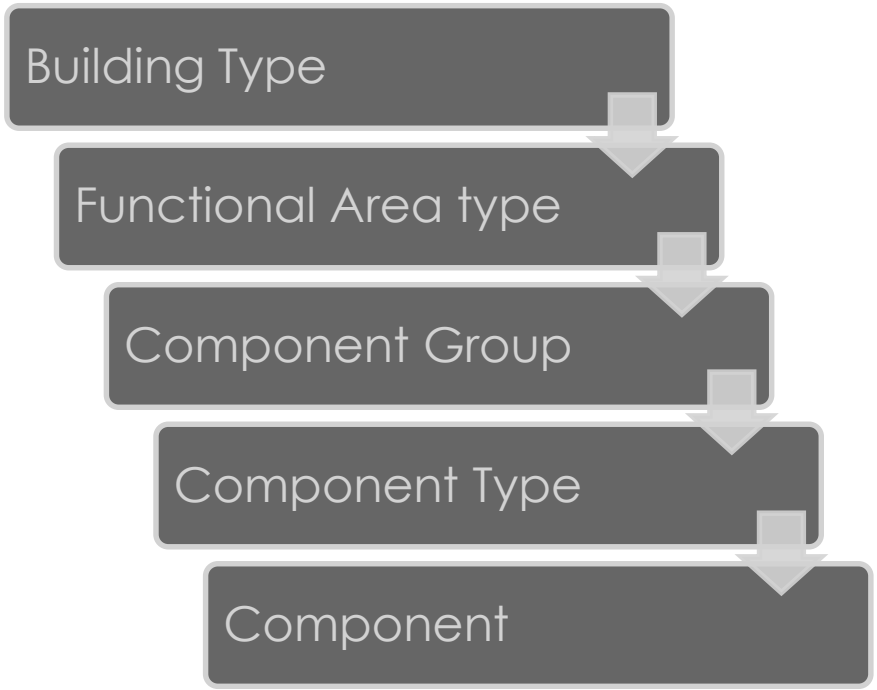
Appearance of the software

- Clear Simple platform
- Progressive step process



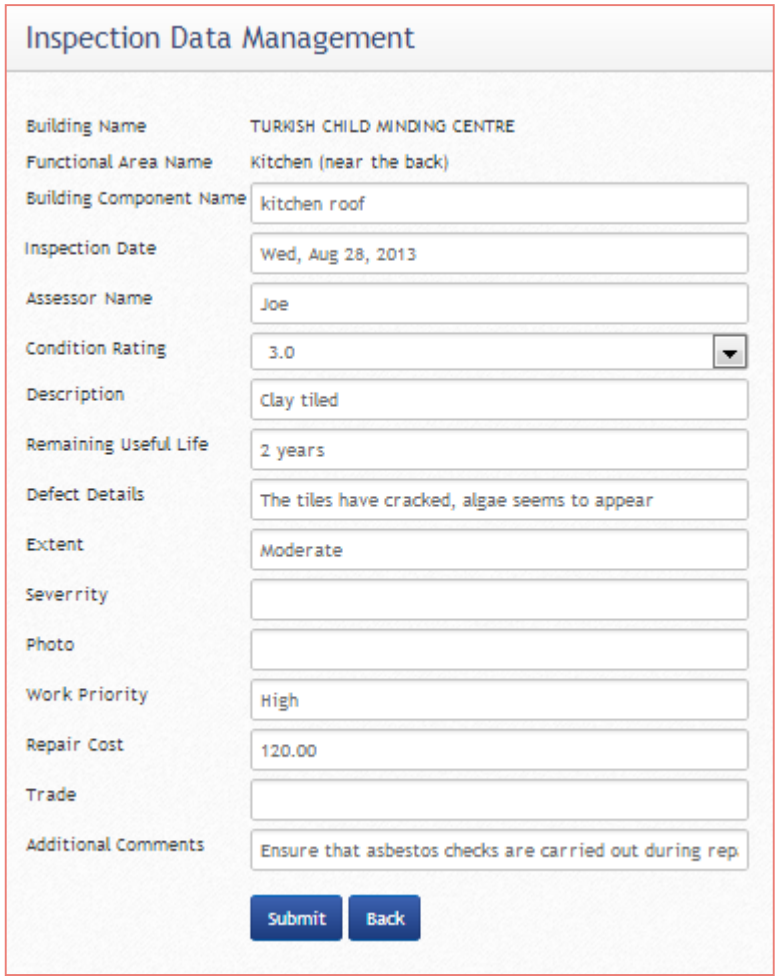
Step 1: Asset registry

- Hierarchical System (5 levels)
  - Building Category, Building, Component Group, component type, Component



Step 2: Inspection score input

- Manual Entry



Inspection Data Management

Building Name	TURKISH CHILD MINDING CENTRE
Functional Area Name	Kitchen (near the back)
Building Component Name	kitchen roof
Inspection Date	Wed, Aug 28, 2013
Assessor Name	Joe
Condition Rating	3.0
Description	Clay tiled
Remaining Useful Life	2 years
Defect Details	The tiles have cracked, algae seems to appear
Extent	Moderate
Severrity	
Photo	
Work Priority	High
Repair Cost	120.00
Trade	
Additional Comments	Ensure that asbestos checks are carried out during rep

Submit Back

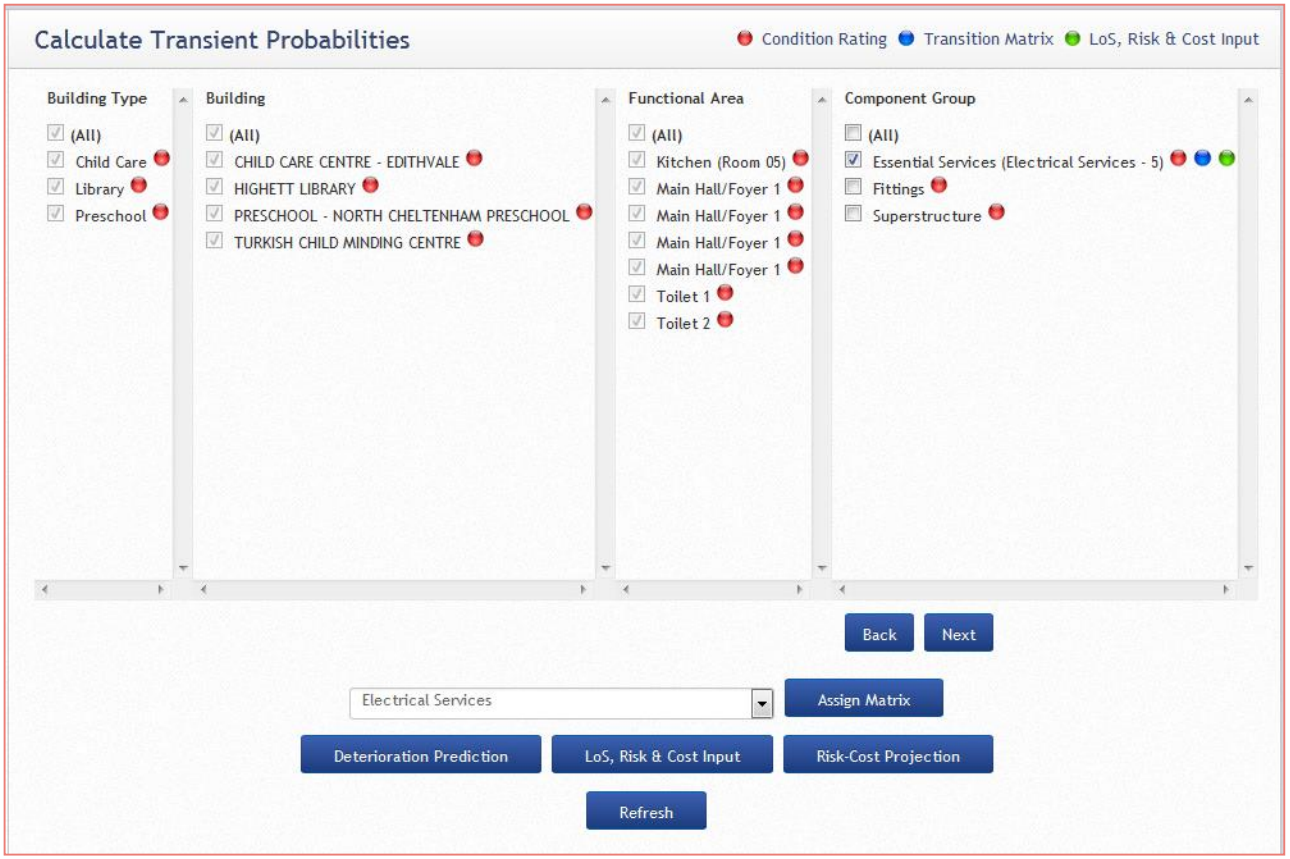
- Excel upload

Unit	Condition Rating	Description	Assessor Name	Remaining Useful Life	Defect Details				Maintena
					Defect	Extent	Severity	Photo	Work Priority
Item	2	weather da	Joe						
Item	1	Perfect	Joe						
Meters	3		Joe						High
Sq. m	1	Roof is in ex	Joe						
Sq. ft	1		Joe						
Meters	1		Joe						
Sq. m	1		Joe						

- Data collection Applet

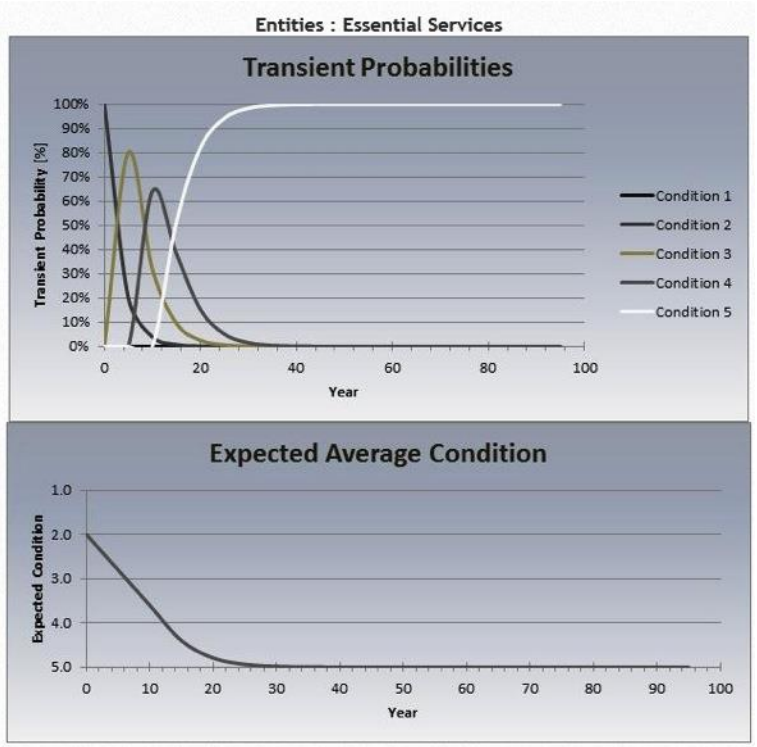
Step 3:Deterioration Risk Cost Analysis

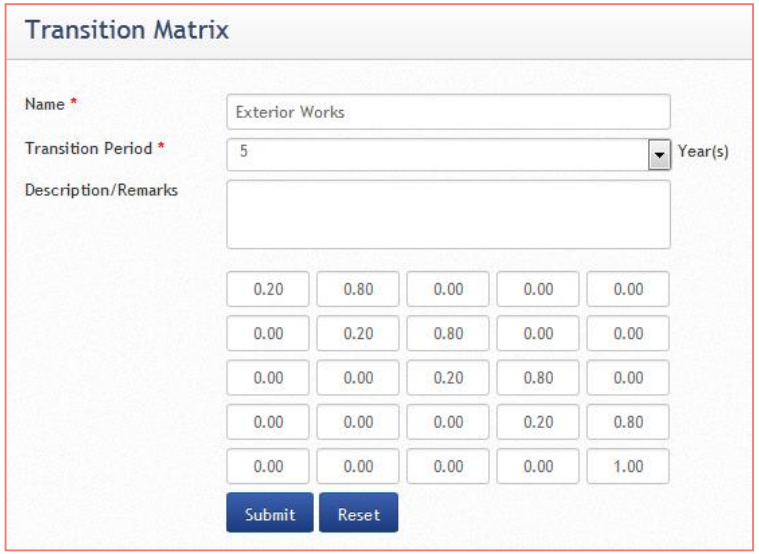
- Indicators to show what information is inputted



Simple Deterioration forecasting

- Inputs Include:
  - Transition Matrix
  - Condition Score





Step 4: Deterioration Risk Cost Analysis

- Inputs Include:
  - Transition Matrix
  - Condition Score
  - LOS, Risk & Cost

Consequence cost is the cost incurred by an element when it is in a given condition. Eg: HVAC in condition 4 () will increase the operating energy by $100 per month

LoS, Risk & Cost Input

Component Group: Essential Services

	Quantity of Element In condition	Consequence Cost of being in condition	If Quantity % Greater than	Intervention Criteria Rehab to condition	Cost/Unit
Condition 1	0	$ 0	100 %	Condition 1	$ 0
Condition 2	1	$ 0	100 %	Condition 2	$ 0
Condition 3	0	$ 100	50 %	Condition 2	$ 201
Condition 4	0	$ 500	25 %	Condition 2	$ 400
Condition 5	0	$ 1000	10 %	Condition 3	$ 500

Submit Close Refresh

Threshold of Consideration
Eg: Only Rehab to condition 2 if the percentage of elements in Condition 4 exceeds 25%

Step 5: What-if Analysis & Backlog Identification

- Inputs

LoS, Risk & Cost Input

Component Group: Curtains & Blinds Group

	Quantity of Element In condition	Consequence Cost of being in condition	If Quantity % Greater than	Intervention Criteria Rehab to condition	Cost/Unit
Condition 1	0	$ 0	100 %	Condition 1	$ 0
Condition 2	1	$ 0	100 %	Condition 2	$ 0
Condition 3	0	$ 1000	70 %	Condition 2	$ 50
Condition 4	1	$ 3000	40 %	Condition 2	$ 100
Condition 5	0	$ 5000	10 %	Condition 1	$ 300

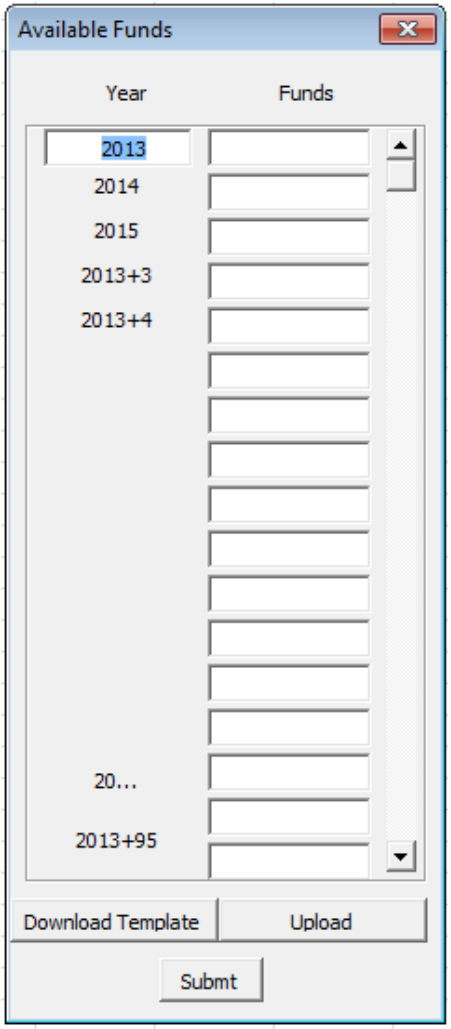
Submit | Close | Refresh | Set to Condition 3 (1, 2, 3, 4)

Could be consequence cost ($) : Detailed
Or Consequence Rank : 1 – 5 or 10 . . .

The risk cost is quantified by applying the formula:

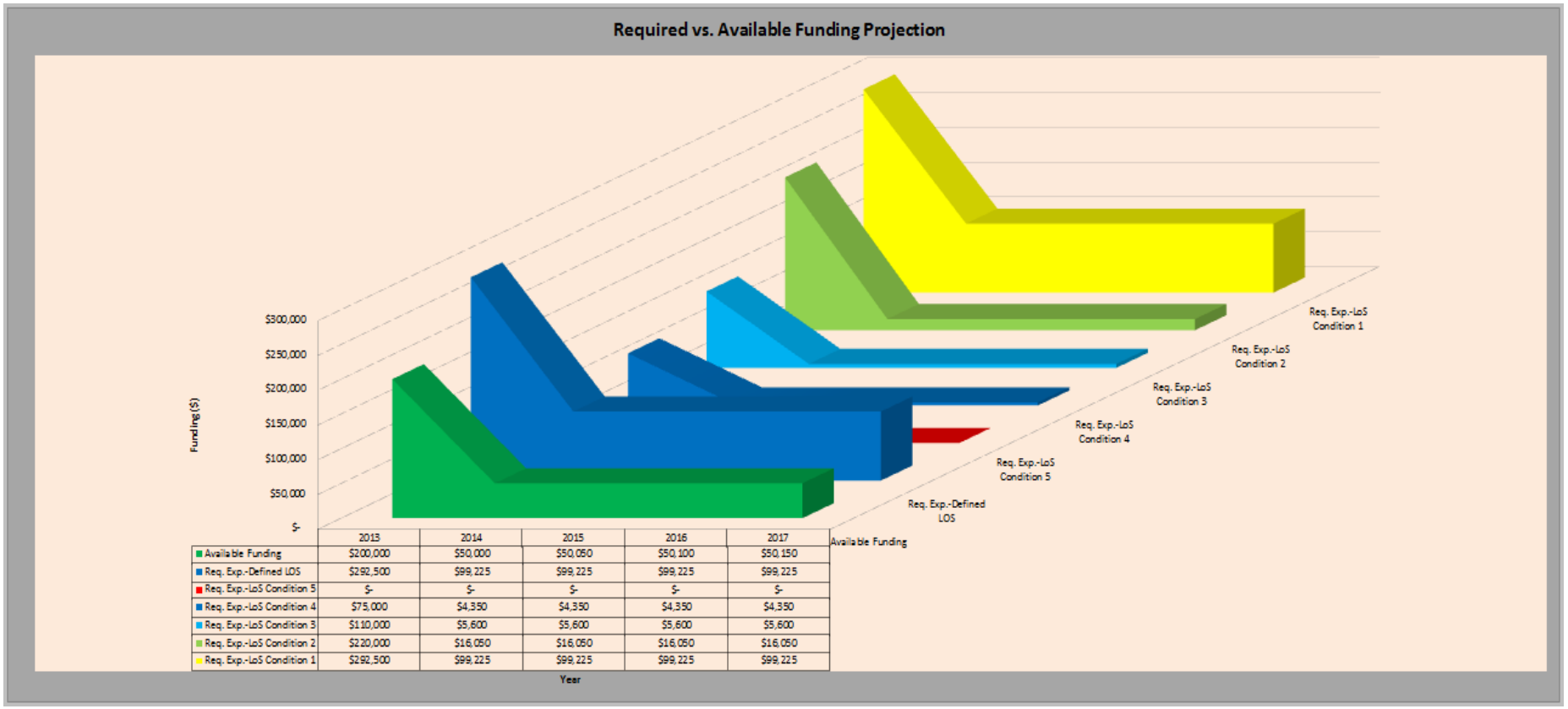
Risk cost = Cost of failure x Probability of Failure

ODM Guidelines



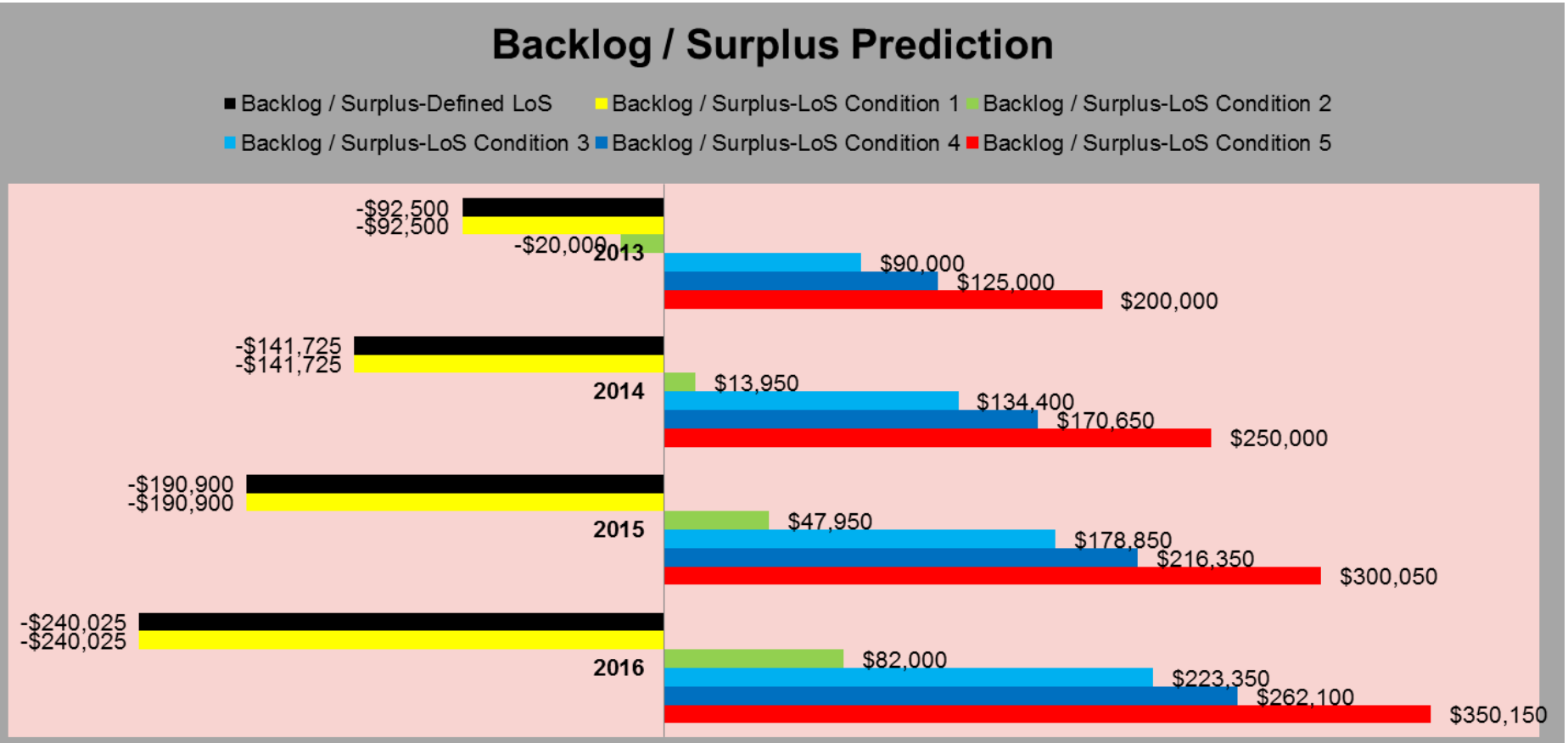
What-if Analysis & Backlog Identification

- Outputs



	2013	2014	2015	2016	2017
Available Funding	$200,000	$50,000	$50,050	$50,100	$50,150
Req. Exp.-Defined LOS	$292,500	$99,225	$99,225	$99,225	$99,225
Req. Exp.-LoS Condition 5	$-	$-	$-	$-	$-
Req. Exp.-LoS Condition 4	$75,000	$4,350	$4,350	$4,350	$4,350
Req. Exp.-LoS Condition 3	$110,000	$5,600	$5,600	$5,600	$5,600
Req. Exp.-LoS Condition 2	$220,000	$16,050	$16,050	$16,050	$16,050
Req. Exp.-LoS Condition 1	$292,500	$99,225	$99,225	$99,225	$99,225

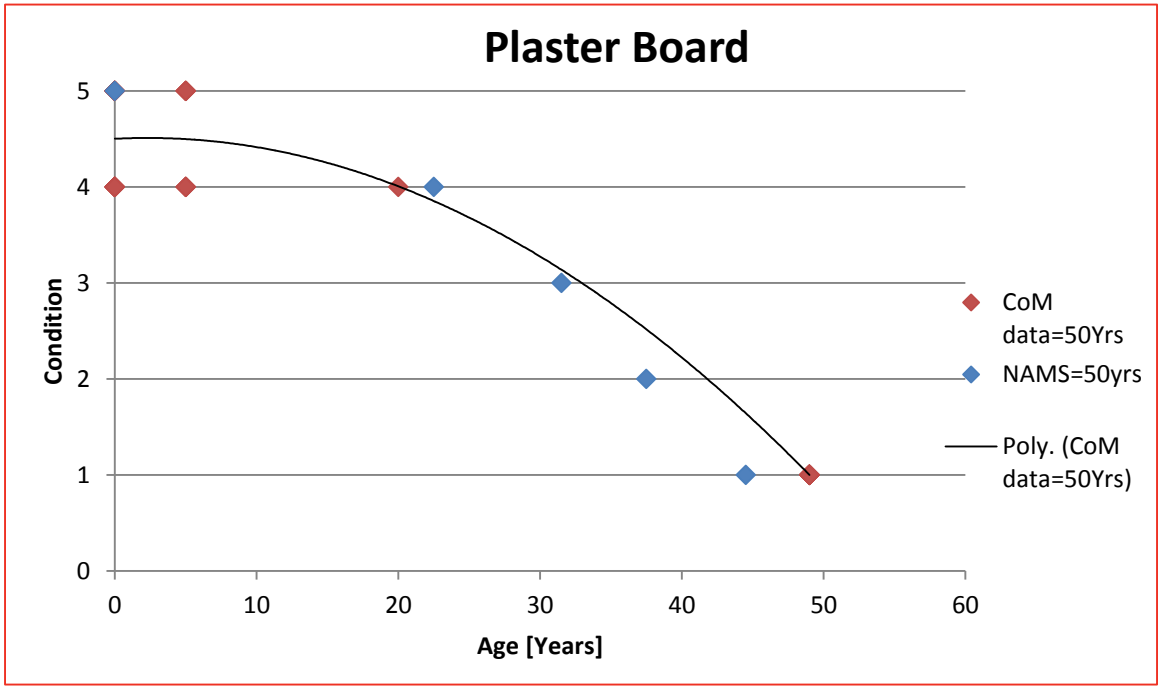
What-if Analysis & Backlog Identification



	2016	2015	2014	2013
Backlog / Surplus-Defined LoS	-$240,025	-$190,900	-$141,725	-$92,500
Backlog / Surplus-LoS Condition 1	-$240,025	-$190,900	-$141,725	-$92,500
Backlog / Surplus-LoS Condition 2	$82,000	$47,950	$13,950	-$20,000
Backlog / Surplus-LoS Condition 3	$223,350	$178,850	$134,400	$90,000
Backlog / Surplus-LoS Condition 4	$262,100	$216,350	$170,650	$125,000
Backlog / Surplus-LoS Condition 5	$350,150	$300,050	$250,000	$200,000

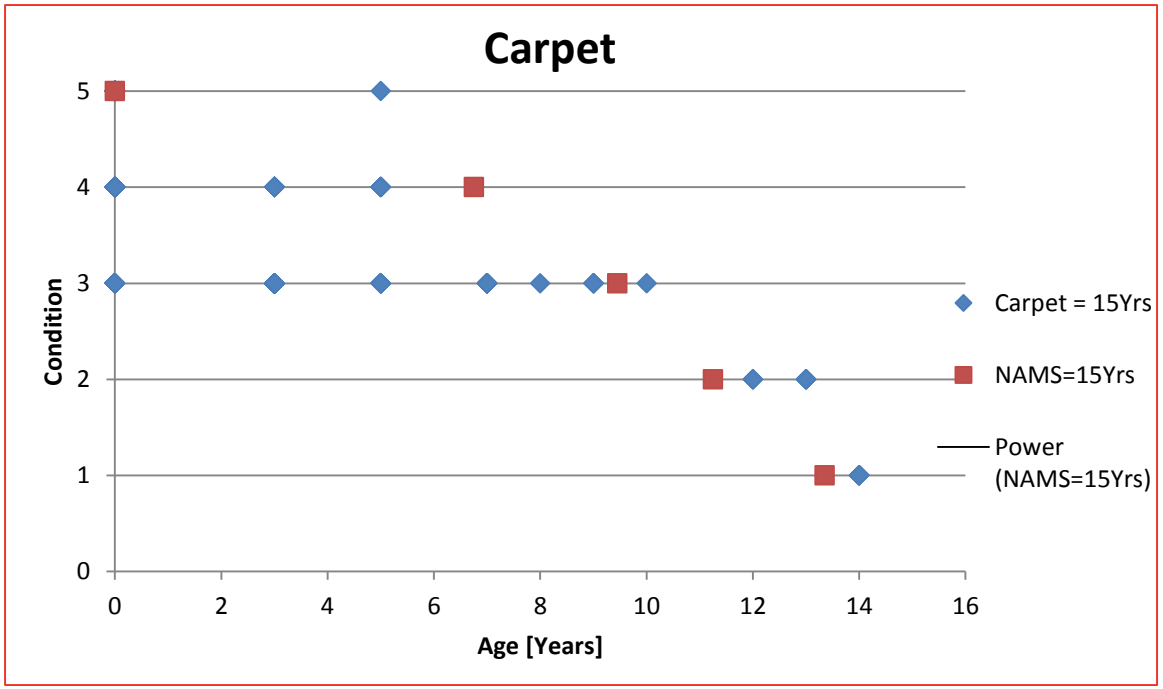
Comparison of COM data and CAMS curves

- Curve validations



Comparison of COM data and CAMS curves

- Curve validations



Technology

- Based on Microsoft's Web Applications Development Platform
  - Microsoft .NET, SQL Server 2008
- Hosted on Amazon Web Services in Sydney
  - Best in class security, scalability and performance
- Each CAMS account runs on a separate database
  - Data segregation
- Cloud based
  - No hardware or special software required
  - New features and updates gets rolled out and immediately available for all users
  - Runs on any compatible browser.
    No installations required

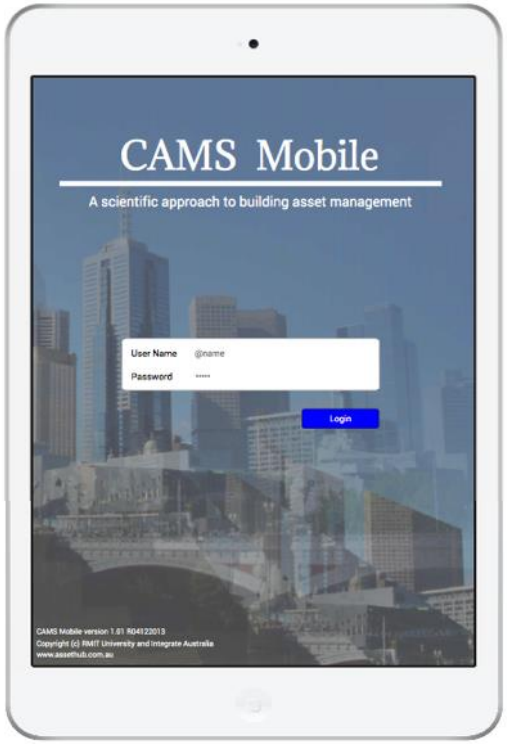
Browser Compatibility

- Compatible with most browsers
  - IE (Version 9.0 onwards)
  - Chrome
  - Mozilla

- Runs on desktop, laptop and tablet versions

In progress- Mobile Inspection App

- A tablet based app for capturing inspection data
- Seamless integration with the CAMS Online application
- Currently in prototype stage



Some recent recognition

- **New grant ($50K) obtained from Victorian Government to implement the tool, with Integrate Australia Pty Ltd.**
- **National Asset Management Council of Engineers Australia Postgraduate Research Awards 2012 and 2013**

Thank you
Q & A